Spatial Analysis of Regional Residential Markets in England and Wales

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A Thesis Submitted in Partial Fulfilment of the Requirement of Nottingham Trent University for the Degree of Doctor of Philosophy

April 2017

Abstract

Purpose – This study examines house price returns and volatilities of the returns in residential markets in England and Wales at a county/unitary authority level for the period from 1997 to 2014. Main driving factors of the returns and volatilities are indicated. Additionally, by using spatial econometrics, we show the existing spatial structure of the returns and volatilities.

Design/methodology/approach – The study employs a variety of data from the demand and supply side of property markets to help explain differences in returns and return deviations among unitary authorities and counties. The data is constructed in cross sections. Descriptive statistics, linear regression models, spatial diagnostics, and spatial regressions are applied to assess the significance and magnitude of the coefficients in order to describe return and return risk distribution across the markets. Additionally, direct and indirect spatial impacts are calculated to enrich the interpretation.

Findings – The results demonstrate that returns and volatilities of the returns have a negative correlation, which is unconventional according to the Modern portfolio theory (Markowitz, 1952). Housing volatility is negatively related with factors that usually suggest stronger economic and property market environment; for example, employment or population. Additionally, average house price level in the area is a significant factor that influences house price returns and volatility. Finally, strong evidence for the spatial structure of returns and return deviations in the property market are displayed.

Practical implications – The study is important for understanding residential property markets. It may help in an investment decision-making process. Additionally, examination of the return deviations in property markets suggests that standard deviation may be an appropriate risk measure, however, it cannot be considered according to a traditional risk return trade off concept, which could be affected by other risk factors that play more significant roles in UK housing markets. In addition, the study questions the trustworthiness of the data and the possibility of research at this disaggregation level.

Originality/value – Few studies investigate the driving factors behind house price returns and returns volatilities in residential market at county/unitary authority level.

Keywords: Risk and return relationship, volatility, returns, residential property markets, spatial econometrics.

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I. Introduction

House price changes has an impact on a wide range of issues, starting from the macroeconomic stability of a country, household consumption, mortgage pricing, and ending with the amount of divorces (e.g. Farnham *et al.* 2011).

The risk of residential real estate markets is a very under-researched subject. While most of the investment products are analysed through the perspective of returns and risks, residential properties are often left behind. This is because residential properties are primarily seen as a consumption product but not an investment (for comparison, commercial real estate, which is often being seen as investment product, is more researched, especially larger stocks that have a demand among institutional investors). To a certain level, residential real estate market risk is analysed together with other property types; however, residential markets are often included just as an example, while comprehensive analysis of the single sector investment risk is avoided. The lack of research on residential property investment risk naturally demands to fill in the gap. However, there are several practical reasons why residential market volatility should be researched. Residential real estate volatility is tightly related with the economic development of a country. It has a great impact on households' wealth and consumption. It could affect business development plans in the area. Finally, it is gaining popularity as an investment asset among financial investors.

Firstly, it is important to investigate residential market and its risk, as it is closely related with economic performance of a country or region. House price volatility has an effect on households' wealth, which, consequently, is important as it has an impact on future consumption, it may provide funds for entrepreneurial activities, or smooth or offset reduced income when person retires or gets sick, thus requiring less social assistance. Thus, residential market risk through households' wealth has an effect on countries consumption growth and stability, and, to some extent, on investments and new job creation processes. Mian *et. al* (2013) showed that housing net worth shocks have a significant impact on consumption, which differs across areas. Carroll *et. al.* (2011) have found that house price movements have an immediate effect on consumption. Chandler and Disney (2014) noted house price volatility could cause behavioural responses by households in terms of spending, borrowing, or labour supply. As a result, understanding country or regional residential market risk may be beneficial for policy makers who want to adjust the direction that society is heading.

Secondly, home ownership is a popular type to acquire housing services - often also seen as an investment - among individuals, resulting in high percentage home ownership among the British. According to the Office for National Statistics (2013), the rate of owner-occupied households in England and Wales at 2011 was 64 percent. This rate is higher compared to many other industrialized European countries, e.g. in Germany, France, and Scandinavian countries. Additionally, the concept of climbing the property ladder is very popular in the UK – it is widely accepted and encouraged behaviour. Furthermore, properties constitute a majority asset for individual householders. Banks *et al.* (2002) analysed the differences between US and UK household wealth distributions, and concluded that households in the UK appear to move into home ownership at relatively young ages and a large part of their household wealth is concentrated in housing. Overinvestment in a single asset may indicate that homebuyers do not adequately estimate the risk they are facing. Thus, housing market risk analysis may help individuals to adjust their investment/savings to reduce the risk or to know the return required from the investment. Furthermore, house price volatility is dangerous not only for homeowners, who are risking their home equity, but also for renters that may not be able to catch up with increasing rents adequate for the increased value of home prices. Moreover, high price volatility may interfere policy makers who want to establish sustainable housing policy in a society.

Thirdly, residential real estate risk assessment is important for the enterprises that are involved in the market. Companies may adjust their investment decisions; in particular, companies that are directly related with real estate investment and development industry estates. Higher risk could modify expansion plans for real estate agencies, development process for the construction companies, lending prospects for banks and building societies, or acquisition decisions for property managers. Additionally, even companies not directly involved in the real estate market could use the information to analyse future perspectives of the residents in the area, such as producers of discretionary consumption goods. Cunningham (2006) investigated house and land prices in Seattle and found that a greater house price uncertainty may postpone the development of land. He noted that a one standard deviation increase in volatility lowers the probability of land development by 11 percent. However, he also found that volatility increases land prices and that one standard deviation higher volatility was associated with 1.6 percent higher vacant land prices. Bulan *et. al.* (2009) investigated property investments in Vancouver and found that home price volatility delays investment. In addition, they found that higher idiosyncratic and higher systematic risk both delay the time of development.

Finally, residential properties are increasingly seen as an investment and not as a consumption product for housing services. The perception on residential properties is changing among occupiers, as well as there is an increase in interest on residential sector from institutional investors. The former could be attributed to increasing financial literacy of the society and developing sophistication of saving market. The later one is probably driven by expanding real estate asset management sector, which is looking for new opportunities and is attracted to residential real estate due to specific residential real estate characteristics, such as relatively low vacancy rate, liquidity, and inflation hedge. The ability to hedge against inflation is very attractive for institutional investors that want to preserve wealth, such as defined benefit pension funds. Kullmann and Siegel (2005) found that higher exposure to housing market and house price volatility were associated with lower financial investment by households. Stevenson (2000) showed that housing market and inflation share a long term trend and are cointegrated in the UK. Joaquim Montezuma (2004) reviewed studies on inflation and housing, and concluded that housing was not very good instrument to hedge inflation, yet it was more effective compared to shares and bonds. Additionally, he noted that residential properties have a low level of correlation with other asset groups, thus are attractive for institutional investors. Consequently, the increasing interest on residential real estate as an investment product increases the demand for research in the field and filling in the gap about property market risk.

Overall, many parties are concerned about house price volatility, as house price fluctuations may disrupt their stability, e.g. households' consumption, home ownership rate, individual savings and investments. In addition, many channels from multiple angles could transfer volatility from housing market to the general economy and activity of a country, e.g. business cycle, migration. In the following sections, we are going to overview possible outcomes and links of house price volatility. Residential real estate market is important for economic performance at all levels: country, corporate, and household. Housing wealth and investments constitutes a large stake in economy, and thus fluctuations in housing market may easily transmit to other areas. Thus, it is meaningful to investigate the risks of the market and price volatilities, as it may improve the decision-making on many levels.

The objectives of the study is to analyse housing markets across England and Wales. There are a few aspects that are emphasised in this study. First, the spatial analysis is important in this study. It is applied for the analysis with the aim to investigate whether spatial econometrics could improve real estate investments decision making. Second, it is focussed on the returns and risk of the housing markets. In this study housing market are investigated as if they were investment assets, rather than consumption goods.

This paper adds new evidence to the literature on housing market returns and volatility. It estimates average returns of the housing markets in England and Wales in the presence of volatility and a spectrum of control variables. Additionally, determinants of returns volatility are considered and estimated. The research indicates how returns and volatilities change across counties/unitary authorities in England and Wales, depending on population, job market conditions, house price level, and changes in house sales. The house price returns were correlated with the traditional demand side variables: population and employment. Moreover, the house price returns were positively related with the house price level, thus suggesting a property market polarization and possibly fly to safety during the crisis period. In addition, it is shown that risk-return trade-off, as defined in a conventional way, does not exist in English and Welsh housing markets but there is an opposite relationship. Furthermore, there is a strong presence of spatial structure in the residential property market. The application of spatial structure indicates that the coefficients in the linear model were biased in terms of size and statistical significance. Finally, housing markets in Greater London was analysed separately as special case. Interestingly, the risk-return relationship in these housing markets have not shown indication of opposite relationship. In addition, the spatial autocorrelation of the returns among housing markets diminished when controlled by a single explanatory variable - unemployment.

The rest of the paper is organized as follows: Chapter II presents research questions, Chapter III discusses the findings in the prior literature; Chapter IV describes the data, construction of the variables, and methodology. Chapter V contains descriptive statistics, the empirical analysis and results, Chapter VI provides discussion and indicates limitations and recommendations for the future research and Chapter VII concludes[1].

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1 This thesis includes content that has been previously published in two conference proceedings. The initiation, key ideas, development and writing up of these papers were the sole responsibility of the candidate, under the supervision of Prof Michael White (see Gostautas, 2013, 2014).

II. Literature review

This chapter covers a wide range of literature in real estate, economics, finance and econometrics. The literature reviewed is divided into several sections. In the first section, studies that analyse real estate market fundamentals are discused. It is important to cover literature on house price fundamental for better comprehension of housing markets, dynamics, and roots of price volatility. In the second section, we cover studies that risk analyse risk in finance, investment, and real estate. Also, the section inludes some motivation behind risk research, some applications of the risk research, discusses capital asset pricing model and other closely realted risk measurement tools. In the third section, the that analyse spatial econometrics and its application in real estate were reviewed. The section discusses problems with analysing spatial data without applying spatial structure for it. It also list advantges and disadvantages of spatial econometrics. The fourth section of the literature review, discuses a wide range of issues that house price volatility could affect. The section includes housing market overview, discusses the importance of housing for overall economy, as well as for more narrow part of economic and social issues such consumption, house ownership, migration, and personal portfolio formation. The final section provides a summary.

1. Fundamentals that drive real estate prices

In order to better analyse residential real estate returns and risk, it is necessary to understand the fundamental forces which drive changes in house prices. The fundamentals that has effect on house prices could be divided into economic, demographic, and physical. On itself, economic factors could be dived into economic activity, employment, inflation, interest rates, and etc. The demographic factors could be divided into population and its structure related, as well as social processes related issues such as crime rate or education level. The last, physical factors covers location, which includes artificial and natural characteristics, amenities of the dwellings, availability of the land.

The review of the real estate market fundamental drivers will provide basis for the analysis and will help to build sufficient model, which could explain real estate risk and return distribution. The literature reviewed contributes selection process of the model variables by providing theoretical background for the factors considered. In the following paragraphs, the most important factors discussed by other scholars in the field are identified, and their links with real estate markets and possible impact on the distribution of its risk explained.

1) Economic drivers of residential real estate

Economic variables are considered the most important factors of the real estate market dynamics. Firstly, the real estate market is not resistant to the contractions and expansions of the economy. Secondly, it is commonly agreed that macroeconomic variables are the best proxy for demand side variables. However, the behaviour of the decision makers on both demand and supply is affected by the general economic environment. In the following paragraphs, employment and income, interest rates, and inflation as variables representing economic activity are going to be considered.

Employment is a strong factor influencing property markets. Decreasing unemployment increases the total amount of disposable income of the households, and is usually followed by an increase in employee compensations. The process shifts the demand curve of the property markets up, thus lifting property prices. Hence, increase in employment, income, or GDP puts an upward pressure on the prices. It was confirmed by multiple studies. Meen (2008) noted that income, interest rates, housing supply, and changes in legislation could explain trends and volatility in the UK housing market. Adams and Füss (2010) analysed the relationship between housing markets and several macroeconomic variables in fifteen countries for a period of 30 years, and found that economic activity, average construction costs, and interest rates do have a high influence. Himmelberg *et al.* (2005) noted that, without accounting for changes in real, long-term interest rates, expected inflation, expected house price appreciation, and taxes, one cannot accurately assess whether houses are reasonably priced.

Andrews (2010) investigated house price volatility in OECD countries from 1980 to 2005, and confirmed that house prices tend to increase with gains in households' disposable income, the elasticity of real house prices with respect to disposable income being close to one. Furthermore, reductions in real interest rates and structural unemployment are also found to be positively related with the house prices.

The majority of properties are acquired with mortgages and loans, while interest rates represent the availability of loans for the homebuyers - as the lower they are, the smaller payments households have to make, and it is easier to buy a house. Thus, interest rates are very important factor when determining house price changes. From the literature reviewed, it is also seen that interest rates are an important indicator in the property markets, and may affect housing markets in many ways. "By raising or lowering short-term interest rates, monetary policy affects the housing market and, in turn, the overall economy, directly or indirectly through at least six channels: through the direct effects of interest rates on, (1) the user cost of capital, (2) expectations of future house-price movements, and (3) housing supply; and indirectly through, (4) standard wealth effects from house prices, (5) balance sheet, credit-channel effects on consumer spending, and (6) balance sheet, credit-channel effects on housing demand," (Mishkin, 2007, p. 5, pg.5). Mishkin (2007, p. 5) added that housing markets are very important for the monetary policy makers who want to achieve price stability and maximum sustainable employment.

Additionally, low interest rates stimulate economy; thus, it may have an effect through increased employment and incomes. Mayer and Hubbard (2010) examined global residential and commercial property markets, and concluded that interest rates have an important impact on housing and real estate prices. Glaeser *et al.* (2012) noted that low rates, combined with other credit market conditions, could drive the housing boom of the 2000s. However, it needs to be emphasized that the relationship between real estate markets and economy is not always clear. Gallin (2006) investigated house markets in the US and found that economic fundamentals such as income do not have a stable long-term relationship with the house prices.

Many scholars attribute interest rates a relatively big role in causing housing market fluctuations. Taylor (2007) overviewed monetary policy, economy, lending system, and housing market development in the U.S., and concluded that loose monetary policy could have caused intense housing market fluctuations of the last decade. Additionally, he notes that the poor credit assessments on subprime mortgages may also have been caused by this.

Del Negro and Otrok (2007) analysed housing markets in the U.S. at a state level from 1986 to 2005 in order to found how expansionary monetary policy is related for the house price appreciation at a national level during the first part of the last decade. They noted that while monetary policy shocks on house prices were noticeable, they were of a small scale if compared to the magnitude of the price increase over the 2000-2005 year period. Thus, they concluded that expansionary monetary policy is not in fault for the housing market boom.

Kuttner (2012) examined the relationship between the interest rates and housing prices using VAR model in the U.S., and then a cross country comparison with Estonia, Iceland, the U.S., the U.K., Korea, and Portugal. He concluded that the impact of interest rates on house prices appears to be modest and the effects are insufficient to account for the rapid house price appreciation experienced in the U.S. and elsewhere during the last decade. He argued that interest rate impact on housing market bubbles is overestimated. He noted that house prices raise when interest rates drop, yet it does not prove that low interest rates cause bubbles, as it does not show that house prices overreact to a reduction in interest rates. Kuttner (2012) also did quite an elaborated overview on the existing literature on the interest rate and housing market relationship, which supports his conclusion.

One more economic indicator widely considered to have a high impact on real estate markets is inflation. There is a strong theoretical basis to support the idea that movements in real estate markets, especially residential, are interrelated with inflation. Firstly, inflation affects nominal prices of properties. As inflation has an impact on income and expenses that households have, it accordingly affects the nominal prices that they are willing to pay for the most desired properties. Furthermore, people expect that real estate value will increase together with inflation. Thus, as they wish to preserve the value of their wealth, some purchase properties because of this reason. Brunnermeier and Julliard (2008) examined the relationship between housing prices and inflation in the UK and the US housing markets. They decomposed house price-rent data into two series: rational and mispricing. They found that mispricing series could be largely explained by fluctuation of inflation. Sinai and Souleles (2005) noted that hedging against rent price inflation is one of the incentives to own a home. Secondly, inflation and housing prices are tightly related indicators. According to The Office for National Statistic (2012), the housing market is second biggest component part of the Consumer Price Index in the UK constituting 14.4 percent. Thirdly, inflation increases interest rates, thus reducing the number of property buyers. Finally, in some markets, the accepted practice is that letting prices are recalculated annually according to inflation. Consequently, returns on properties to let are related and, in some markets, tied with the changes in general price level. Yet the link through the letting agreements may be more uncertain than it may look, as the letting prices were recalculated after the actual inflation was already observed. Furthermore, when letting agreement is finished, a new letting price may be set below a certain level - which would have been right, if price were recalculated according to inflation. Thus, the lifetime rent curve of a property may look not as a straight increasing line (in case of constant level inflation), but more as a saw. To sum up, real estate markets to a certain degree depend on inflation, though the relation is not linear and constant.

The findings of real estate and inflation link in previous studies are rather equivocal. Hoesli *et al.* (2008), using Error Correction Model, investigated inflation hedge capabilities of direct and indirect real estate in the UK and US from 1977 to 2003. They found that expected and unexpected inflation are significant in directly and indirectly owned real estate in UK in the long-term and short-term models. Yet, in the US, neither expected nor unexpected inflation was significant for the short-term models. Additionally, they found that real GDP is highly significant for directly owned real estate in both markets for long and short-term models. Moreover, country's policy on inflation also matters. Frappa and Mésonnier (2010) found that an inflation-targeting policy has a positive impact on house prices. Overall, property is considered a "real good", i.e. its price is expected to increase in line with inflation. However, real estate scholars have not succeeded in finding consensus on the movement correspondence between real estate price and inflation.

To sum up, multiple earlier studies have found that major economic variables, which often also indicates the general health of the economy, also drives residential real estate prices and has an impact on price volatility. Economic activity, employment, compensation per employee, inflation and interest rates are all strongly related variables not only among themselves but with the house prices and price volatility. However, as the variables are strongly related and often capture similar effects in the following only selected variables will be applied. Furthermore, some of them are cannot be disaggregated at a smaller geographical scale (for example interest rates), thus they will not be considered further.

2) Demographics

One of the major factors in housing markets is demographics and its structure. Size of the population, its growth, and age structure does affect demand on the housing. Additionally, high population density may have effect on supply elasticity. Andrews (2010) researched the factors, which influence the level and volatility of real house prices in a panel of OECD countries from 1980 to 2005, and found that demographic developments influence the demand for housing, thus increase in population originating from net migration raise real house prices. Levin *et al.* (Levin, Montagnoli, & Wright, 2009) investigated demographics and housing markets in England and Scotland, and concluded that demographic factors influence house prices, especially age groups that are associated with the first time buyers and house movers, and that decreasing population put a downward pressure on property prices. Miles (2012) analysed the impact of demographics on housing stock and values, and concluded that the combination of rising population density and incomes led to rising house prices. He added that the impact of density is not linear, as the increase of density in sparsely populated areas may not have an effect. This could be due to structure of the house price. House value could be decomposed in two elements: land value and building value. The two elements are fundamentally different in terms of their markets. Land has a limited supply and, in market with a growing population, is determined for rising prices. The augmentation of prices is unavoidable in the areas that observe population growth, unless convenient transportation ways are established, that "provides" more land in the market, or technologies that are more efficient are used to exploit existing land area for a more living space. While building structure is not a scarce good, which can be provided relatively easy, and should not cause huge fluctuations in a normally functioning not heavily over or under supplied market. Bostic, Longhofer, and Redfearn (2007) argued that home value notion should be deconstructed into land value and construction value, and that the magnitude of the house price response to housing market shocks will be positively related to the extent of land leverage. Zhou and Haurin (2010) investigated house value volatility and found that the more highly ''land leveraged'' houses have a greater variance in its value.

Low population density could also affect real estate prices via low market liquidity. In small and illiquid markets prices tend to fluctuate more. A situation in a small market when there are few transactions is called thin market effect. Thin markets are associated with several characteristics, such as low liquidity, volatile prices, larger bid, and ask price spreads. Real estate markets usually have few transactions, especially if compared to other markets where this concept is often applied - for example, financial markets, and stock markets. Thus, real estate markets frequently possess thin market's characteristics. Current research is performed at a relatively low disaggregation level, which may, due to few transactions, highlight these characteristics even more. Furthermore, thin market characteristics could have an impact on the precision of results. "The core estimation problem for small-area price indexes is the lack of degrees of freedom," (Schwann, 1998, p.270). Francke (2010) discussed a repeat sales index methodology for thin housing markets using data in the Netherlands. He showed how house price indices at an aggregated level are smooth and are becoming more volatile with every disaggregation level. Schwann (1998) showed how volatility of housing indices increase with a decrease in the number of observations.

To sum up, population size, growth, structure, and developments must be considered when analysing housing markets. Generally, all these factors have a positive impact for the house price development, if they are related to higher amount of households or larger required space. However, if there is no scarcity of the land in the area, the impact of demographics could be rather small. On the other hand, a small market could have a few transactions, which could cause higher price volatility in the market.

3) Physical factors

The physical factors are also very important in determining residential real estate prices, as they cover many issues that buyers often considers in the house purchasing process. The importance of the physical factors on house prices increases with a smaller disaggregation level of the market. Starting from location characteristics, land availability, ending with amenities and hedonics there are a large amount of fundamental factors to consider that could change house prices significantly. A very simple example could be that people value the living comfort of the area; thus, they are willing to pay more for amenities such as good schools, transport system, and crime level. The topic of hedonics and amenities is broadly covered in previous studies. Thus these factors are not covered in detail. A good revision of studies regarding these determinants was done by Gibbons and Machin (2008). Regarding the impact of the location on housing prices, it will be covered in greater detail in the following sections.

4) Other factors driving residential real estate prices

In a short term perspective, there are more factors that has an effect on residential real estate prices and price volatility. In the context of portfolio investors, properties are not a consumption product but also investment objects that are bought for speculative purposes. Thus, the behaviour of real estate market also depends on how investors see it in the context of other investment markets. At first, real estate has to compete for investors' money with other assets, e.g. stocks, bonds, commodities. Hence, changes in the features of competing markets (e.g. expected return, expected risk, liquidity) may trigger changes in real estate markets. At second, stocks, bonds, commodities, and real estate markets share some demand side fundamentals. Thus, the changes in fundamentals lead to price changes in all the markets. If we assume that some markets are more transparent and efficient, it could be that they may also have some explanatory power for the real estate markets. Moreover, the behaviour of investment markets is the indicator of the health of the economy. For example, a well-performing stock market may signal the high profitability of the companies and conclusively higher employment. Higher corporate bond yields may indicate changes in policy or investors' confidence. A good performance of the investment markets may indicate increase in the hiring of financial sector, which is an important employer in the UK. Thirdly, real estate market, asset market and construction sector are linked together via capital market and interest rates. For example, if a value of a house is worth all the future cash flows from rent (or imputed rent) divided by a discount rate and there is an upward shift in interest rates. Than value of a house decreases and there is less incentive to construct new houses. During some time the housing stock and supply decreases. If demand stays the same, than rent raises, which increases cash flows from housing and consequently house prices. The rate (adjusted by risk) by which the future cash flow is divided is universal across the different markets. Moreover, it is driven by the amount of money and could be affected by processes in different markets. For example, if there is a crisis and there is a shortage of money in one market (for example stock market) either because of deleveraging or unwillingness to take risk, than interest rates could raise and spill over to other markets and affect housing prices (for more please see Geltner, Miller, Clayton, & Eichholtz, 2014).

On the other hand, households rarely make these comparisons because they utilize their house. Yet households has the most important role in residential real estate markets. Households own an absolute majority of the residential stock in the England and Wales. In 2015, owners occupied 62.9 per cent of dwellings according to the data of Office for National Statistics. Vice versus, individual households play a small role in the financial markets were they are dominated by institutional investors.

A direct comparison of different assets are usually made by investment managers, who possess larger amounts of assets and can adopt various investment strategies to reach higher returns, yet their importance in the residential markets are rather small as they own only a small part of overall residential stock. Private parties that rent out 30.0 per cent of occupied dwellings. The institutional property investors play a very small role in the residential market. In terms of value they owe only 2.9 per cent out of 1 trillion pounds worth of privately rented properties in the UK[2], while in total the value of residential stock in the UK was 5.4 trillion pounds.

The previous findings on the topic are obscure. Chervachidze *et al.* (2009) investigated the US real estate markets in the period from 1980 to 2007, and found that higher spreads between corporate and government bond, and change in growth of debt to GDP level, are statistically significant in explaining capitalization rates of all property types (office, industrial, residential, and retail). Guo and Huang (2010) analysed Chinese house and stock markets, and concluded that “hot money” contributed much to the increase of prices and volatility in both markets. Hossain and Latif (2009) noted that housing market volatility has an influence on a number of other markets; for example, mortgage, mortgage insurance, mortgage backed securities, and consumer durables.

[2] There is no data available specifically for England and Wales, yet it is assumed that the UK data provides a good indication about the size and structure of the market.

To sum up, residential real estate market could be affected by the performance of other assets such as stocks or bonds; however the impact would most likely be indirectly via economy or house buyers' confidence level, because only small part of participants in residential markets and financial markets overlap.

5) Real estate price cyclicality

A part of the housing price fluctuations could be attributed to housing price cyclicality. Real estate cycles could be described as repeated periods that have continuous property price increase and its following price decrease. Much of housing markets cyclicality could be explained by observable fundamentals, as house prices are based on many economic and social factors that are also cyclical; for example, economic growth, changes in population. When economy, employment, and income are growing, it positively impacts real estate market activity and prices. Furthermore, improving economy makes borrowing conditions easier achievable, thus credit financing usually raises, which stimulate house prices uptrend. In other words, real estate markets are very pro-cyclical to economic conditions and vice versus real estate booms could stimulate economy, while busts could lead to economic recession.

However, previous research has shown that commonly agreed housing market fundamentals are not enough to justify all the price movements. Capozza, Hendershott, and Mack (2004) showed that residential real estate markets show strong serial correlation that causes market swings, which are followed by mean reversion. Furthermore, Claessens, Kose, and Terrones (2012) noted that housing market cycles tend to be longer, deeper and sharper compared to business cycles. They also added that interactions between housing market and business cycles depend on the linkages such as credit market. Muellbauer and Murphy (2008) noted that in addition to housing market fundamentals, such as income, the housing stock, demography, credit availability, interest rates, house price are also driven by a lagged appreciation, which is a potential mechanism for overshooting.

Property prices are unavoidably cyclical because the market possesses some very specific characteristics. Firstly, real estate markets are not liquid markets due to large price of a single unit tradable in the market. Additionally, the transaction costs are high, thus preventing market participants from frequently selling and buying houses, which also reduces liquidity. Secondly, short-term supply is fixed in a real estate market. It takes time to plan and build a new house, thus it is impossible rapidly increase a supply of the market, which leads to price overshooting. Thirdly, real estate booms and busts highly depend on credit constrains and availability. Low property prices indicate lower risk for mortgage issuers, thus easing access to credits. This leads to more mortgages issued and higher property prices, which restricts lenders who issue fewer mortgages, thus putting a downward pressure on prices. Additionally, there exist certain degrees of homebuyers and sellers irrationality, which may cause price discrepancy from what market fundamentals would indicate, especially as the primary purpose of houses is consumption.

The importance of real estate sector for economy determined that its cyclicality is an extensively studied and documented subject. Glaeser, Gyourko, and Saiz (2008) investigated house price elasticities in the U.S., noted that house price volatility in some places cannot be explained by fundamentals and that places with lower supply elasticity are more volatile, and have longer and higher real estate booms. Barras (1994) noted that cyclicality is inevitable in property market because of long supply response to the demand. Hendershott, Hendershott and MacGregor (2005), who investigated mean-reversion in real estate markets, among the reasons for price reversals, noted high transaction costs, long construction periods, principal-agent problem, and minor degrees of irrationality. A few studies point out that property cycles may differ among the regions (or even postcodes), property types, or when compared to other asset price or economic cycles. Wheaton (1999) investigated property cycles by type (offices, industrial, retail, and multi-housing) in the U.S. from 1968 to 1996, and concluded several things. Firstly, different property types do have different cycles. Some property types are strongly correlated with macroeconomic variables, thus their cycles are only shocks transmitted from economic cycles, while other types have little connection with economic cyclicality. Ghent and Owyang (2010) analysed residential real estate cycles in fifty-one U.S. cities, and concluded that local cycles do not always match aggregate country level real estate cycles. Andrews (2010) found that house price volatility among OECD countries tends to be higher in environments characterised by high rates of leverage and countries that have more generous tax relief on mortgage debt financing costs. While he adds that a more responsive housing supply, greater transaction costs, and prudential banking supervision reduces real house price volatility.

To summarize, real estate has cyclical characteristics that make property prices fluctuate beyond the impact of fundamentals. The cycles may not coincide in different regions or among different aggregation levels, and thus contribute to overall property market volatility.

6) Real estate market volatility and business cycles

It is important to note that an influence between real estate and macroeconomic variables is mutual. This means that changes in macroeconomics have an impact on real estate markets, and that movements in the real estate market may have an impact on the business cycle and economic stability in the region. Demary (2009) analysed the impact of technology shocks, inflation, and monetary policy on house prices, as well as the impact of the housing market on the business cycle, inflation, and money market rates in ten OECD countries from 1970 to 2005. They found evidence that real estate prices have a large impact on these macroeconomic variables. They conclude that house price shocks are relevant for aggregate demands shock, because they raise output and prices, and lead to increasing money market rates. They ground the findings on the hypothesis that increasing house prices leads to an increase in households' net worth, which leads to increasing consumption expenditures, and thereby stimulates aggregate demand. Increased aggregate demand causes higher economic output and pressures inflation, which by itself activates tighter monetary policy.

Mishkin (2007) noted that the housing market may have an effect on credit markets; for example, rising delinquencies of subprime residential mortgages in the U.S. have led to substantial losses to holders of securities backed by those mortgages, which led to an increase in credit spreads. Even more, a crisis in the subprime mortgage market affected credit risk and risk pricing, thereby widening spreads in general and weakening the balance sheets of some financial institutions.

Loutskina and Strahan (2012) investigated financial integration, housing markets, and volatility, and found that a 1 percent rise in housing prices increase local economic growth by about 0.3 percent. The impacts of housing price changes were greater in more financially integrated areas. Furthermore, they have found that external house price shocks in financially connected markets negatively affect local economic outcomes.

7) Summary of the fundamentals that drive real estate prices

The subsections above we review the literature review that discusses driving factors of residential real estate prices and price volatilities. We divide the fundamentals into several groups economic, demographic, and physical. All three groups of factors are fundamental in driving residential prices. Multiple previous studies have shown that major economic variables, such as economic activity or employment, demographics, such as population size or density, physical factors, such as neighbourhood characteristics, have a significant impact on house prices. In the end, we also discuss whether prices other in financial assets could have an impact on residential real estate markets, which they probably could via general economy and economic confidence.

2. Residential real estate as an asset class: motivation, risk, and portfolio formation

The story of the residential real estate as an asset in the context of an investment portfolio varies significantly depending on the investor. In case of homeowners, one house entity is often a single biggest asset in the homeowner's portfolio. Buy-to-let investors vary a lot and could own from one up to hundreds of residential stock. Institutional investors usually own many properties. Even more, in many cases residential properties only constitutes a small part of their portfolio. According to Investment Property Forum (2016), which collects data on institutional property investors, in 2015 residential real estate including student accommodation constituted 6.4 per cent of institutional property investors' portfolios (the rest being commercial real estate in various forms). However, the interest of the institutional investor in residential real estate is increasing. This is demonstrated by an increase in the share and the total value of residential stock in institutional investors' portfolios (see more Investment Property Forum, 2016). This could be due to multiple characteristics that residential real estate possess, which are attractive for the institutional investors, some of which are covered below.

1) Inflation Hedging

Often the task of the investors is not to achieve as higher returns as possible but to preserve the value of money, when it is depreciating because of the inflation. Because of this investors often target real estate as there are obvious links between real estate and inflation. However academics and practitioners still actively discuss whether residential real estate is a good hedge against inflation. Housing market returns do not always move in parallel with the inflation. A good example is the last decade, during which a big gap between house prices and CPI appeared due to the faster pace of a house price growth compared to inflation. The returns on housing and changes in CPI also differed considerably; the former had much wider amplitude. In a study by Brounen *et al.,* that operated a unique data set covering Amsterdam residential real estate market from 1814 to 2008, it was concluded that owning a house offers inflation protection in the longer run, both against actual as well as expected inflation. However, they added that, during periods when inflation is not persistent, as was the case in the nineteenth century, housing returns are not positively related to the inflation rate. Additionally, inflation may affect house prices indirectly through inflation targeting monetary policies. Some countries consider inflation target being the main task of their monetary policy; thus, if they observe or anticipate inflation rate higher or significantly lower compared to objective, they may adjust interest rates accordingly. Even more, occasionally governments may modify fiscal policy in order to keep inflation rate among the target boundaries. Frappa and Mésonnier (2010) investigated seventeen countries from 1980 to 2007; nine of the countries have had inflation targeting policies at some point during this time. They found robust evidence that there is a significant positive effect of inflation targeting on real house price growth and on the house price-to-rent ratio. Overall, there is a good incentive to think that inflation and house prices should be positively correlated; however, neither data nor previous research could strongly support it.

2) Hedging house price risk

Like with any other asset, owning a home puts a burden of changing price risk. Managing this risk could be part of many businesses; for example, investors who own properties to let, developers who still are in progress of completion, financial investors into mortgage debts. Alternatively, individuals who own a house or plan to purchase it in the near future may also consider reducing their home equity risk or hedge against potential increase in prices. Hedging against house price movement is important for individual households, as house value usually constitutes a large part of overall household's financial portfolio. One way to manage home price risk is hedging your assets by entering into property derivatives positions, such as home price futures. While property derivatives are not widely adopted across countries, it is relatively new product. Chicago Mercantile Exchange (CME) introduced property derivatives that replicate S&P/Case–Shiller house prices indices only in 2006. Futures for ten metropolitan areas and a composite index are traded. Similar products that follow residential property market indices do not yet exist in any other country. In the UK, there is no financial derivatives that could be used for residential real estate price risk hedging (yet, there are derivatives that cover commercial real estate market). However, if it originates at some time - according to the example in the US where futures of only ten metropolitan areas are traded - it will probably not cover all the UK, and most likely is going to be based on all country data or London, and a few other large urban areas. Thus, it is important to find how this "theoretical" product would be applicable across the country.

Bertus *et al.* (2008)_ENREF_12 analysed hedging efficiency in Las Vegas metropolitan area using futures traded at CME, and concluded that house price volatility risk could be reduced up to 88 percent for theoretical investors whose portfolio is spread across the area. Yet, for a homeowner or business, which is concentrated in one location, home price risk hedging possibilities are very limited. Moreover, they found that it is easier to hedge existing homes compared to new homes, as S&P/Case–Shiller house price indices use repeat sales methodology, thus making futures applicable to reduce business risk for the developer of new homes. Additionally, Bertus, Hollans, and Swidler (2008) noted that hedge ratios vary over time, thus complicating house price risk hedging even more. The findings are very interesting for current study, because it indicates that local house price volatilities may differ compared to areas index, to such extent that it would not be efficient to hedge against house price risk. Similar conclusions were made in other studies. For example,

De Jong *et al.* (2008) analysed how useful house price futures are and their incorporation in a long-run households' financial portfolio in addition to other financial assets. They concluded that there is little value from house price futures, because of large idiosyncratic variation in house prices and because hedging is costly. In most cases, they found optimal positions in house price futures being close to zero. However, they added that a hypothetical house price future, which fully covers house price risk, would be beneficial for homebuyers. Yet, the findings show that it is possible to reduce house price risk if hedging property markets are decomposed into relatively small areas, thus justifying the need of smaller scale research on a real estate prices.

Scholars for a long time have promoted the benefits of covering house price risk. Real estate economists encourage permitting house price risk hedging with property derivatives, as it would take off the risk from households whose financial wealth is often overexposed to house price risk.

One of a few early studies that led to the creation of financial instruments covering housing market in the US by Shiller and Weiss (1999) noted that the risk of decline in the market value of homes is far greater than the risk of fire or other physical disaster. Consequently, they stress that the potential significance of an insurance industry that protects the market value of homes is much larger than that of the existing homeowner's property insurance industry.

A disproportionate risk of housing markets to personal wealth was recorded by several studies. Englund, Hwang, and Quigley (2002) investigated investment portfolios that are exposed to housing in Sweden. They noted that because of homeownership, average households contain more than 100 percent of their wealth invested in housing, up to until they are fifty years of age. However, for short holding period, the optimal investment portfolio holds no housing, while for long-run, a low-risk investor holds only from 15 to 50 percent of housing in his investment portfolio. The scholars added that there is a big potential gain in permitting house price risk hedging for households, especially for younger and poorer ones.

Moreover, Iacoviello and Ortalo-Magné (2003) analysed a possibility for households in London to adjust the exposure to housing market by using property derivatives. They noted that house price risk hedging provides benefits. It may improve welfare, especially for the case of poorer homeowners who face the highest net wealth volatility and shortfall risk. Additionally, they noted that existing possibilities to spread bet on house price indices are exploited wealthier clientele who are pursuing for high risk–high return strategy, and who are looking to be exposed to housing returns without being directly involved in property market.

Academic support for implementing financial instruments to reduce house price risks for households at some time may provide a basis to establish accessible trading of instruments representing house price movements in the UK[3]. In that case, it is important to know the differences between the house price volatility among different areas in the country.

3) Real estate in an investment portfolios

Residential properties are of interest for the investors. Large investors, who own multiple stocks, are also considering various methods to reduce their risk and increase returns. Consequently, real estate portfolio formation and diversification are important topics to the practitioners and academics. In a survey of UK real estate industry members by Newell *et al.* (2004), "diversification within property portfolios" was the fifth property research priority. This should not be surprising, as a portfolio of properties may significantly reduce risk for investors compared to single property. Callender et *al.* (2007) investigated randomly selected portfolios from 1994 to 2004 in UK, and found that thirteen property portfolios are enough to reduce the risk of an individual property by 80 percent, while thirty may reduce by 90 percent. Much of the studies on real estate as investment asset, which investigates real estate portfolios and risks, are done on commercial property markets. However, some findings could be transferable.

The primary ideas of investment portfolio diversification were created for financial markets. Thus, much of the influential research that is done on an investment risk were based on equities and bonds (e.g.Markowitz, 1952; Sharpe, 1964). Although real estate has its' own specifics compared to stocks (e.g. supply, transaction frequency, non-existing central market etc.) some of the findings in finance could be applicable in real estate. According to modern portfolio theory, investors are averse to risk, thus they should seek a way to minimize the risk given expected return or vice versus should maximize return given a specific risk level. Based on the theory if performance two assets are not perfectly correlated than it is often more beneficial to hold more than one asset in a portfolio and thus to diversify the portfolio's risk by combining different assets. Ideally, the portfolio should be

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[3] Please note that there already exist some instrument allowing to bet on the house price index performance (see Iacoviello & Ortalo-Magné, 2003), yet actual futures and options representing UK house price movements do not exist.

combined from assets whose prices move inversely, or at different times, in relation to each other. Investment returns should be weighed against the risk and when an investment portfolio is being constructed it the minimal total risk should be achieved for a particular return. A portfolio, which has the same return, yet higher risk, is not considered efficient (see Markowitz, 1952). A set of optimal portfolios that provides highest returns with an increasing risk level is called efficient frontier. The method is often utilized in investment management.

Not all risk can be diversified. A part of risk that is non-diversifiable is called market risk, which is also sometimes called systematic risk, could not be diversified. Examples of market risk could be market cycles, interest rates, banking crisis. A part of risk that is diversifiable is called specific risk. There are limited ways to combine a real estate portfolio, thus in the context of residential real estate the examples of specific risk could be geographical area, location, structure.

The reviewed real estate economic literature mentions three kinds of direct real estate portfolio diversifications: geographic, economic, and property type. Geographic diversification assumes that properties, distant from each other or located in separate areas, perform in a different way. Economic diversification is based on an idea that real estate in districts with a different economic background (e.g. dominating industries, employment, economic growth) act independently. Diversification by property types is based on an assumption that different property types react individually under the same economic circumstances.

Some scholars argue that geographic diversification could reduce portfolio risk, yet it is not efficient compared to the economic or the property type diversifications. Mueller (1993) compares the geographic and the economic diversifications in the USA and found that the latter provided better efficient frontier[4]. Hoesli *et al.* (1997) investigated UK commercial property markets and concluded that property type is the most important dimension in determining different types of

[4] Efficient frontier is a concept in modern portfolio theory, which helps to define the optimal portfolio form given assets when the returns and risks of assets are known or forecastable (see Markowitz, 1952).

behaviour, yet they also found proof of a geographical factor. The relative weakness of evidence could be partly explained by the administrative districts used in the research of geographic diversification, which makes little economic sense. Brown *et al.* emphasized that geographic diversification disappoints because "pure" geographic diversification, according to administrative boundaries, is fundamentally naïve. Hoesli, Lizieri, and MacGregor (1997) noted that there were geographical factors dividing UK in to three super-regions (London, Southern ring, and peripheral markets). Moreover, they noted that one reason why the identification of clear regional patterns failed is the definition of administrative regions, which are unlikely to be homogeneous with respect to the driver variables. Byrne and Lee (2011) added that functional grouping of areas in UK commercial real estate areas can provide greater risk reduction compared to administrative regions. Lee and Devaney (Lee & Devaney, 2007) investigated commercial properties in the UK from 1987 to 2002, and found that sector-specific factors dominate regional-specific factors in explaining property returns, and especially during volatile periods; while during calm periods, the importance of the factors were more equal. However, on international level, sector-specific factors dominate regional-specific factors not everywhere. Gabrielli and Lee (2009) investigated the Italian commercial real estate market from 1989 to 2007, and found that the sector specific factors started to dominate region-specific factors only from 1997. Newell and Keng (2003) examined the Australian property market from 1995 to 2002, and found that geographic and sector-specific factors contributed to the portfolio diversification. Thus, property investments that are geographically diversified could be beneficial.

To sum up, the evidence for geographic diversification is weak, yet, in some cases, it could be efficiently combined with the other strategies. Furthermore, previous studies on geographic diversification could have been misguided by artificial geographical boundaries, and thus may not disclose all the potential. Furthermore, positive results for diversification according to economically homogeneously areas suggest that carefully selected locations could reduce the risk of portfolio.

The institutional investors and large buy-to-let investors are the most likely to apply various risk diversification and portfolio formation methodologies. However, even for investors without complex investment portfolios, the spatial analysis of the risks could be useful for deeper understanding of the processes in the residential markets.

4) Residential real estate return risk

In order to construct investment portfolio or just to compare the investment, risk measures should be defined and its dynamics should be explained. There are various types to quantify risk. Real estate economists have tried to explore housing price risk from several perspectives. The risks have been compared across regions, its changes were observed in time, and it was calculated in a few different ways. Many results of the overviewed literature are based on non-UK housing markets, yet findings are interesting and potentially applicable in England and Wales.

Many studies investigate house price volatility in time. Lin Lee (2009) investigated housing markets volatility using an exponential-generalised autoregressive conditional heteroscedasticity (EGARCH) model in Australia from 1987 to 2007. They found that volatility had a tendency to be clustered and time varying. Also, it was found that volatility tended to asymmetrically respond to bad and good news, with bad news having larger impact. Additionally, it was found that nationwide inflation was statistically significant in explaining house price volatility, while some also had significant impacts of unemployment, population, and income. Finally, they noted that volatility dynamics and determinants varied among the different cities.

Hossain and Latif (2009) investigated housing market volatility time series' relationship with other economic variables using VAR and Granger causality in Canada from 1980 to 2006. Volatility was estimated with GARCH using regression residuals from rational expectation models of home value appreciation rates. They find that GDP growth rate, home value appreciation rate, and the positive rate of inflation Granger cause housing price volatility significantly. While vice versus, housing price volatility Granger causes the negative GDP growth rate, the negative home value appreciation rate, and future volatility significantly.

Zhou and Haurin (2010) investigated determinants of house price volatility in the U.S. from 1974 to 2003 at an individual house level, and found that house values at the extremes of the quality distribution of houses are more volatile compared to those with median quality levels. The more atypical a house is, the more volatile its house value; the more highly land leveraged a house is, the more volatile is its value; and houses owned by black household heads have a more volatile price than those owned by whites. Additional, they find that the house value estimates of female, elderly, people with lower education, and long-residence householders are more volatile.

Miller and Pandher (2008) suggested that housing market, unlike financial market, could not offer full investment diversification because of dual use for consumption and investment, higher transaction costs, higher liquidity risk, and economic constraints on holding diversified housing portfolio due to large costs of one housing unit. Thus, there should be a risk premium for idiosyncratic risk in housing markets returns. They calculate idiosyncratic volatility as the standard deviation of residuals from a two-factor regression of housing returns - the two factor being the stock and housing markets - and investigate the cross-sectional relation between idiosyncratic volatility and housing returns using disaggregated U.S. housing market data at a zip code level from 1996 to 2003. Their results show that idiosyncratic volatility does positively influence housing returns. The results are robust to socioeconomic differences across the areas, such as income or price level. Additionally, they show that idiosyncratic volatility could be used as a reduced form factor for local supply-demand dynamics that operate autonomously of macroeconomic variables.

Bostic et al. (2007) argued that house is not a single good but a bundle of goods, and that changes in house prices depends on how much of the property price could be assigned for the land and how much of it constitutes the value of construction.

Not all the prices of houses at the same market increase or decrease at the same rate. Bourassa *et al.* (2009) analysed the reasons for different house price appreciation rate within the market using data from 1989 to 1996 in three New Zealand metropolitan areas. They concluded that in a bullish market, atypical properties and properties with a high ratio of land to total value observe faster price raise compared to the rest of the market. In their research, these were smaller, older, centrally located properties. They hypothesise that in a strong market, exclusive properties grow faster as sellers do have more bargaining power due to limited supply of such properties. They also find opposite relationships in a bearish market; even more, the effect of atypical properties is stronger in weak markets.

Zheng (2015) investigated whether house price volatility measured as conditional variance of a Generalized Auto Regressive Conditional Heteroscedasticity (GARCH) model could be explained by liquidity factor in Hong Kong from 1993 to 2010. He found that volatility transmits from smaller housing units to larger housing units, while less liquid houses classes were more liquid to unexpected liquidity shocks. Additionally, he noted that pricing errors were reduced with higher home sales volume, which he suggested happened due to more increased flow of information and, consequently, more accurate house price valuation.

Zheng *et al.* (2015) analysed housing market and liquidity risk in Hong Kong from 1991 to 2011. Using multiple risk factors style model, they showed that liquidity was significantly pried in the cross-sectional asset-pricing model, i.e. higher liquidity risk was rewarded by higher returns in housing market.

Glaeser *et al.* (2005) investigated metropolitan housing markets in the U.S. from 1950 to 2000. They noted that since 1970, real house price volatility increased 247 percent compared with a 72 percent increase in average prices. Additionally, the gap between house prices and house construction cost increase from significantly. Moreover, they discussed that prices at the upper part of price distribution increased substantially compared to middle or lower price properties, mostly due to limited housing supply in more expensive areas. They conclude that changes in housing supply regulations, which led to a decline in new construction, may be the most important transformation that has happened in the American housing market.

Glaeser *et al.* (2008) researched housing supply and bubbles in the U.S. metropolitan areas from 1982 to 2007, and concluded that house price volatility is higher in the areas with less elastic housing supply. In addition, these areas should experience longer and larger price bubbles.

Davis and Palumbo (2008)investigated housing markets in the U.S. metropolitan areas from 1984 to 2000, and found that housing become much more land intensive, and that the value of land in housing costs increased from 34 percent to 50 percent across the U.S. Consequently, they conclude that house price appreciation rates and volatilities in the future is going to be determined more by demand factors.

Saiz (2010) analysed terrain elevation and presence of water bodies around the U.S. metropolitan areas, trying to find whether they have an impact on housing prices and housing supply elasticities. He found that most of the areas that are considered to have inelastic supply are severely land constrained by their geography.

Gyourko, Mayer, and Sinai (2006) analysed housing markets in the U.S. metropolitan areas from 1950 to 2000, and noted that some areas appeal more to people than others do, and if these areas have a limited supply, they do not need an increase in productivity to observe an increase in housing prices. They argue that widening house price gap among most expensive metropolitan areas and average areas, and growing number of high-income families nationally are related. They add that rich people push out poorer families and increase house prices in popular areas, where housing supply is limited, and, while the number of rich families is increasing, the housing and land prices are increasing even more. Gyourko et al. (2006) called areas that attract and concentrate relatively more high-income earners “super star cities,” and argue that house price premiums in the super star cities can persist, if the growth of the absolute number of high-income families continues. Their findings could be directly applied on English and Welsh housing market, as it has at least one obvious “super star city” - London.

Campbell *et al.* (2009) analysed housing markets in the U.S. metropolitan areas, census regions, and nationally from 1975 to 2007. They deconstruct rent-price ratio into the expected real risk-free rate of interest, the expected risk premium for housing, and the expected growth rate of rents, and find that risk premium plays an important role in house price fluctuations at the national, regional, and metropolitan levels.

Han (2013) investigated risks and returns housing markets at Metropolitan statistical areas in the U.S. from 1980 to 2007. He concluded that some housing markets show a negative relationship between risks and returns, because houses provide a hedge against increased housing consumption costs in the future, in an environment with low supply elasticity and growing population growth. He noted that hedging incentives were stronger in housing market compared to other assets.

Miles (2008) analysed housing market risk across the U.S. from 1979 to 2006 by employing different time varying volatility measuring methods, and found widely varying results. Returns on volatility were found positive in some states and negative in others.

Dolde and Tirtiroglu (2002) analysed conditional volatility in the U.S. at an aggregated and regional levels from 1975 to 1993. They found income growth, inflation, and interest rates being significant in explaining volatility. They also found a significant diffusion among regions in volatility when it increases but not when it decreases.

Guirguis *et al.* (2007) investigated housing returns and volatility spill over from large city to small town in Spain from 1991 to 2006, and found that there is returns spill over, yet there was no volatility spill over.

Majority of the studies investigate housing markets in a single country or even area. Engsted and Pedersen (2014) analysed house price returns using the return variance decomposition in eighteen

OECD countries from 1970 to 2011. They decomposed the housing returns into three elements (changing expectations of future rents, changing expectations of future risk-free rates, and changing expectations of future risk premium), and were looking how each of them contributed to the house price volatility. They found that in majority of the analysed countries, news about future returns were the most important factor in explaining return variability among housing markets, while news about rents were less important factor. Additionally, they noted that interest rate news played a major role in explaining future risk premia.

Jin *et al.* (2014) analysed housing market prices in the U.S. from 1998 to 2008. They investigated returns that were in excess to risk, and tried to capture irrational market sentiments. They found that non-fundamental based homebuyers' sentiment had an impact on housing prices. Additionally, almost in all analysed areas, volatility was statistically significant factor explaining house price variability.

Cuerpo (2014) analysed European house markets and rental regulations, and found that rent control measures were likely to increase housing market volatility when fundamentals shocks - such as changes in population, income, or interest rates - were observed. They argued that this was because restrictions on rent reduce renting opportunities, thus putting a pressure on households to buy homes.

House prices fluctuates due to multiple reasons, and compared to other asset classes, have some specific fundamentals that affect its price movements. For example real estate prices have lower short-term volatility compared to stocks and commodities. There could be several reasons for this. Firstly, the reason of real estate prices being less volatile relative to other investment asset can be very simple; real estate could be less risky. Many real estate investors consider properties being a safe investment. They may provide with a constant cash flow, do not require complicated audits as companies, have additional value of insurance, consumption and inflation hedge, usually have a wide potential demand, and are owned all or a significant part that provides a control of the entity.

Secondly, property prices may appear being less volatile due to limitation of data and the way real estate indices are being constructed. Due to large absolute prices, expensive transaction costs, and nonexistence of a central market place, transactions in property markets are relatively rare. Low liquidity of the real estate prevents from frequently setting market prices. Additionally, the heterogeneity of houses does not allow to properly comparing transactions among themselves. As a result, various index construction methodologies are being applied that may smooth prices. Thirdly, real estate prices may be less volatile because of its ability to serve several purposes: investment asset, insurance against rent price increase, and consumption good. Properties that are bought for personal purposes often are looked not as investment but rather as a consumption good. Thus, homebuyers will not necessarily try to evaluate potential return on the money spend and but rather consider what satisfaction the purchase is going to bring. Consequently, home prices are less affected by constantly changing economic environment.

The existing literature places real estate between stocks and commodities, and bonds. Few studies compare residential housing with other assets. Chan *et al.* (2011) analysed returns' relationship among stocks, oil, gold, treasury bonds, and residential real estate in the US from 1987 to 2008. They note that during the investigated period, real estate, which was represented by Case-Shiller house price index, was the least volatile asset. However, the return was the second highest, just after stocks. They also found that volatile periods in real estate are related with positive returns, and low volatility periods with negative returns. Flavin and Yamashita (2002) investigated the composition of the household portfolios in the US form 1968 to 1992. They noted that residential real estate standard deviation (0.14) is higher than treasury bills (0.04) or treasury bonds (0.08), but lower than stocks (0.24). The list looks the same if sorted according to the returns.

Some findings in real estate are commonly applied for residential and commercial real estate due to many shared fundamentals. Both sectors are affected by land supply, construction costs, economic conditions, transaction costs, etc. Yet, residential real estate has some characteristics that distinguish it from other real estate classes; for example, it carries roles of consumption good, and insurance against rent price increase. As a result, price movements among these real estate classes differ.

Davis and Heathcote (2005) investigated housing market and business cycles in the US. They indicated that residential investment characterizes high volatility. According to their findings, residential investments are more than twice as much volatile as non-residential. They ground high residential investment volatility on labour intensive construction and slow depreciation of the residential structures. "Being construction intensive is important for volatility, both because construction-sector productivity is highly volatile and also because construction is labour intensive, so that construction output can be increased relatively efficiently without waiting for additional capital to become available. The fact that residential structures depreciate very slowly is important because this increases the incentive to concentrate production of new structures in periods of high relative productivity." (Davis & Heathcote, 2005, p. 780, pg. 780). Additionally, they note that residential investments, GDP and non-residential investment all co move positively. However, residential investment leads GDP growth, while non-residential investment lags.

Overall, housing prices fluctuations could be caused by multiple reasons, e.g. GDP growth rate, the negative home value appreciation rate, leverage, liquidity, housing supply elasticity. Additionally, unlike many other investment objects, residential real estate could be consumed and may affect a relative risk level of residential properties. Real estate is not considered very volatile among other investment assets and usually is considered less risky than stocks.

5) Risk assessment methods

Most common way to calculate risk is to account for the investment returns volatility, usually in standard deviations or variance. Volatility is calculated from the return data.

In this study, the volatility was calculated using following formulas:

$$SD = \sqrt{\frac{\sum(x-\bar{x})^2}{(n-1)}}$$

SD – standard deviation, also often marked as σ;

x – return for the period

$\bar{x}$ – sample average;

n – sample size.

Additionally, the volatility was annualized according to the following formula:

$$SD_{annual} = \frac{SD}{\sqrt{P}}$$

P – time periods.

Some economists argued that volatility may not be constant over time, and that more recent observations had higher probability to predict current volatility compared to older observations, yet usual calculations were providing equal weights for all observed periods. Thus, conditional volatility models were developed. These models are based on Autoregressive Conditional Heteroscedasticity (ARCH) method, which was introduced by Engle (1982), or General Autoregressive Conditional Heteroscedasticity (GARCH) method, which was introduced by Bollerslev (1986). GARCH (1, 1) process, where (1, 1) represents respectively one GARCH term and 1 ARCH term, looks like this:

$$\sigma_t^2 = \alpha_0 + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2$$

σ_t^2 – variance for time period t (ARCH term);

ϵ_t – residuals for time period t (GARCH term).

Conditional volatility is often used in financial and economic calculations due its favourable characteristics. Conditional volatility models allow for time variation, serial dependence, and non-

Gaussian distribution of date. Economic and financial data often possess these characteristics. Conditional volatility is most often calculated with GARCH models. Hossain and Latif (2009) analysed housing market volatility using GARCH models. Miles (2008) analysed volatility in the U.S. housing markets and noted that mean variance compared to conditional volatility could underestimate the risk of loses due to present ARCH effects.

The study provides only a small fraction of various risks measures from a large pool of risk assessment instruments in the finance field. The risk assessment is a widely research topic thus as there are many risk assessment methods, which occasionally seems to differ little one form another. Each of them was created with an intention to adjust existing methods for some specific drawback and is most likely outperforming other methods in certain circumstances. This study limits itself to some more popular in the finance field.

6) Capital asset pricing model

One way to define investment risk and return relationship is by Capital asset pricing model. The model describes the relationship between systemic risk, market return, and expected return. The concept was introduced by several economists around the same time (see French, 2003; Lintner, 1965; Mossin, 1966; Sharpe, 1964). The CAPM is a popular method among finance scholars and practitioners. It assumes that investor should be compensated for the time that he puts his money for and the risk that he takes in a particular investment. The compensation for time is considered a return on a very safe asset, which is often referring to as a risk-free. Thus compensation for time is called risk free return. The return that is above the risk-free return is considered a compensation for the risk taken or risk premium. Using the CAPM, it is possible to calculate a required return for a particular risk level. This is done by comparing the investment return and risk to respective indicators of the market. If investors pursue the logic of the model than expected returns and risk should be positively correlated, as the riskier the investment should be compensated with a higher return.

Critics point unrealistic assumptions of the model. Actually the model has a significant amount of unreasonable assumptions, for example, the CAPM assumes that all investors are rational, that it is always possible to borrow and lend money at a risk free rate for all market participants, that markets are efficient[5] and thus it is possible to know expected returns, that there are no transaction costs and taxes, that investments are tradable and divisible. Fama and French (2004) note that the CAPM remains the main asset pricing model and is able to explain the relationship between risk and return in a simple way. However, they emphasise that the model failed to perform in empirical way due to its multiple simplifying assumptions. Unrealistic assumptions prevent straightforward CAPM application in residential real estate market, especially for households who are the main residential real estate market participants. Institutional investors are able to achieve, that some assumptions are comparable to the ones in theory via scale, accessibility to different markets, tax optimization, etc. However, for an average household, which is a most common residential real estate market participant, the assumptions are much more distant, thus they are less likely to apply the idea when making a decision. Furthermore, return and risk may not be priorities for households at all when they are making a decision because houses could be purely a consumption product for them. As a consequence, the results of the CAPM should be treated cautiously.

The CAPM was created with the incentive to apply it for the stock market, yet since then it was used also for other asset classes, not excluding real estate. While there are many differences between real estate and stocks (e.g. liquidity, duration), the valuation principals should be the same (e.g. future cash flow, discount rate). Draper and Findlay (1982) note that the CAPM posits that an asset's expected return, in excess of the risk-free rate, is a positive, linear function of its covariance of return with a portfolio of all risky assets. Consequently, the model is often used to compare different investments across different asset classes, including real estate (e.g. Bond & Mitchell, 2010; de Wit, 2010; Lorenz & Trück, 2008). Among few studies that include return and risk

[5] More about efficient market hypothesis, please see Fama (1970) and Read (2012)

relations in real estate markets in a cross sectional and panel analysis, there is Cannon *et al.* (2006), which investigated the U.S. metropolitan housing market risks and returns in a cross sectional analysis using zip level data spanning from 1995 to 2003. They show that there is a positive relationship between housing returns and volatility, with returns rising by 2.48 percent annually for a 10 percent rise in volatility. Additionally, they find a positive but diminishing price level effect on returns, and that stock market risk is priced in the housing market. The results are robust when controlled for metropolitan statistical areas and socioeconomic characteristics, such as income, employment rate, managerial employment, owner-occupied housing, gross rent, and population density. Case K. *at al.* (2011) investigated cross sectional housing market total, systematic, and idiosyncratic risks versus returns in the U.S. from 1985 to 2007. They used a single risk factor model and found that market factor statistically significantly explains a sizeable part of housing price variation. Furthermore, the returns and market risk were positively related, indicating that homebuyers were compensated for taking higher risk. Domian *et al.* (2015) investigated house price risk and returns using the CAPM style risk factor model in the US from 1987 to 2011. They have found that housing market consistently underperformed according to the risk the markets carried. They argued that residential real estate risk, which is relatively low compared to other asset classes, whether it would be standard deviation or beta, should be adjusted by liquidity and leverage. The adjusted beta proved to be more in line with the academic consensus. Additionally, they have found that risk and return levels vary greatly depending on geography, Thus could be compared to different asset class, e.g. some had characteristic similar to gold, while other similar to junk bonds.

The CAPM model was successful in explaining only part of stock market returns and thus it as was complemented by adding other factors, such as size, growth, and momentum, which gained popularity in explaining stock market and bond market returns (Carhart, 1997; Fama & French, 1993; Fama & MacBeth, 1973). The success of the CAPM and multifactor models also influenced some real estate economist to analyse property markets using additional risk factors. Beracha and

Skiba (2013) investigated cross sectional variation of house prices in the U.S. from 1984 to 2009. They proposed a four factor economically, geographically, and psychologically motivated the CAPM style house pricing model. They found that income growth, land supply elasticity, pricing momentum, and a risk factor that was based on U.S. market wide housing return were all important in explaining cross sectional house price changes. Additionally, they noted that four factors, which were local housing market related, were able to capture the same country-wide risk, i.e. the inclusion of the factors reduced the sensitivity of house prices in a local market relatively to country-wide house price changes. They found a positive relationship between idiosyncratic risk and returns. A 10 percent higher idiosyncratic risk was associated with 1.88 percent higher house price returns. However, not all multifactor models have provided expected results. Pai and Geltner (2007) investigated real estate markets in the U.S. from 1973 to 2006 using similar risk factor model to the one created by French and Fama[6], and while the model had explained a cross sectional variation relatively well, the received results were opposite to what was expected. For example, larger properties and properties located in larger metropolitan areas where seen as more risky, while, to the contrary, stock of larger companies were often considered less risky. Thus, the authors had made three conclusions. First, that market was right, and that models represented risks that were important to investors, even if has not made immediate economic sense, especially because the model fitted well for the data. The second conclusion was that markets acted irrationally in a long property market cycle, thus there appeared opportunities for arbitrage, i.e. specific properties were returning more on invested capital with lower risk. The third explanation was that the empirical study was flawed because of the relatively short (20 years) analysed period or omitted risk factors.

The CAPM model was also considered in the spatial context. It is important to combine the two, because a decision to purchase or rent a particular real estate stock often depends on a spatial

[6] For more about French-Fama risk factor model, please, see Fama and French (1993).

context and finances[7]. In terms of real estate it is important to consider spatial factor as real estate prices, real estate returns and risk could vary across different locations. For example, Ortalo-Magné and Prat (2016) analyse housing decisions using spatial analysis and the CAPM. They found significant interactions between the space market and the asset market. They found that housing location choice depends on income, income risk, rent and the risk premium embedded in the price of local homes, which vary across locations.

Using the CAPM it is able to indicate returns that are above or below the level that should have been obtained at a certain risk level. The measure of excess returns is called "Alpha" (or "α") and it shows how much more or less return the investment achieved compared to the market[8]. It is often used to compare the performance of actively managed investment portfolios (e.g. Bond & Mitchell, 2010). In case of actively managed portfolios, a positive alpha shows that a manager of the portfolio outperformed the market and it is opposite if alpha is negative. A zero alpha shows that the fund was tied to the performance of the market i.e. a market wide portfolio will a have a zero alpha. The former portfolio is going to possess a risk level that is called market risk or systematic risk.

Systematic risk indicates how a particular investment is sensitive to market-wide fluctuations. Market risk is a risk that does not depend on a specific asset's characteristics but rather on risks that are common for all market, e.g. global economic changes, political changes, and natural disasters. Market risk cannot be diversified by including other assets in the portfolio (more see Markowitz, 1952). The systematic risk is measured as correlation coefficient of the market return variable in a linear regression (or multiple if other variables are included) where asset return serves as a dependent variable, i.e. market risk is the betas, as of a regression coefficient. An asset, which has a

[7] Spatial analysis and the CAPM were considered not only in real estate context but also for other asset classes, such as stocks (e.g. Fernandez, 2011), credit defaut spreads (e.g. Eder & Keiler, 2015) or energy (e.g. Yu, 2003).

[8] More about alpha, please see Jensen (1968)

systematic risk of one beta, fluctuates synchronically with the market. A lower beta indicates lower market risk, while higher beta indicates higher risk.

The beta is obtained using the following formula of the CAPM:

$$r_i = \alpha + \beta_i(r_m - r_f) + \varepsilon$$

r_i – returns for the asset i;

r_m – market returns;

r_f – risk free rate;

β_i – systematic risk for asset i;

α – returns above the risk, also called alpha.

However, systematic risk does not account for the market wide slowdowns. Housing market is positively correlated with the overall state of the economy in the country. Thus, portfolio even if portfolio are well composed according to the CAPM framework, they may still be vulnerable for the economic fluctuations. This is especially important for the average household that receives other income from salaries and business income, which tend to positively correlate with the economy.

While systematic risk or market risk are not diversifiable, individual assets also possess a risk that diminish in an optimally selected portfolio. Such risk is called idiosyncratic or asset specific risk is a term in a certain way opposite to systematic risk and should be independent from it. Idiosyncratic risk arises from specific assets characteristics, e.g. companies' management or properties location. It could be reduced by diversification, i.e. including more assets in the portfolio that do not carry the same idiosyncratic risk characteristics. Usually, idiosyncratic risk is obtained by substituting systematic risk from the total asset risk. There are several idiosyncratic risk calculation methods. One of them equates unsystematic risk to squared residuals of the CAPM (or other factor model). There is also one method that equates unsystematic risk to unexplained lack of the CAPM explanatory power (1- R2) or just explanatory power (R2) with inverted interpretation. While many papers use the two terms interchangeably, Li et al. (2014) showed that the two measures result in different outcomes unless an analysed asset return is not affected by market risk.

Idiosyncratic risk is asset-specific risk that theoretically could be diversified in a multi asset portfolio and should not be priced. However, residential real estate is a specific asset, which due its size, the purpose of investment, and transaction costs, often carries idiosyncratic risk. Miller and Pandher (2008) in a study about idiosyncratic risk in a housing market calculated idiosyncratic risk as a standard deviation of the error terms from a two-factor regression model on housing returns.

Overall, the CAPM is the dominant asset pricing theory in finance. It provides an attractive explanation between risk and return. Furthermore, it is widely used and it has many variant of applications. However, the model is not without flaws as it has many unrealistic assumptions. The institutional investors and large buy-to-let investors are the most likely to apply various risk measurement methodologies, yet even for investors without complex investment decisions, the CAPM could be useful for investment decision making.

7) Summary of residential real estate as an asset class

Overall, residential real estate is an asset that distinguishes itself from other investments. Housing market is different compared to other asset because its return and risk dynamics. Furthermore, residential properties stands out from other asset classes, because housing market is dominated by households, while asset such as stocks or bonds are primarily acquired by institutional investors. Households are not necessarily always motivated by financial reasons when acquiring houses. Also they are not able to apply various return and risk measurement methods that already are used in the markets of other asset classes. However, the distinguishing characteristics of the housing market attracts institutional investors' attention to a typically household dominated market. Institutional investors are motivated to invest in residential real estate as it provides wider return, risk diversification, and risk hedging possibilities. Consequently, a task of residential property incorporation in to investment portfolio emerge. The research covered in this section shows that there were a wide range of possible solutions. We notice that there is little research on the risk assessment of the residential real estate analysis. We cover some more popular risk assessment methods that could possibly benefit residential real estate market analysis.

3. Spatial analysis and real estate investment risk

An important aspect of residential real estate markets is that they are diverse and heterogeneous; however, at the same time, the locations correlate among each other. There are several reasons why residential real estate markets should be analysed spatially.

Firstly, real estate is a heterogeneous market; thus, higher disaggregation of the market may reveal deeper insights. The evaluation of aggregated country-wide data may lead to losing information that otherwise could be used to provide better conclusion. For example, if in half of the country property prices are falling, while in other rising, probably the resulting country-wide index is going to show little changes, which would not be very representative and useful for a market participant. This is of particular importance in the UK, which historically showed different economic and real estate market development patterns across country; London and South of England are developing faster compared to North of England. The South-North division is well documented. Rowthorn (2010) analysed various aspects of North and South division, including population, migration, and employment. He noted that since 1970, North compared to South has observed a higher decline of industrial employment, which was caused by initial dependency on mining and heavy industry, while South enjoyed growth of employment in financial and business services. Also, employment in private sector declined in the North while public sector employment increased; while the South observed a reverse trend. Furthermore, the share of population in the North have steadily declined since 1970, due huge international migration flows to the South, especially London. Finally, Rowthorn (2010) excluded London as a special case, which observes large disparities, as it has surplus of unqualified workers, partly because of industrial past and partly as a result of international migration; yet, it also observed a large growth in service industry and demand for skilled workers. Hincks et al. (2013) analysed housing market trends in the UK at a sub-regional level and concluded that the recent economic slowdown has slightly increased convergence among different areas of the UK, yet a more rapid rate of development in London compared to the other regions after the recession diminished the convergence. However, they also added that, despite the evident gap among London and the South East, and the rest of the country, there also exist considerable intra-regional differences. Tsai (2014) analysed regional and national housing market in the UK from 1995 to 2011, and found that there is information spill-over among the regions in the UK. Furthermore, he noted that during a decline period, all regions acted in a similar way; yet after the crisis, the southern regions recovered more rapidly, while the northern failed to rebound, suggesting that division between the South and the North housing markets is being worsened during price growth period. Additionally, he indicated the importance to segment London as a separate housing market that has different pattern compared to the rest of the country. Similar results were obtained in a previous study by Cook (2005), who has indicated different adjustment speeds to the equilibrium by the southern and the northern regions when house prices increase or decrease.

Secondly, relative position of the property has an effect on the way real estate markets should be researched. In other words, everyone knows that location is essential feature in real estate, however, when analysis is done, it is important not only to identify the location but also to identify its relative position in among other locations. This has to be done because locations affect each other; furthermore, characteristics of locations are usually also related and may have an influence on each other. Thus, failing to identify these relations, the analysis may be incomplete and biased (more section II). Baltagi *et al.* (2014) analysed UK housing market using spatial autoregressive spatial panel model from 2000 to 2007 in three hundred and fifty-three local authority districts, and they found significant positive effects on housing market returns from income within commuting distance, while housing stock had a negative effect on house prices. Additionally, they found a significant spatial lag effect, which suggests house price correlation among nearby districts. Furthermore, Hilber (2005) investigated neighbourhood qualities (junk and litter, street noise, neighbourhood noise, and crime) and homeownership rates in the U.S. He concluded that worse neighbourhood qualities decrease the probability of homeownership in the area. Overall, spatial analysis may provide deeper, more complete and less biased results of the real estate markets.

1) Spatial econometrics

The reasoning behind spatial econometrics could be expressed by Tobler's (1970, p.236) First Law of Geography: 'Everything is related to everything else, but near things are more related than distant things.' The methodology is a branch of econometrics and deals with data that have spatial effects, i.e. when observations are not spatially independent. This characteristic makes data more difficult to analyse by using standard econometrics, and may lead to wrong results if disregarded. Furthermore, spatial econometrics may also provide additional information. Much of the current spatial econometrics are well-explained by works of Anselin (1988), and LeSage and Pace's (2009).

Accounting for spatial issues by the methodology is beneficial when applied in real estate, as real estate data undoubtedly has spatial correlation, spill-overs and dependencies because its data is distributed in space. If data is spatially dependent, than ignoring the issue could provide non robust results and, in case of linear regression, would violate the error independence assumption.

Additionally, real estate markets are usually very heterogeneous and, consequently, collecting all the necessary data may become very inefficient. Thus, a methodology, which is able to obtain more information from the same amount of data (or from data relatively easy to collect), may be very convenient.

It could be useful to analyse housing markets spatially in England and Wales because, while the country is not large (in comparison, for example, to US, where spatial econometric studies are more common), it still possess visible regional differences - for example in economic growth and employment structure. The differences to a certain extent are transferred to the property markets and have an effect on their risks. As a result the spatial analysis could help to correct for omitted variable bias.

Spatial econometrics has its limitations and shortcomings. In particular, it has mainly been criticised for functional form issues. For example, the weights of weight matrices are often based solely on the researcher's preference, as there is no structural way to find which one suits best. It is hard to adjust weights in weight matrices for them to represent real spatial connections and at the same time clearly present the estimations. Additionally, isotropy while creating weight matrices is often taken for granted; however, it is highly possible that dependence is one directional or not equal, especially in the analysis of heterogeneous data such as in property markets. Furthermore, Corrado and Fingleton (2012) argued that the significance of spatially lagged explanatory variable (WY) may be misleading, since it may be simply picking up the effects of omitted spatially dependent variables (WX), incorrectly suggesting the existence of a spill-over mechanism. Moreover, spatial models are lacking the ability to identify causality processes. McMillen (2010) noted that spatial econometrics fail to identify the causes of spatial autocorrelation. Gibbons and Overman (2010) argued that spatial econometrics is not appropriate for investigating economic processes, as the method cannot identify causal relations. While causality is often the aim of the research in economics, this limits the applicability of the methodology.

Spatial data patterns possess a lot of information about relationship among the areas. This information could be disaggregated into direct and indirect impacts. Direct impacts are straightforward, as they indicate changes in a region due to changes of an explanatory variable. Indirect impacts show how the explanatory variable affects neighbouring regions. "A change in a single observation (region) associated with any given explanatory variable will affect the region itself (a direct impact) and potentially affect all other regions indirectly (an indirect impact)," (LeSage & Pace, 2009, p. 33, p.33). Direct and indirect spatial impacts make the interpretation of explanatory variables more complex. Seldadyo *et al.* (2010) explained that the indirect effect measures the impact on the price of a particular apartment from changing an exogenous variable in another apartment, or the impact of changing an exogenous variable in a particular apartment on the price of all other apartments.

To sum up, spatial econometrics helps to find whether data observations are spatially dependent (e.g. residential real estate prices) and take into account spatial interactions between data observations, thus it is possible to get less biased estimators. Moreover, spatial models helps to overcome omitted variable bias. If disregarded, a spatial structure of data could violate error term independence assumptions. On the other hand, spatial econometrics has some limitations, starting from mismatch of real spatial connections and how they are represented by weight matrices, to interpretation of the results but most importantly inability to pick causality of the processes.

2) Applications of spatial econometrics

There are several reasons why it is important to research house price risk and returns, and their relation to location. Firstly, it affects the decision to build or not for the developers, and thus affects resource distribution. Secondly, changing values of the properties redistribute wealth among homeowners and renters. Finally, residential properties possess features attractive for investors, such as relatively low vacancy rate, liquidity, and inflation hedge; thus, the importance of the residential real estate as an asset class is growing among institutional investors. However, the place of residential properties in investor's portfolio is not clear.

To date, few authors have examined and exploited these spatial relationships in property markets. The present research reasons that the spatial analysis of the property markets could add value in the decision-making process of real estate market participants or policy makers. It aims to simplify the ways of examining a range of property market issues - for example, regional division and real estate investment risk diversification when creating direct real estate portfolios.

Location is a very important characteristic when dealing with real estate. Systematic factors, such as country's economic development, interest rates, and legislation are the main factors describing real estate market tendencies. However, there are evident differences in regional house price movements, and real estate investors are interested in particular properties and locations rather than country-wide "average house". Himmelberg, Mayer, and Sinai (2005) analysed U.S. housing markets and concluded that house price dynamics is a local phenomenon, while national data obscure important differences. They add that different areas may react differently to economic changes. Wheaton and Nechayev (2008) analysed US housing markets according to metropolitan statistical areas from 1998 to 2006, and found that excess house price increase not explainable by fundamentals were greater in large areas, areas popular for second home and investment, and areas where subprime lending was more active. Gray (2012) explored England and Wales house price movements on a local authority level using spatial diagnostic techniques, mostly global and local Moran's I (Moran's I is explained in Methodology part, pg.10). He concluded that there is evident ripple effect, though it is uneven. Additionally, he finds that the house price growth among districts is comparable in the long run, yet idiosyncratic in the short run.

There could be many reasons why property prices, returns, and risks are different in different locations; for example, building restrictions and land availability, taxes, distance to the economically important centres, transport links, and clustering of industries and neighbourhoods cause differences in prices movements. Meen (1999) examined UK regional house prices and ripple effect, and concluded that changes to regional house prices can be decomposed into three elements: common movements, differences in economic growth, and structural differences in regional housing markets. Corrado and Fingleton (2012) noted network economics, commuting, migration, displaced demand and supply effects, input-output linkages, competition and coordination between firms, social networks, interaction between policy makers, tax policies, and arbitrary boundaries as causes of spatial interactions. To sum up, there could be many reasons for return and risk similarities and differences among different property markets; however, there is high possibility that some of the characteristics could be captured by geographical proximity.

Much of the real estate explanatory data is applicable for broad areas, which sometimes include districts that behave differently. The situation leads to real estate market modelling, which explains artificial “average” unit of the market or whole market, yet, says little about individual properties. Gardiner and Henneberry (1989) emphasized that one of the most important considerations for a decision-maker in a property market is whether the market in any particular area can be expected to perform better or worse than a national average. Moreover, Hoesli et al. (1997) noted that data disaggregation into large regions, which are not classified according to economic function, make it difficult to test the geographical diversification benefits. Additionally, as different factors have different impact across the markets (or submarkets), their significance could diminish when universal models are created. Consequently, market analyses of a smaller scale are required. Yet, in order to capture inefficiencies and variances in small areas, more data of a better quality is needed, which is difficult to collect. Furthermore, to describe location well, analysis has to include many determinants, such as local natural vacancy rate, degree of economic diversification, neighbourhood, nearby infrastructure, density, demographics, pollution, and building characteristics. This leads to statistical models that are not parsimonious. Dubin et al. (1999) noted that “the vast number of potential influences on property value create problems in creating a parsimonious model.”

Spatial econometrics may help to overcome some of the difficulties stated above. Spatial econometrics uses dependency or heterogeneity between neighbouring properties to capture information. Therefore, there is no need to describe the location, as the impact of differences between the locations is already captured in the prices.

Following this, spatial real estate modelling could lead to more efficient parameter estimation, as spatial structure could explain a significant part of the variation with fewer variables. In early spatial econometric-based research on real estate, Dubin et al. (1999) suggested that such techniques can make a substantial improvement in predictive accuracy, change parameter estimates and their interpretation by controlling omitted variables correlated with location, and improve inference. What is more, spatial econometrics is not limited by artificial geographical boundaries, as it uses the unique geographical reference of every data point. Pace *et al.* Pace, Barry, Clapp, and Rodriquez (1998) while analysing Virginia's housing market, shows that spatiotemporal models explain more sales price variability than multiple regression models, and they are more parsimonious. Holy *et al.* (2011) used spatial econometrics to examine house price diffusion in the UK. The only study that uses spatial econometrics to examine direct real estate investment is by Hayunga and Pace (2010) on the UK commercial real estate market. They showed that spatial correlation between properties is an unsystematic risk; furthermore, that spatial statistics could improve diversification of direct real estate investment portfolios. However, they noted that the spatial diversification is not enough for direct real estate portfolio to reach efficient frontier.

On the other hand, spatial econometrics has limitation. First, spatial structure cannot help to single out where the spatial effect comes from, the causal effect, i.e. it only captures the overall effect. "How can you distinguish between something unobserved and spatially correlated, driving spatial correlation in y from the situation where y is spatially correlated because of direct interaction between outcomes? Further, how can you tell whether an individual is affected by the behaviour of their group or by the characteristics of their group when group behaviour depends on the characteristics of the group? (Gibbons & Overman, 2010). Additionally, Corrado and Fingleton (2012) noted that if spatially lagged endogenous variable is of a high significance, there is always a possibility that it actually captures the omitted variables; yet, the highly significant spatially lagged explanatory variable may misleadingly indicate spill-over effect. Secondly, it is hard to avoid endogeneity even for spatially lagged explanatory variables. (Manski's 'reflection problem': only the overall effect of neighbours' characteristics is identified, not whether they work through exogenous or endogenous neighbourhood effects). Thirdly, spatial econometrics is being criticized for weight matrices, which are often constructed arbitrary. The true weights are almost never known. (Corrado and Fingleton (2012)) elaborated the criticism for spatial econometrics, in between also the shortcomings of weight matrices, and noted that weight matrices may be biased because of isotropy, as in the real world, spatial effects are not evenly distributed to all directions.

In conclusion, previous research, which has investigated or applied spatial econometrics, indicates that the method could provide a useful tool in analysing real estate markets, and could improve analysis by helping to obtain more robust results, to avoid violation of the error term dependency and to capture omitted variables. Yet, spatial econometrics was criticised for difficulty to correctly interpreting the results and not being able to capture causes of the process, which often is the main reason behind research.

3) Summary of spatial analysis and real estate investment risk

Overall, there is a clear reasoning according to which better results of real estate markets research could be anticipated if spatial analysis is used. A heterogeneous nature of the real estate market makes it more likely, that disaggregated, more detailed, and location based data may provide better results. The spatial analysis may be helpful in extracting information from this kind of data by exploiting relative positions of the property's location and its' relation with the surroundings. Spatial econometrics could help in finding whether data observations are spatially dependent and deal with it, thus it is possible to get less biased estimators. This was shown by multiple previous researches. Disregarding a spatial structure could violate error term independence assumptions. However, as every method spatial econometrics has its limitations. For example, spatial structure cannot distinguish the causal effect. Secondly, spatial econometrics is being criticized for weight matrices, which often does not represent actual relationships between the observations and ignores that spatial effects are not uniformly distributed to all directions.

4. Areas that residential real estate risk could affect

Volatility is used to assess investment risk and together with returns are the most popular tools in investment decision making. However, the mere size of housing market makes it an important part of economy and society, thus a distress in the market could impact many areas. Houses are constitute the largest part of an average households assets, while combined total residential properties are an important part of total nation's wealth. Housing markets are important for consumption, finance, investment, and other sectors of the economy. In addition, activities in housing market could an effect on trends in society, for example on migration or home ownership. As a consequence, housing market risk has important implications in many other areas and thus is worth analysing.

1) Macroeconomic stability

Housing markets are important part of the economy. They are important for stability and development of the economy and could be roots for its crises. The latest financial crisis have shown that housing market can have a widespread impact on macroeconomic stability. "In the recent crisis we had a housing boom and bust which in turn led to financial turmoil in the United States and other countries" (Taylor, 2009). There are many links between housing market and macroeconomic stability and development. The connection between housing market and economy is recognized and often exploited by monetary policy makers. Housing markets are expected to be a monetary policy transmission channel to achieve price stability and/or employment tasks.

Mishkin (2007) noted that monetary policy decisions could affect housing market and eventually the overall economy via directly or indirectly through at least six channels. Monetary policy decisions have a direct effect via interest rates on the user cost of capital, expectations of future house-price movements, and housing supply. Whereas indirectly economy could be affected through standard wealth effects from house prices, balance sheet, credit-channel effects on consumer spending, and balance sheet, credit-channel effects on housing demand.

Houses are important part of households' wealth, thus shifts in house prices could have an impact on consumption, saving, and investment decisions. In case of house price increase, households and companies that own real estate may be willing to borrow and spend more. Vice versus, a house price reduction may lead to a moderate spending due to observed or assumed decrease of wealth. Hartmann (2015) noted a decline in real estate prices could affect welfare of firms and households that own real estate. He added that construction projects or house purchases are often credit financed and the credit is often provided by leveraged lenders, thus price correction could cause amplified losses, defaults and deleveraging processes throughout the economy. Finally, he indicated that due to high transaction costs, infrequent trades, and inability to short sell, real estate prices and supply adjust slowly, which additionally could contribute to the illusion of a continuous trend. The wealth effect is discussed more detail in fourth subsection of this section about housing and consumption.

House price dynamics are tightly related to the development of leverage and credit portfolio, which may affect bank lending. Houses are often purchased with borrowed money, thus house price declines could put a pressure on the banking system as the value of mortgage collateral decreases. Increased risk of loan portfolios may hurt trust of banks that are involved in mortgage market, thus making it more difficult to finance banking activities. In order to reduce risk, banks may be forced to reduce lending thus triggering a deleveraging of the economy, which could itself turn into an economic slowdown or recession.

Jord, Schularick, and Taylor (2014) note that in the second part of the 20 century the leverage of the financial sector increased significantly because of mortgage financing. According to them, the growth of mortgage credit became a source of financial sector's vulnerability and started shaping business cycles. Pavlov and Wachter (2011) found that experienced aggressive lending practices led to magnified real estate cycles and areas, which observed such practices, were more likely to have larger price declines. Furthermore, they noted that large price declined were likely to be followed by a withdrawal of an aggressive lending. Anundsen, Gerdrup, Hansen, and Kragh-Sørensen (2016) found that imbalances in house prices increase vulnerability of the financial system. Aßmann, Boysen-Hogrefe, and Jannsen (2013) found that housing crises are followed by recessions that are longer than other recessions. They calculated that housing market crises on average cause output growth decline by 2 and 1.5 percentage points in the following year and the second year. Barrell, Davis, Karim, and Liadze (2010) analysed OECD countries and found that property prices are stronger banking crises predictors than traditional macroeconomic variables, such as GDP, interest rates or inflation.

Overall, there are many researches that show links between housing market and wellbeing of the general economy. Housing market being an important part of the economy has a large influence on its development primarily through household and firm wealth, tightly related housing and credit markets, and financial system stability. The importance housing market on macroeconomic stability and development is recognized and exploited by monetary policy decision makers

2) House ownership rate

Fluctuations in housing markets may equivocally influence its ownership rates. High real estate price volatility is undesirable phenomenon, which may disturb consumption and wealth distribution of the community. Solely from an investment perspective, higher volatility may lead investors to reduce exposure for the asset. Yet, as houses serve not only as investment assets, market participant reaction to higher price volatility may turn out to be ambiguous. Sinai and Souleles (2005) investigated housing markets in forty-four Metropolitan Statistical Areas in the U.S. from 1981 to 1998, and concluded that greater housing market volatility can increase the demand for owning homes because of the insurance-against-rent-risk role that house equity plays. Even more, Sinai and Souleles (2009) analysed housing markets in the U.S. cities and concluded that households which are planning to sell their houses and move to other cities within two years are more likely to own a home. Furthermore, they noted that households tend to move across cities, which housing market correlates more. They also add that house owners that plan to move are in a better position than renters are. The volatility of their current house price partially hedges the price volatility of their next house. At the same time, renters face housing cost risk in their current and future housing markets. Glaeser and Gyourko (2007) analysed arbitrage possibilities in housing markets. They noted that risk-averse renters willing to own a house prefer to acquire it now rather than delay, and profit from possible arbitrage opportunities because of high house price volatility and large single stock cost that dominates most households' wealth. Delaying entering homeownership market may cause large volatilities in wealth. Therefore, high price volatility increases ownership rates as it prompts risk-averse potential homebuyers to rush in to the market.

On the other hand, it is discussed whether house ownership rate has an effect on the macro economy and whether it is positive or negative. A possible links between house ownership and economy include wealth and propensity to consume from wealth, labour mobility, unproductive wealth concentration and others.

Firstly, that house ownership could have an effect on the overall economy is through increased household and consumption. Raising housing prices increase the wealth of households. If household have a propensity to consume some the wealth, it may fuel the economy and vice versus. The issues is discussed more detail in the following fourth subsection of this section.

Secondly, house ownership could affect economy is through labour mobility. Effortless workforce movement within an economy could help it adjust to shocks. High ownership rate could indicate migration constrains in housing market, which mean less flexible and efficient labour market through poorer career choices and longer commuting distances.

Thirdly, large wealth concentration on housing could have an effect on entrepreneurship, saving behaviour, and consequently investment in to more economically effective projects. Weale (2007) noted that rising house prices could maintain a high level of demand in the economy, yet reduce saving, at least provided that homeowners will be willing to trade down or consume their house equity in other way once they retire. Lower savings reduces the economy's stock of productive capital or results in investment being financed from abroad. Usually, debt requires interest payments must be paid, thus both actions may hurt the economy. Weale (2007) estimated that the macro-economic burden imposed by the observed house price rise from 1987–2007 was approximately equal to an annual government deficit of 4 per cent of GDP.

To sum up, there is some evidence that house price volatility may have an effect on the house ownership. Higher house price volatility tend to motivate households to purchase houses in order to prevent negative wealth effects in the future in case of a house price increase. However, whether high house ownership rate is desirable status for the economy overall remains an open question. O'Sullivan and Gibb (2012) argued that there is no substantial evidence neither for positive neither for negative effect of housing ownership on the economy in the UK.

3) Housing and consumption

The relationship between consumption and housing is widely discussed subject among real estate economists. On the one hand, it is stated that an increase in housing prices is followed by an increase in consumer spending. This is mostly based on an idea that house prices increase inflate wealth of homeowners and homeowner households would distribute their consumption over time based on anticipated increase on all their wealth. While housing wealth is not liquid, easily countable, or divisible, the wealth transfer to consumption may not appear straightforward. Benito, Thompson, and Waldron (2006) extensively discusses possible transfer channels between housing wealth and consumption.

First, changes in house prices redistribute wealth; for example, increase in house prices increase wealth of homeowners and reduce wealth of renters. Thus, if the consumption of the two groups reacts differently to change in wealth, it may increase overall spending. Benito *et al.* noted that in practice, renters tend to be younger households and homeowners tend to be older households, and the latter could start spending more, as they need to spread their wealth less over time compared to younger households. Additionally, Schmalz *et al.* (2013) have noticed that increase in house prices leads to a raise in new business ventures created by homeowners compared to renters.

Second, houses are one of most accustomed collaterals for personal loans, thus increase in house prices increase the size of collateral. Hence, banks are more willing to lend money, which leads to larger loans available, smaller interest rates, or less prerequisites for the borrowers, even for those who had no ability to take loans before. Additionally, more loans through a money multiplier "produce" more money in the market. Therefore, higher house prices lead to easier access to loans and higher spending. Furthermore, shocks in house prices via leverage may have amplified results on the household spending. Also, in case of interest rate decline, it could be difficult for households to renegotiate the terms of their mortgages if house prices are volatile and declining; thus, the households would not be able to potentially spend the loan price difference. Carroll *et al.* (2011) analysed house price movements in the U.S. and consumer spending, and have found that a short-term impact of house price changes on consumption was around cents per dollar, while longer term results were from two to five times larger. Mian *et al.* (2013) found that when home values were declining areas with a high housing loan to value ratio and low income experienced a larger drop in home equity limits and a reduced ability to refinance into lower interest rates. They also have found that more levered and poorer neighbourhoods observed a larger drop in credit scores. Adelino *et al.* (2015) noted that collateral in the form of real estate assets allows people to start new business ventures. They have analysed house price movements, collateral, and new job creation in the U.S., and found that increase in house prices causes a raise in new small firms' number, even when controlled for changes in local demand. Schmalz *et al.* (2013) analysed French new business ventures and housing markets, and have found that house price appreciation has an impact on business scale and probability to survive if it was owned by a homeowner. Corradin and Popov (2013) investigated home ownership and new business creation in the U.S. from 1996 to 2006, and found that a 10 percent higher home equity was associated with 14 percent higher probability for the homeowners to become entrepreneurs.

Third, changes in house prices may have an effect on saving that households are making to insure stable financial situation in the future. Increased house prices will increase household wealth; thus, even without withdrawing the wealth, people will feel safer about their future, save less, and boost consumption.

Finally, increase in house prices may spur housing market developments, which by itself would stimulate consumption because of moving related expenses. However, Benito et al. (2006) pointed that spending related to moving houses is small and short-term.

There are a few well-quoted research papers, which concluded that changes in house prices and housing wealth have an effect on consumer spending. For example, Case *et al.* (2005) investigated links between housing wealth and consumer spending in fourteen developed countries for various years during the period from 1975 to 1999 annually and in U.S. states from 1982 to 1999 quarterly, and found that housing wealth has a large effect on household consumption. Researchers find that, internationally, 10 percent increase in housing wealth led to increased consumption by 1.1 percent, while in the U.S. by 0.4 percent. In a similar way, Dvornak and Kohler (2007) analysed a relationship between housing market and consumption in Australian states from 1984 to 2001 quarterly, and found that increase in housing wealth by 1 AUD has a significant effect on consumption by three cents. In a study of a smaller scale, Campbell and Cocco (2007) investigated UK household level data in the period from 1988 to 2000, and concluded that there is an effect of house prices on consumption. Yet, they found that the largest effect of changes in house prices on consumption was for older homeowners, while there was no effect on consumption for young people that are renting their living space, which is reasonable taking into account the differences in the wealth between the two populations. It is interesting and relevant for the current research that they also found that regional house prices affect regional consumption growth.

On the other hand, changes in house prices should not necessarily transform in changes in consumption, because spending housing wealth is restricted, house prices influence on consumption is overestimated, or its positive influence is countered by negative influence.

Firstly, a house is not a typical financial asset like stock or bonds, but it also has a role of consumption good or insurance. Thus, increased house price for the owner may mean nothing and have no actual wealth effect if he does not plan to sell the house and obtain the gain, but plans to live in it for unlimited amount of time. Additionally, the access to the increased housing wealth is limited and, even more, it is harder to account the gain compared to other more liquid and more frequently traded asset classes; for example, stocks or bonds.

Secondly, it could be that it is not housing wealth that has an effect on consumer spending, but that house prices and consumption are driven by the same factors. An example of factors that drive both indicators could be the expected incomes of households, interest rates, economic liberalization, or tax cuts. (Muellbauer, 2008) noted that credit market liberalization had improved access to unsecured and secured credit. Thus, allowing first-time homebuyers to borrow money at a lower loan to value or loan to income ratio. The higher loan to value ratio cancelled out the counterbalance effect, as young renters do not need to save more for the down payments and reduce consumption. At the same time, it is easier for existing homeowners to take advantage of increased home equity and improve their spending. As a result, the aggregate effect is increase in consumption. In an analysis of Bank of England by Benito et al. (2006), the relationship and links between house prices and consumption in the UK from 1971 to 2006 are discussed. They note that the relationship is not stable over time but there are many common driving factors; for example a reduction in interest rates, an increase in people’s access to credit, and an improvement in income expectations. Moreover, Attanasio *et al.* (2009) analysed around 7,000 annual surveys conducted in the UK from 1978 to 2002. They were trying to find out which of the three hypothesis that explains consumption and house prices co-movements is true: 1) House prices has an effect on consumer spending through household wealth, 2) House prices and consumption are both driven by same factors, i.e. expected future income, 3) Raise in house prices increase housing collateral, which is particularly important to the young, as they are more likely to be credit-constrained and, thus, increase consumption. They found evidence that common causality is the most significant explanation.

Thirdly, the arguments of those stating that house prices affect consumer spending may be countered. For example, an increase in housing wealth of homeowners, and thus, it following increase in homeowners' consumption, may be counterbalanced by a decrease in spending by current renters who have to save to acquire a home in the future.

Overall, both sides have strong arguments for and against the relationship between changes in house prices and fluctuation in consumer spending. However, it seems that there is more empirical evidence that supports the former side. Moreover, both sides agree that house price volatility has an effect on wealth distribution. This is very important aspect in our research, because if households see house value as an integral part of their total wealth - which has an effect of their consumption, even if aggregated consumption of all sort of groups sums to zero - then house price volatility may disturb planned consumption and cause social problems. A volatile house market would be especially harmful for older households, who constitute the majority of householders. For example, it is advised to plan personal investments and savings so that the level of risk would decrease with age, e.g. younger groups should own relatively more risky assets and older should own relatively less risky assets. It is considered that younger groups, even in case of negative outcome, will have time to recover during their working age, while older groups cannot take risk as their working age has passed. However, if older households have more equity in houses and if it has an effect on their consumption, then in a volatile house market, the older households have to make adjustments in their personal portfolio to ensure a stable financial situation in case of decreasing house prices.

4) Migration and housing markets

Movement of people to and out of an area has an obvious effect on housing markets. Migration reduces the population and consequentially the demand for housing in the areas of negative netto migration, and adds to the areas that has positive netto migration. Meen (2012) noted that changes in the number of households in any locality are determined either by natural rates of population increase, changing headship rates, or by moves between different locations; and with a differing importance, it is true for all spatial dimensions, whether it would be nation, region, or metropolitan area.

However, house prices also have a coming-back reaction on migration among areas. High house prices may prevent people from moving in or settling in an area. Sometimes it even may encourage certain groups of population to leave in order to profit from reduced housing costs, e.g. pensioners may find it quite attractive selling homes in expensive urban areas and moving in more recreational areas, at the same time cashing out some of their house equity. On the other hand, the raising trend of property market may stimulate population inflow through a more active labour market, and through speculative behaviour of homebuyers who are willing to acquire homes and benefit from capital appreciation.

Cameron (2005) analysed internal migration and housing markets in England and Wales from 1970 to 2003. He noted that high levels of house prices in the region and expected price increase in other regions might be one of the motivating factors for people to migrate between the regions. He argued that when a household is making a location choice, it, among other things, considers several housing market related factors. For example, relatively high house prices will tend to reduce the attractiveness of choosing the location because of cost of living effect and credit constrains. Furthermore, a recent (short to medium term) decrease in house prices will also reduce the amount of migrants. However, low density per unit of housing may improve the abilities of the region to attract mobile workers. Moreover, Cameron (2005) adds that, because of commuting options, contiguity matters and housing market comparison with the neighbouring regions is more important than with the average of all regions.

England and Wales have a significant inflow of international migrants who also contribute to the real estate market. Many international immigrants come the UK only temporarily and do not want to become homeowners; thus, international migration may improve the attractiveness of buy to let houses and move their prices. Additionally, international immigrants often look for more economic housing solutions. As a result, it could be that immigration outbursts may stimulate previously less attractive housing markets. Nygaard (2011), who analysed international migration trends in the UK from 1975 to 2009, noted that immigrants resided in rented accommodation upon arrival and that their home ownership ratio converged with the UK average in the twelve–fifteen years after arrival. Moreover, international migrants who arrive looking for job opportunities may strengthen the impact of employment market on housing prices. During the time of strong economic growth and easier possibilities to find a job, immigration inflow is stronger and all the new immigrants shift the housing demand curve to the right. Yet, when economy weakens, housing demand declines not only due to the lower income of the population but also because part of the migrants return to their home countries. Furthermore, strong housing market stimulates employment in the construction sector. Many jobs in the construction sector do not require sophisticated education, excellent knowledge of the language and established peer network, and are relatively well-paid, hence are well-desired working places among newly arrived immigrants. In other words, high real estate prices may stimulate economic immigration to the country. Nygaard (2011) indicated that some periods of international migration coincided with the housing cycle.

In brief, housing market and migration are mutually dependent. Consequently, volatility in house prices may affect people's decisions to move to a particular area. A strong housing market may be attractive and repulsive for migration, depending individual household preferences. Finally, real estate market fluctuations may have an effect on both internal and international migration flows.

5) Personal portfolio formation

Changes in housing market affects finances of a majority of individuals because everyone participates in a housing market, as everyone needs a place to live. Many of them are or plan to become homeowners; thus, house price volatility may have an effect on personal portfolio formation.

Usually, the younger part of a society, which is less financially stable, tends to rent a living space. However, young households often make a decision to acquire a place for accommodation and become homeowners before their economic strength increases enough to incorporate a house in their personal portfolio in a balanced way. Englund *et al.* (2002) investigated the Swedish housing market and concluded that a majority of homeowners up to an age of fifty possessed strongly unbalanced personal finance portfolios. Flavin and Yamashita (2002) analysed housing market in the U.S. and noted that young households invest more than three times their net wealth in housing. Furthermore, even after acquiring a home, households do not stop increasing their exposure to the housing market. Households are inclined to purchase homes that are more expensive when their financial situation gets better, in order to upgrade their living conditions.

Additionally, house price volatility is an important factor that must be considered when forming personal investment portfolios, because many people move due to job opportunities or family affairs; thus, a decision to purchase a house is made not once but multiple times in a lifetime. Often these new house purchases are partly financed with equity that was accumulated in houses that were acquired before. For many households, a home constitutes a major part of all possessed assets. Some households direct more than 100 percent of their wealth to real estate as they acquire homes with leverage. The impact of changes in prices is amplified because many households do not own 100 percent of house equity and their positions are leveraged by mortgages. Leverage may create overexposure for households with portfolios of relatively smaller size; for example, the ones of younger households.

Additionally, real estate transforms a personal investment portfolio's features, as it is illiquid asset. Yet, it may also provide homeowners with consumption benefit. Households may avoid leveraged exposure to property markets and increase in their personal investment portfolio's illiquidity by renting. Studies analysing life cycle savings and investment portfolios often, in addition to other assets, discuss housing or housing related expenses. Besides, housing market volatility may have an effect on those who do not own any residential property. Renters are exposed to swings in house prices through housing costs that may change because they are bonded with house prices by a required return on capital.

On the other hand, acquiring a house with a mortgage and gradually repaying it becomes a widespread and solid household saving instrument. According to Quigley (2006), "Homeownership has proven to be a powerful vehicle for wealth accumulation by owners," (p.170). Thus, unaccounted house price volatility may expose household's lifetime wealth to an undesirable and disproportionate risk.

Banks *et al.* (2004) investigated housing market volatility in the US and UK, and they argued that the risk-averse behaviour of individuals in a housing market is an exception. According to them, due to absence of financial products to insure housing price risk, individuals are forced to invest in housing early in the life cycle as a way of insuring future price fluctuations. Consequently, higher volatility leads to higher owner-occupation rates, more housing wealth and less propensity to realize capital gains on housing through refinancing to fund non-housing consumption.

Hu (2005) discussed households' life cycle investment portfolio selection in relation to housing in U.S., and concluded that when households are able to invest in owner-occupied housing, their financial portfolios are very different from those of lifetime renters. He added that homeownership crowds out the stock market participation in portfolio, as house equity is a risky asset and it substitutes for stocks.

Kraft and Munk (2008) analysed life-cycle utility maximization problems simultaneously involving dynamic decisions on investments in stocks and bonds, consumption of perishable goods, and the rental and the ownership of residential real estate. They noted that there was a high correlation between labour income and house prices, which implied the following distinct life-cycle pattern in the investment exposure to house price risk. When human wealth is big relative to financial wealth (e.g. early in life), the individual should invest very little in housing so that the desired housing consumption is mainly achieved by renting. When human wealth is low relative to financial wealth (e.g. late in life), the optimal housing investment is quite big due to its fairly attractive risk-return trade-off. They find that the optimal housing investment varies much more over the life-cycle than the optimal investments in bonds and stocks.

A spatial investigation of housing price risks may alter rational decisions when forming personal portfolios. If different areas carry specific characteristics, they may have different volatility, and consequently transform a shape of a balanced portfolio.

6) Summary of residential real estate risk impact

Volatility is a popular method to assess investment risk, which often accompanies other metrics to support investment decisions. It is important to research housing price volatility for these decisions to be more informed. However, other implications of housing market risk could also be significant. A mere size of the housing market makes it one of the most important sections of the economy and every price movement could have an impact in other areas. Firstly, housing market is closely related with the credit market and financial sector, thus fluctuations of house prices could put a pressure on the financial stability of the sector. Secondly, through wealth effect housing market could have an impact on consumption dynamics. Thirdly, volatility of house prices may have an impact on the demographics of the area through migration. Furthermore, house price volatility could have an impact on people’s desire and abilities to own houses. Additionally, if housing is considered as an investment, then volatility could have an impact on how it is incorporated in to investment portfolios. As a result, housing market risk is worth researching because it could have important implications in many areas.

5. Summary

This chapter reviewed a wide range of studies on real estate market fundamentals, real estate investment and risk, risk assessment methods, spatial analysis, and motivation why it is important to research housing price risk. The first section covers economic, demographic, and physical factors that have an impact on the price dynamics in housing markets. The section provides an overview of previous studies examining the impact of economic activity, employment, population size, or hedonics on house prices. It is important to understand the fundamentals of the housing prices in order to better explain what could affect house price volatility. The second section provides a review on investment and investment risk related studies within real estate context. It shows that residential real estate could be assessed as other financial assets. Various risk metrics could be applied for housing as they are already being applied for other assets. Furthermore, the demand of these metrics exists as housing is considered and compared among other asset classes. The third section emphasizes benefits that spatial analysis could provide in housing research and overviews related studies. In the end, studies that relate to housing price dynamics to various fields are overviewed, to show that housing market risk is worth researching because it could have important implications in many areas.

III. Methodology

The thesis applies various methodologies for risk calculations, to achieve explanatory factor coefficients, identify spatial patterns, etc. This chapter presents the methodology used in the study. In the first section, risk assessment methods are discussed. In the second section, weight matrix creation, weight assigning, and spatial diagnostics methods were overview. In the third section, regression methodology was overviewed. The last section is for summary.

1. Risk assessment methods

There are many methods that could be used to measure investment risk. Most of them were developed for exchange traded financial assets and later applied for other assets. The main risk assessment method in the thesis is return volatility (volatility). We also use some other popular risk assessment methods used for financial assets, such as systematic risk, idiosyncratic risk, and Sharpe ratio. All of them are discussed more in detail below.

1) Volatility

Most common way to calculate risk is to account for the investment returns volatility, usually in standard deviations or variance. Volatility is not an observed variable and must be calculated from the return data.

In this study, the volatility was calculated using following formulas:

$$SD = \sqrt{\frac{\sum(x-\bar{x})^2}{(n-1)}}$$

SD – standard deviation, also often marked as σ;

x – return for the period

$\bar{x}$ – sample average;

n – sample size.

Additionally, the volatility was annualized according to the following formula:

$$SD_{annual} = \frac{SD}{\sqrt{P}}$$

P – time periods.

2) Systematic risk

Systematic risk or market risk indicates how a particular investment is sensitive to market-wide fluctuations. The coefficient of systemic risk indicates the relation of the asset return and market wide return over risk free rate. Market risk is part of the CAPM model concept that was introduced by several economists around the same time (see French, 2003; Lintner, 1965; Mossin, 1966; Sharpe, 1964). Market risk is a risk that does not depend on a specific asset's characteristics but rather on risks that are common for all market, e.g. global economic changes, political changes, and natural disasters. Market risk cannot be diversified by including other assets in the portfolio (more see Markowitz, 1952). In this thesis we use Lintner-Sharpe version of CAPM and market risk (more see Fama & French, 2004). The systematic risk is measured as correlation coefficient of the market return variable above the free risk rate in a linear regression (or multiple if other variables are included) with asset's return above the risk free rate serves as a dependent variable, i.e. market risk is the betas, as of a regression coefficient. An asset, which has a systematic risk of one beta, fluctuates synchronically with the market. A lower beta indicates lower market risk, while higher beta indicates higher risk. The beta is obtained using the following CAPM formula:

$$r_i - r_f = \alpha + \beta_i(r_m - r_f) + \varepsilon$$

r_i – returns for the asset *i*;

r_m – market returns;

r_f – risk free rate;

β_i – systematic risk for asset *i*;

α – returns above the risk, also called alpha[9];

ε – asset specific return not explained by other factors.

In addition to systematic risk, the formula also provides alpha or Jensen's alpha (α) measure. Alpha could be an investment asset performance measure, which if significant and positive, indicates assets risk adjusted performance above what the CAPM model would predict it to be. If it is negative, then it indicates underperformance of the asset, if it is positive than it indicates that asset perform better than its risk would predict. In the presence of efficient market[10], the alpha should be equal to zero.

3) Idiosyncratic risk

Idiosyncratic or asset specific risk is a term in a certain way opposite to systematic risk and should be independent from it. Idiosyncratic risk arises from specific assets characteristics, e.g. companies' management or properties location. It could be reduced by diversification, i.e. including more assets in the portfolio that do not carry the same idiosyncratic risk characteristics. Usually, idiosyncratic risk is obtained by substituting systematic risk from the total asset risk. There are several idiosyncratic risk calculation methods. One of them equates unsystematic risk to variance of the residuals (σ_{ε}^2) of the CAPM (or other factor model).

$$\sigma_{\varepsilon}^2 = \sqrt{Var(\varepsilon)}$$

σ_{ε}^2 – unsystematic risk;

ε – asset's specific return not explained by other factors from the CAPM model.

There is also one method that equates unsystematic risk to unexplained lack of CAPM explanatory power or coefficient of determination (1- R^2) or just explanatory power (R^2) with inverted interpretation. While many papers use the two terms interchangeably, Li *et al.* (2014) showed that

[9] More about alpha, please see Jensen (1968)

[10] More about efficient market hypothesis, please see Fama (1970) and Read (2012)

the two measures result in different outcomes unless an analysed asset return is not affected by market risk.

Idiosyncratic risk is asset-specific risk that theoretically could be diversified in a multi asset portfolio and should not be priced. However, residential real estate is a specific asset, which due its size, the purpose of investment, and transaction costs, often carries idiosyncratic risk. Miller and Pandher (2008) in a study about idiosyncratic risk in a housing market calculated idiosyncratic risk as a standard deviation of the error terms from a two-factor regression model on housing returns.

4) Sharpe ratio

Sharpe ratio is a measure that adjust returns to volatility, thus, it is easier to compare investment asset performance. It shows how much return the asset generated per unit of risk. Sharpe ratio was developed with the idea to measure mutual fund performance by William Sharpe (1966).

Caporin *et al.* (2014) noted that Sharpe ratio, despite several drawbacks, is still considered as a reference of investment performance measurement. Sharpe ratio is calculated according to the following formula:

$$Sharpe\ ratio = \frac{r_i - r_f}{\sqrt{\sigma^2}}$$

r_i – returns on an asset *i*;

r_f – risk free rate;

σ^2 – variance of the asset returns.

5) Summary

The study provides only a small fraction of various risks measures from a large pool of risk assessment instruments in the finance field. The risk assessment is a widely researched topic, consequently as there are many risk assessment methods, which occasionally seems to differ little one form another. Each of them was created with an intention to adjust existing methods for some specific drawback and is most likely outperforming other methods in certain circumstances. This study limits itself to some more popular methods in the finance field, such as volatility, market risk, idiosyncratic risk, and Sharpe ratio.

2. Regression analysis

In the study among other methods, regressions are applied to research the data. We also apply spatial regressions for the housing data. Data could be analysed in spatial way using weight matrices, which define spatial links among the observed data. The weight matrices are constructed according to researcher's perception about existing spatial structure. However, despite that intuitively housing data seems to possess spatial patterns, they must be identified by spatial diagnostics. In this chapter, analysis methods used in the study are discussed. The sections of the chapter are sorter according to application step order. In the first section we overview the weight matrix construction methods. In the second section, spatial diagnostics for spatial structure of the data is discussed. In the third section, regression analysis methods were considered.

1) Weight matrices

The main difference between linear regression models and spatial econometric models is that, to tackle spatial dependence or heterogeneity problems, square weight matrices are introduced. Weights describe the relationship between the values of the variables. In other words it quantifies the existing spatial relations into the weights structure. They are equal to zero if observations are not related and greater than zero if they are connected. On the diagonal of a matrix, weights are always zero, as observation is not dependent on itself at an exact moment of time. (More about matrix construction methods please see LeSage & Pace, 2009). Additionally, weight matrices were corrected according to actual easiness to access the neighbouring area. If the areas share a border, yet it is not possible to access a neighbouring area by land or bridge, the two areas are not considered as neighbours.

Among the most widely used methods to create weights, matrices are distance and contiguity. Yet, the weights could reflect a wide variety of relations, e.g. trade amount between the subjects, border lengths, travelling time. Additionally, the weights may be arranged in different ways, e.g. "n" nearest observations, observations within particular distance, and all observations. Moreover, weights may be adjusted by applying decay effects, inversing, and etc. Alternatively, to the method used in the study, economic links based weights could be applied in weight matrix construction. However, in housing market, relatively a physical distance, social factors, and transport infrastructure are important drivers. Thus to properly weight and, especially interpret the results would be complicated.

In current research, weights matrix is constructed according to the 'queen' contiguity of the region, i.e. if it is a neighbouring region, even if only corners are touching, than the element representing the region in the matrix is equal to unity, otherwise it is zero.

There are also other ways to construct weight matrixes. Among often presented examples in the spatial econometrics, there is "k" nearest neighbours, neighbours within particular distance, linear contiguity (areas must share eastern or western borders), rook contiguity (areas must share a border of a certain distance), bishop contiguity (opposite of rook contiguity, i.e. a shared border must be shorter than a certain distance). There also could be second order contiguity, where weights are assigned for neighbours regions that share a border with a first order neighbour, yet in this thesis, only first order contiguity is used. We reject the above mentioned and weight matrix construction methods, as they seem to be not applicable for housing market, were shared border indicates a physical proximity of the housing markets, thus border length or direction could play only a small role.

In the end, weight matrix was row standardized. This way the results are less ambiguous and less difficult to interpret for the reader. In the process of row standardization, weight of each neighbour is divided by the sum of all neighbour weights of the area, thus rows sum to unity.

Spatial weights are row standardized to create proportional weights in cases where observations have an unequal number of neighbours. It creates proportional weights for the neighbours and makes total effect of the neighbours on the observed area equal to average effect on the area. The weights could be interpreted as the fraction of all spatial influence on an area that could be assigned to a corresponding neighbouring area.

Without standardization the interpretation of the results could be confusing, would depend on a number of neighbours, and could be biased to sampling design or an imposed aggregation scheme. Row normalized weights are a common practice in spatial analysis (more see Getis & Aldstadt, 2010). However, Tiefelsdorf, Griffith, and Boots (1999) warn that row standardized of weight matrices gives too much weight to observations with relatively weak spatial links, for example on the edge of the observed area. Furthermore, it provides more influence for neighbours of observation with a few shared borders.

2) Spatial diagnostics

Before applying spatial econometrics it is necessary to identify whether there is a spatial problem. It is not always necessary to use spatial econometrics, as data may not have spatial characteristics. There are tools that help to find out whether data may contain spatial effects. The most popular is Moran's I, which tests for correlation in the nearby locations in a space (Moran, 1950). Among other indicators of spatial autocorrelation, there are Geary's C and Getis' G (more about spatial autocorrelation measures see Ord & Getis, 1995). It is important to note that observations may be correlated in the small parts of investigated area (locally), while it may not have correlation on a larger scale (globally), and vice versa. However, Moran's I, Geary's C, and Getis' G limitation is that it is likely to average local patterns of variations over global ones. Local spatial autocorrelation always exists when there is global spatial autocorrelation, yet it may also exist when there is no global spatial autocorrelation. To manage this problem, Anselin (1995) introduced local indicators of spatial association (LISAs), which are the same indicators (Moran's I, Geary's C, and Getis' G) adapted to capture local patterns of spatial autocorrelation. LISAs identify local areas in an examined area where outlier observations tend to cluster and are homogeneous. Global and local indicators are often used together. Spatial analysis is started by calculating Moran's I for average returns and standard deviations. This is conducted to investigate whether the data does have a spatial structure. Then spatial models are chosen by using Lagrange multiplier tests for spatial dependence. Finally, the spatial model is estimated.

3) Regression models

Before estimating spatial regression, multiple linear regressions are used to get non-spatial estimates of the variables. We run a few linear regressions each time, deducting insignificant variables and targeting a higher coefficient of determination. The models are of the following forms:

Linear regression

$$R_i = \alpha + \beta^k X_i^k + \varepsilon_i$$

R_i – return of housing market in the area;

α – intercept;

β^k – coefficient of *k* variable;

X_i^k – *k* variable of *i* area;

ε_i – error term.

In order to estimate the cross sectional regression analysis it must be assumed observation are independent, thus error terms have a mean of zero. Furthermore, they should have a constant variance and should be uncorrelated. Finally, they should be a normally distributed. If data has spatially dependent, than it is likely that the assumption will not be satisfied. There are two reasons why data could be spatially dependent. Firstly, boundaries of geographical units that boundaries for which data is collected do not accurately represent the underlying process generating the sample data. Secondly, a socioeconomic links could affect spatial dependency.

In case of spatial dependency, to correct the biased estimations spatial structure of the regression models should be used. The spatial dependency could be targeted by two main spatial regression models: spatial error and spatial lag. If data has spatial error problem, than the linear regression has correlated error terms and thus violates one of the cross sectional regression assumptions. The spatial error indicates that there are omitted variables. Consequently, not applying the spatial error model may lead to inefficient regression coefficients. If data has spatial lag problem, than the linear regression has correlated error term and observation are dependent, thus violating two regression assumptions. Spatial lag indicates a possible diffusion process. Avoiding applying spatial lag model for the data that has spatial lag structure could lead to inefficient and biased coefficients.

After linear regressions are performed, we investigate for spatial patterns in the data because of implied strong spatial effects in a relatively small yet densely populated England and Wales housing market. If the patterns exists than the spatial models are applied for the data. In such circumstances, the spatial form of the model allows more accurate evaluation of independent variables.

Spatial lag regression (*see* LeSage & Pace, 2009; Bivand et al., 2015):

$$R_i = \alpha + WR + \beta^k X_i^k + \varepsilon_i$$

R_i – return of housing market in the area;

α – intercept;

W – weight matrix;

R – returns of housing markets in all areas;

β^k – coefficient of k variable;

X_i^k – k variable of i area;

ε_i – error term.

Spatial error regression:

$$R_i = \alpha + \beta^k X_i^k + u_i$$

$$u_i = \lambda W u + \varepsilon_i$$

The above linear and spatial regressions are for the cross section data, i.e. it is applied for the data that does not vary in time. While the data possessed extend in multiple years, yet time variation is reduced when returns and risks are calculated, which reduces the time span to one period. While risk and return relationship is not always analysed in cross section way, in housing it could be more applicable, because of low data frequency, which limits ways to calculate risk. Returns and risk relationship in cross sections were analysed by Cannon, Miller, and Pandher (2006), Miller and Pandher (2008), Zheng, Chau, and Hui (2015).

The models for the volatility analysis were identical just substituting returns to volatilities.

With a purpose to prevent multicollinearity, the regression variables are analysed by calculating the variance inflation factor and examining correlations among the variables. The variables are considered not to cause multicollinearity problem if the coefficient is lower than five.

Alternatively, some studies do analyse returns and risks across the real estate areas in panel data setting (for example see Guirguis, Giannikos, & Garcia, 2007; Hossain & Latif, 2009; Miles, 2011; I.-C. Tsai & Chen, 2009; I. C. Tsai, Chen, & Ma, 2008) and there are some that analyse housing price volatility in spatial panel data setting (for example Zhu, Füss, & Rottke, 2013). The advantage of panel data is that it could assess time varying dynamics of the variables.

The advantages of the spatial modelling are more efficient parameter estimation in case that the data analysed has spatial structure. Furthermore, spatial structure could explain a significant part of the variation with fewer variables. On the other hand, spatial econometrics cannot identify the causal effect and captures the overall effect. Additionally, there are chances that spatially lagged variable captures the omitted variables, while spatially lagged explanatory variable may misleadingly indicate spill-over effect. Moreover, only the overall effect of neighbours' characteristics is identified. Finally, there is no method to decide whether spatial weight spatial matrices correctly reflects existing links.

4) Summary

The main difference between linear regression models and spatial econometric models is that, to tackle spatial dependence or heterogeneity problems, square weight matrices are constructed with equal weight for every neighbour that shares a border using queen contiguity. Than weight matrices are used for the spatial diagnostics to find out whether data may contain spatial effects. For this Moran's I and Lagrange multiplier tests are applied. While there are other possible tests like Geary's C and Getis' G (more about spatial autocorrelation measures see Ord & Getis, 1995), Moran's I is most widely used for spatial pattern identification. Before estimating spatial regression, multiple linear regressions are used to get non-spatial estimates of the variables.

IV. Data

This chapter presented the methodology and data used in the study. In Section one econometric models, weight matrix construction, and spatial diagnostic are described and discussed. In Section two sources of the data, data and constructed variables are presented and explanations were provided.

1. Original data and data sources

The data used in the study was obtained from the Office for National Statistics, Land Registry, and the Bloomberg Professional service. It covers England and Wales housing markets. The summary of the data is shown in Table 1. Where possible and applicable the data was disaggregated at a county/unitary authority level, according to administrative borders of 2013. In total, there are one hundred and thirteen authorities; however, all islands are excluded, in order to simplify weight matrix and spatial regression calculations. Additionally, Inner London and Outer London were counted as a single authority because separate house price indices are not available, thus leaving one hundred and nine counties/unitary authorities. Chosen geographic units (County/Unitary level), may appear very different size or urbanization. In addition, more disaggregated data could be more precise, however, it is difficult obtain other data for smaller geographical units. For example, Land registry provides housing indices, sales, and price data only at county/unitary authority and borough level. Furthermore, not all socioeconomic indicators were accessible at a lower geographical scale. This limited the thesis for deeper disaggregation.

All the original data from Land Registry is of a monthly frequency. However, from the existing data, variables were calculated for each county/unitary authority; thus, the study operates a cross-sectional data set. House price indices, average house prices, and sales volume were obtained from Land Registry. Sales volume is amount of residential property transaction recorded at a particular area by the Land registry. The institution register residential property transactions in England and Wales, which are used in index construction.

An average yield from British Government ten year Real Zero Coupon securities was considered to be a risk-free rate. The data on yields was obtained from the Bloomberg Professional service.

The rest of the data was obtained from the Office for National Statistics (labour data was obtained from Nomis website, which is a service of the ONS). The most of the data from the Office for National Statistics is of yearly frequency, except Jobseeker’s allowance claimants’ rate, which is of a monthly frequency. Jobseeker’s allowance claimants’ rate is the number of people claiming Jobseeker's Allowance and National Insurance credits at Jobcentre Plus local offices. This is not an official measure of unemployment, but is the only indicative statistic available for smaller areas. Hourly compensation for work is based on Annual Survey of Hours and Earnings, which is conducted by ONS and is most detailed and comprehensive source of earnings information. They measure median gross earnings.

Table 1. Description of original data

Data	Geographical breakdown	Measure	Frequency	Data source
House price indices	County/Unitary authority	Units	Monthly	Land Registry
Average house prices	County/Unitary authority	£	Monthly	Land Registry
Sales volume	County/Unitary authority	Units	Monthly	Land Registry
Jobseeker’s allowance claimants	County/Unitary authority	Units	Monthly	ONS
Harmonized consumer price index	UK	Units	Monthly	ONS
10 year Real Zero Coupon	UK	%	Monthly	Bloomberg
Hourly compensation for work	County/Unitary authority	Units	Yearly	ONS
Population	County/Unitary authority	Units	Yearly	ONS
Size of the area	County/Unitary authority	Hectares	-	ONS
Geographical data	County/Unitary authority	-	-	ONS

The investigated period is from 1997 to 2014. England and Wales data is disaggregated at a county/unitary authority level. The data is adjusted according to the administrative boundaries changes that appeared from 1997 to 2012 at a unitary authority and county level in England and Wales. The disaggregation of the data at a county/unitary authority level may seem coarse as it includes areas of rather different scales. However, the availability of other explanatory data for a geographic unit was taken into account. While smaller geographic units may contain more spatial information, economic and demographic data is usually collected at smaller geographic entities or is collected yet is of poorer quality. A county/unitary authority geographical breakdown seemed an optimal solution to catch spatial patterns and to control for economic and demographic differences.

2. Data constructed for the research

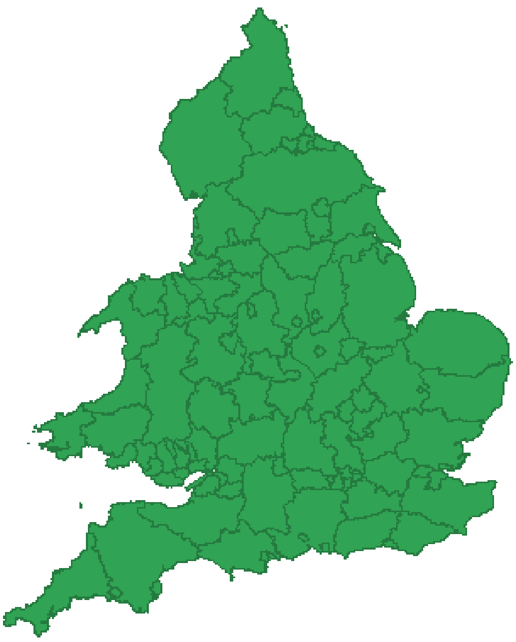


Figure 1. Disaggregation level (Counties and Unitary Authorities)

Source: ONS (2015)

England and Wales housing market was disaggregated into one hundred and twelve areas at unitary authority/county level (there are one hundred and thirteen areas, yet inner and outer London were not separated). Additionally, for the simplicity of spatial calculations, islands were not included in the calculations (Anglesey, Isle of Scilly, and Isle of Wight), thus resulting one hundred and nine analysed housing markets (figure 1). For spatial analysis, a square 109 on 109 weight matrix is created based on each region's contiguity by a 'queen' principle, i.e. every neighbouring region is given a weight of one even if only an edge is shared with the neighbouring counties/unitary authorities. Regarding the geographical level chosen, further disaggregation was limited by housing and socioeconomic data available. As I did not have access to a smaller scale dataset, it prevented deeper geographical disaggregation.

The geographical level could have a disaggregation bias as for the housing market perspective the boundaries are relatively arbitrary and does not always represent existing social and economic areas, while administrative borders does not necessary indicate the links. Furthermore, the county/unitary authority data includes very different housing markets, for example, urban and regional.

In the end, the weight matrix is row standardized. The matrix has five hundred and eight nonzero links, or 4.28 percent. Ten regions have only one link; Powys has the highest number of links (thirteen). There are no regions without links as all the island were removed from the dataset. To determine whether the England and Wales residential property market actually has a spatial structure, and to calculate the final spatial form of the model, Moran's I spatial diagnostics tests are performed (*see* Cliff & Ord, 1981).

The above data was used to calculate variables used in the analysis (table 1). Housing market returns used in the study were calculated as compounded annual growth rates for the period from 1997 to 2014, according the following equation:

$$R_i = \left(\frac{I_n}{I_1}\right)^{\frac{1}{n}} - 1$$

R_i – housing market returns in area *i*;

I – housing market index in area *i* in period *n*;

n – ending period number.

The returns values are in real terms, i.e. house price indices were adjusted according to harmonized consumer price index. Volatility was calculated as a sample standard deviation, which was obtained from the returns series of the house indices and was annualized. Systematic risk and both idiosyncratic risks were calculated according to CAPM and the formulas in the methodology section using quarterly data and cumulative returns.

Sharpe ratio is calculated according to the formula in the methodology sections. House price level was measured using only data from the first year, as otherwise it could be that house price levels could capture increases or declines in returns that already were included in the prices. Unemployment rate was calculated as average unemployment rate per observed year. Employment compensation was adjusted by harmonized consumer price index. Geographical data was used for drawing maps and constructing weight matrices. The rest of the variables were used as provided by data sources.

Table 2. Variables used in the analysis

Variable	Explanation
Returns	Compounded annual capital returns on house price index changes, %
Volatility	Annualized standard deviation of the returns
Idiosyncratic	Idiosyncratic risk
Systematic	Systematic risk or beta coefficient from CAPM model
Idiosyncratic 2	Idiosyncratic risk according to adj. R-sqrt
Sharpe	Sharpe ratio
House Price	Average house price in the area, £
Population	Population growth in an area, %
Hourly Pay	Growth of average compensation for employees per hour, %
Claimant Rate	Growth of Jobseeker's allowance claimants per active population, %
Volume	Growth of houses sold in an area per month, 10 thou.

None of the series was de-seasonalised, because they were treated as financial data. Seasonally adjusted data series would artificially seem to fluctuate less and, thus, may indicate having lower financial risk than it actually possess.

The majority of the analysis is performed in cross sections. The variables in the table 2 were computed as if it was for one period. There are few studies that analyse cross sectional returns and risks in housing (for example see Cannon et al., 2006; Miller & Pandher, 2008; Zheng et al., 2015). Additionally, we believe that the cross section data fits the task of the thesis to compare the English and Welsh housing market and apply spatial econometrics technics. Housing market data is of a relatively low frequency and possess relatively strong momentum, thus making the data relatively smooth. Yet the traditional way to compute volatilities may require relatively many data observations in time, thus we decide to focus on cross sections. Furthermore, we believe that cross sectional setting could help to exploit existing spatial methods more actively.

Alternatively, some studies do analyse returns and risks across the real estate areas in panel data setting (for example see Guirguis et al., 2007; Hossain & Latif, 2009; Miles, 2011; I.-C. Tsai & Chen, 2009; I. C. Tsai et al., 2008) and there are some that analyse housing price volatility in spatial panel data setting (for example Zhu et al., 2013).

V. Descriptive analysis of housing data of England and Wales

In section one, market overview is provided, short historical market development, correlations among the regions and summary of the returns and returns volatilities. In section two, housing markets at county and unitary authority level are described, including descriptive analysis of the variables and characteristics of the markets, and spatial distribution of the variables and characteristics. Section three, compares correlations among the variables. Section four, provides a summary of the chapter.

1. Market overview

Housing market in England and Wales experienced a house price growth for almost two decades (figure 2). Since 1995 the average house price in Eglish and Welsh residential market increased almost four times up to almost 200 thou. pounds. House prices had risen 16 years from 20 observed years. Three of these annual house price declines were a consequence of the last financial crisis, which was started by a real estate price decline in the U.S., and economic stagnation after it.

The long lasting house price increase was caused by many favorable factors. The countries experienced a decline in mortgage cost, population increase, economic and income growth, a limited supply of new houses, a decrease in a size of an average household. The growth of the residential housing market was led by the largest market – London. The capital and economic centre of the country and areas that surround it were the most vital housing markets in England and Wales. This is was caused by outstanding development of the area. It has experienced the most rapid economic (figure 3) and population (figure 4) growth among the regions. The markets were less active and prices changes were modest further up to the north. Likewise, it is seen that housing market driving factors were relatively weak.

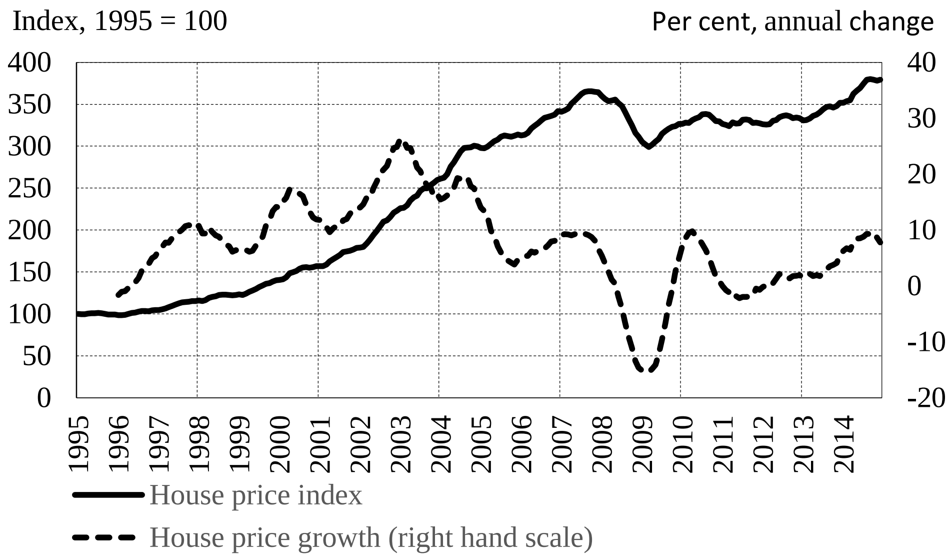


Figure 2. House price dynamics

Sources: Land Registry and author's calculations.

The only sharp decline in almost two decades that England and Wales experienced was during the latest financial crisis. In 2009 house prices declined more than 15 per cent, however in consecutive year the house prices smoothed the decline by almost half. It was fallowed by a few years of modest changes, yet since 2014 the prices were raising relatively fast and the house price index reached all times high. The initial response of a sharp house price drop is understandable because the UK contain a sizeble financial industry, which was hit the most by worldwide financial markets colapse. Additionally, the financial crisis developed into economic slowdown in the UK and most of its main partners, thus trade and investments decreased and unemployment have risen. However, countermeasures were taken, such as large interest rate cuts, which eventually have led to a recovery of economy and financial markets. As a result house price started growing rapidly again. In general, house prices seemed to be very procyclical and progress inline with economic development.

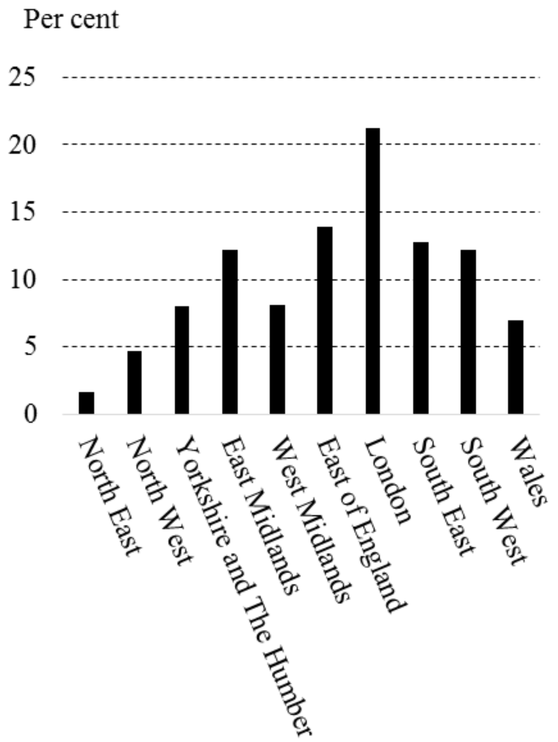


Figure 3. Regional population growth 1997-2014.

Sources: ONS and author's calculations.

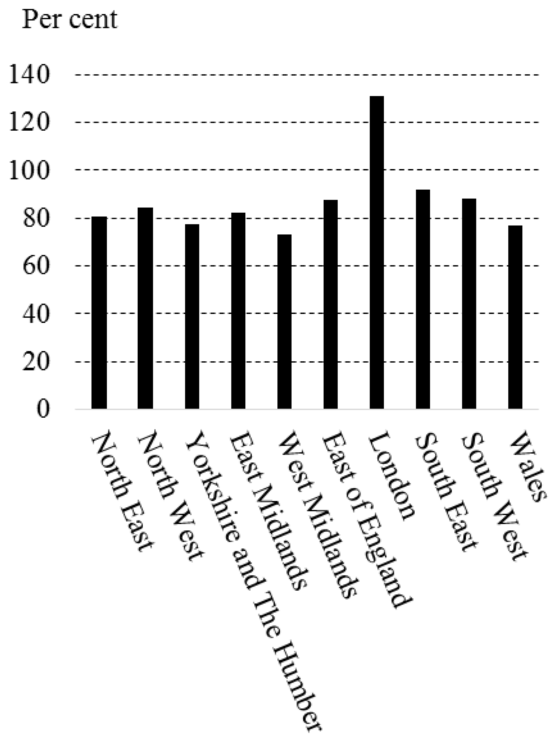


Figure 4. Regional economic growth (gross value added) 1997-2014.

Sources: ONS and author's calculations.

2. Descriptive analysis

This section presents the descriptive results of the research. In addition to complete data set lasting for eighteen years from 1997 to 2014, we also split the data into two periods from 1997 to 2007 and from 2008 to 2014, and analysed the differences and changes over time. The data was split in order to check the robustness of the results, yet it was not split in equal number of years. The two periods approximately coincide with a pre-crisis period until 2007, when economy and housing prices were increasing rapidly, and crisis and "after crisis" period, when the economic growth stagnated and house prices in real terms were falling. Thus, the two analysed periods make it an interesting case in terms of the latest economic crisis. The data in the section is described using simple statistical measures, such as averages, means, ranges, minimum and maximum values, frequency distributions, and data distributions on a geographical map of England and Wales with the administrative boundaries of counties and unitary authorities.

In order to compare regional housing market differences, Pearson correlations are calculated for the regional house price indices (table 3). All the regions are highly correlated with the others. Greater London area slightly stands out because it is least correlated with the other regions. East Midlands, West Midlands, and South West are most correlated with the other regions. While North East, North West, Yorkshire and the Humber, Wales, and London have most varying results. Overall, it seems that correlation analysis groups regions into clusters according to their geographical location.

From 1997 to 2014, the Greater London was also the best performing regional housing market. Its compounded annual returns adjusted by inflation were 6.65 percent. The worst performing regional market was North East, which house prices raised 1.77 percent, less half of the national increase. North East was also a most volatile housing market. Its housing market returns fluctuation was 3.10 standard deviation, while the least volatile region was West Midlands where the volatility was 2.51 standard deviation.

Table 3. Correlations of the returns among the regions

	E&W	NE	NW	Y&H	EM	WM	W	E	L	SE	SW
England and Wales	1.00										
North East	0.81	1.00									
North West	0.84	0.89	1.00								
Yorkshire and the Humber	0.87	0.89	0.90	1.00							
East Midlands	0.95	0.85	0.86	0.91	1.00						
West Midlands	0.96	0.87	0.88	0.92	0.96	1.00					
Wales	0.88	0.87	0.90	0.91	0.89	0.91	1.00				
East	0.96	0.70	0.75	0.78	0.90	0.90	0.80	1.00			
London	0.85	0.50	0.53	0.55	0.72	0.72	0.60	0.88	1.00		
South East	0.94	0.62	0.68	0.70	0.85	0.85	0.75	0.97	0.94	1.00	
South West	0.97	0.73	0.79	0.80	0.91	0.91	0.83	0.97	0.85	0.95	1.00

Source: author's calculations

Table 4. Regional returns and volatilities (% and standard deviations)

	England and Wales	North East	North West	Yorkshire and the Humber	East Midlands	West Midlands	Wales	East	London	South East	South West
Return	3.84	1.93	2.54	2.66	3.23	2.86	2.87	4.27	6.16	4.21	4.16
Volatility	2.49	3.10	2.69	2.76	2.70	2.51	2.89	2.66	2.85	2.65	2.72

Source: author's calculations

English and Welsh housing markets during the last eighteen years have observed significant annual increase in house prices. English and Welsh housing markets have observed 3.84 percent annual compounded growth when adjusted for inflation. During the boom period from 1997 to 2007, the compounded capital gains in the country were 5.07 percent per year, while during a slower period from 2006 to 2014, the compounded capital gains were negative -1.16 percent per year when adjusted for inflation.

During 1997-2014, annual capital returns on houses in an average county/unitary authority area, even adjusted for inflation, were 3.26 percent. Slightly higher median 3.40 percent, negative skewness and low kurtosis show that the values are leaned more to the higher side (left tail was longer) and were relatively flat distributed. The difference between least appreciated and the most appreciated areas was 5.93 percent. The highest capital returns on housing were in Brighton and Hove (6.50 percent), a popular seaside resort in South East England region, while the lowest returns were Middlesbrough (0.01 percent), an industrial town in North East. As it is seen from the plotted returns (figure 5), there was a visible difference among southern and northern counties in terms of house value appreciation. Southern counties especially around London and near the coast observed the highest increase in house prices (East of England, London, South East, and South West regions), while the returns gradually decreased when going up to the northern counties, with North East region having multiple counties that were among the lowest capital gainers.

Looking at the returns in the split data series (table 5 and table 6), a huge gap was observed between the first period from 1997 to 2007 and the second period from 2008 to 2014. The first period generated 8.62 percent compounded annual return after adjusting for inflation in an average administrative area. However, during the second period, real house values have decreased by -3.94 percent in an average county or unitary authority. The average range between highest and lowest performing counties have increased from 5.04 percentage points during the first period to 11.26 percentage points during the second period, indicating that differences in price developments among the markets were milder in the first period.

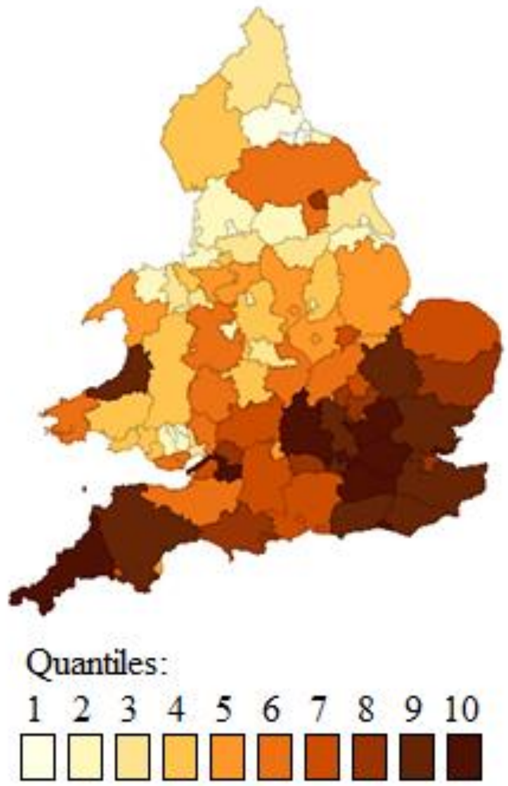


Figure 5. English and Welsh housing returns

Figure 6. English and Welsh housing return volatility

Source: author's calculations

Table 5. Descriptive statistics.

1997-2014	*Returns*	*Volatility*	*Idiosyncratic*	*Beta*	*Idiosyncratic 2*	*Sharpe*	*Price level*	*Wage*	*Unemployment*	*Sales*	*Population*
Mean	3.26	2.95	10.96	0.96	0.28	1.69	149873	0.98	-2.30	-0.86	0.63
Standard Error	10.98	0.17	1.68	0.01	0.02	0.15	4841	0.04	0.08	0.05	0.07
Median	3.40	2.26	4.22	0.97	0.24	1.46	143620	0.96	-2.26	-0.89	0.57
Standard Deviation	1.15	1.78	17.58	0.11	0.19	1.56	50539	0.45	0.81	0.50	0.72
Kurtosis	0.33	5.73	21.22	7.85	-0.69	4.63	1.71	2.70	-0.45	2.95	60.49
Skewness	-0.25	2.03	4.12	-1.71	0.53	1.59	1.09	0.57	-0.03	0.46	6.77
Range	5.93	9.87	118.71	0.88	0.77	9.63	254509	2.92	3.65	3.44	7.30
Minimum	0.57	1.15	0.40	0.35	0.00	-0.29	68331	-0.14	-4.16	-2.45	-0.25
Maximum	6.50	11.02	119.11	1.24	0.77	9.34	322840	2.78	-0.51	0.99	7.06
Count	109	109	109	109	109	109	109	109	109	109	109
1997-2007	*Returns*	*Volatility*	*Idiosyncratic*	*Beta*	*Idiosyncratic 2*	*Sharpe*	*Price level*	*Wage*	*Unemployment*	*Sales*	*Population*
Mean	8.62	2.27	6.43	1.01	0.22	7.81	141900	0.03	-5.36	1.42	0.56
Standard Error	9.44	0.13	1.00	0.02	0.01	0.37	4459	0.00	0.12	0.17	0.04
Median	8.49	1.79	2.72	1.00	0.19	7.56	138181	0.03	-5.24	1.09	0.57
Standard Deviation	0.99	1.35	10.39	0.25	0.15	3.89	46553	0.01	1.21	1.79	0.41
Kurtosis	0.57	6.11	25.35	0.92	-0.81	-0.81	1.36	5.76	-0.11	1.50	0.31
Skewness	0.67	2.09	4.43	0.15	0.55	0.24	1.00	1.44	-0.09	1.17	-0.11
Range	5.04	8.06	78.25	1.58	0.59	16.57	235715	0.07	5.96	9.43	2.23
Minimum	6.54	0.86	0.47	0.20	0.00	1.16	64087	0.01	-8.54	-1.14	-0.48
Maximum	11.58	8.92	78.72	1.78	0.59	17.73	299802	0.08	-2.57	8.29	1.74
Count	109	109	109	109	109	109	109	109	109	109	109

Descriptive statistics (continued)

2008-2014	*Returns*	*Volatility*	*Idiosyncratic*	*Beta*	*Idiosyncratic 2*	*Sharpe*	*Price level*	*Wage*	*Unemployment*	*Sales*	*Population*
Mean	-3.94	3.61	17.63	0.94	0.28	-0.67	162403	-1.01	2.30	-3.18	0.68
Standard Error	19.47	0.22	2.80	0.01	0.02	0.06	5472	0.06	0.22	0.13	0.13
Median	-3.65	2.66	6.24	0.97	0.26	-0.68	154234	-0.97	2.20	-2.94	0.53
Standard Deviation	2.03	2.32	29.24	0.14	0.21	0.63	57130	0.65	2.26	1.39	1.38
Kurtosis	0.10	5.75	24.59	6.97	-0.56	6.55	2.29	2.67	0.56	-0.43	93.49
Skewness	-0.28	2.01	4.40	-2.04	0.59	1.24	1.22	0.13	0.48	-0.34	9.33
Range	11.26	13.40	215.97	0.98	0.84	4.86	305530	4.42	11.99	6.55	14.66
Minimum	-10.02	1.33	0.93	0.22	0.00	-2.25	74999	-3.03	-2.67	-6.58	-0.19
Maximum	1.24	14.73	216.90	1.20	0.84	2.62	380529	1.39	9.32	-0.03	14.47
Count	109	109	109	109	109	109	109	109	109	109	109

Source: author’s calculations

The best performing area during the first period was Gwynedd (11.58 percent), a coastal, sparsely populated county in the west north of Wales; while the lowest capital gains were in Nottingham (6.54 percent), an ex-industrial city in the middle of England. Thus, during the high growth period, even the worst performing areas have generated relatively high inflation adjusted annual returns. During the slowdown period, London, the capital of the country, was on the top of all areas in house price increase. The prices in London have increased by 1.25 percent (Brighton and Hove were second with annual price decrease of 0.001 percent). The biggest decrease was observed in Middlesbrough (-10.02 percent). From the returns quantiles in the maps (figure 7, figure 8), it is seen that during the high growth period, high returns were scattered around the country. While London and some nearby areas have observed high house price growth, there were counties and unitary authorities on the western coast in South West region and Wales that have seen the same level growth in housing markets. Yet, during the slowdown period, higher house price returns were more concentrated in and around London, while areas that are more distant were obtaining lower annual house price returns, with northern areas having the lowest increases.

The volatility in England and Wales has not changed considerably during the higher and lower growth periods. From 1997 to 2007, volatility in the country was 0.70; while during the second period from 2008 to 2014 volatility was 0.91. Volatility for the whole period in the country was 0.92 (a complete period volatility was higher compared to volatilities in separate periods, because returns could be concentrated at different levels in split data, and standard deviations do not capture return fluctuation that were not in the sample).

Figure 7. Returns in England and Wales from 1997 to 2007

Figure 8. Returns in England and Wales from 2008 to 2014

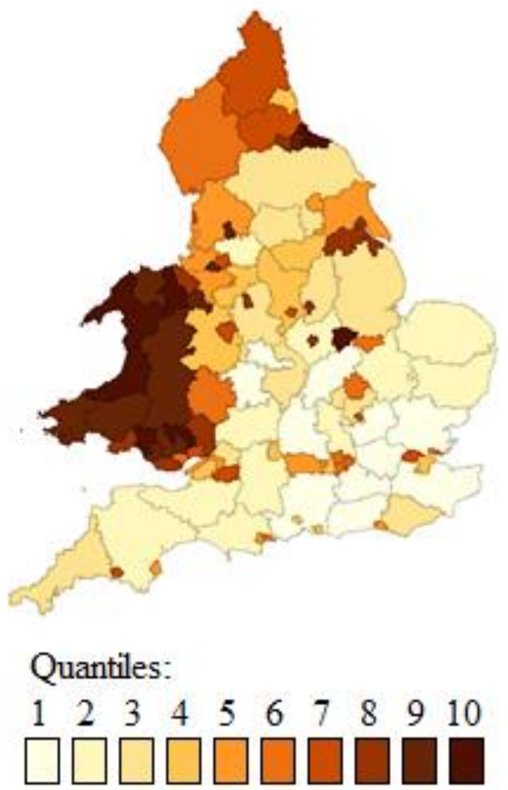


Figure 9. Volatility in England and Wales from 1997 to 2007

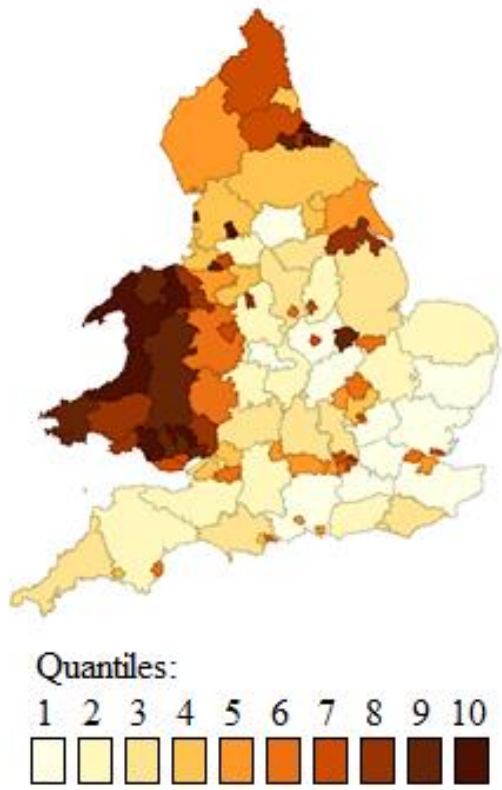


Figure 10. Volatility in England and Wales from 2008 to 2014

Source: author's calculations

From 1997 to 2014 house price volatility in an average county or unitary authority was 2.94, while the median was lower 2.23. During the high growth period, volatility was relatively lower (mean 2.37, median 1.86), while it increased during declining period (mean 3.33, median 2.46). Lower medians compared to averages indicate that volatility in certain areas could have relatively more extreme values or that it is not normally distributed. From the map (figure 6), it is seen that volatility was higher in Wales, Northern England, and more densely populated areas. While East England, London, and South East contained areas that are of a lower volatility. A Welsh county, Blaenau Gwent, was the most volatile area (10.92). The lowest volatility was observed in South Eastern region in a coastal county of Hampshire (1.14). Hampshire is among the largest counties in the sample and is much larger county compared to Blaenau Gwent. Its area size is approximately thirty-four times larger and population approximately eighteen times larger compared to the Welsh county. In addition, Hampshire is among more well-economically developed counties in the sample, while Blaenau Gwent was much poorer than Hampshire and one of the poorest among the sample in terms of wages, unemployment, and housing prices.

From two maps based on a split data (figure 9, figure 10), it seems that volatility have remained approximately the same during the expansion and during the declining periods. The regions around London were less volatile compared to Welsh and Northern regions. The most volatile county during the high growth period was the Welsh county of Merthyr Tydfil (8.97), which is known for its coal mining, steel, and iron works industry (Blaenau Gwent was the second most volatile county). The least volatile area in the sample was London (0.91) (Hampshire was the second). During the declining period, Hampshire and Blaenau and Gwent shared the most and least volatile area positions in the sample, with 1.22 and 13.37 return standard deviations.

Systematic risk in an average area was 0.96. Considering that, systematic risk measures how sensitive a housing market is compared to the rest of the country; then it should be around one and the difference from one is caused just because equal weights were given for all counties and unitary authorities during averaging process. From the systematic risk distribution and high kurtosis (7.85), it is seen that the most of the counties and unitary authorities act relatively similarly to the rest of the country. However, negative skewness (-1.71) and higher than average median (0.97 and 0.96) indicates that the dynamics in some areas differ significantly from the country's housing market. The highest systematic risk was in a Welsh county of Wrexham (1.24), which is located in a coal mining area. The lowest systematic risk was in another Welsh county of Blaenau Gwent (0.35). Both counties may correctly suggest that Wales contains counties with extreme values of systemic risk (figure 11). Those in the lowest quantile are concentrated more near the coast, while the ones more inland generally have systemic risk in the highest quantile.

While there is almost clear separation and concentration of systemic risk in Wales, the rest of the country does not seem to have a pattern. High and low values of systemic risk seem to be scatter around the country randomly.

Figure 11. Market risk in England and Wales

Source: author's calculations

As expected, from 1997 to 2007 and from 2008 to 2014, systematic risk indicators were also close to one - respectively 1.01 and 0.94. However, during the first (high growth) period, systematic risk was spread more widely, yet more evenly compared to the second (crisis) period; this could be said from much lower kurtosis (respectively 0.92 and 6.97), wider range (respectively 1.58 and 0.98), and close to zero skewness (respectively 0.15 and -2.04), which indicates short tails (figure 12, figure 13). Distribution across country of systematic risk also differed in separate periods. In the high growth period, systematic risk indicators were more concentrated according to levels. South East region near London had the largest concentration of counties and unitary authorities that observed low systematic risk. With some exceptions, counties and unitary authorities seemed to gain a gradually higher systematic risk as further they were from the area.

In a crisis period, the numbers have turned upside down, yet a distribution of systematic risk is less clear. Peripheral areas in Wales, North of England, and South West of England had relatively lower systematic risk compared to London and surrounding areas. The exception was eastern counties of Wales, which maintained a high systematic risk. The lowest systematic risk during both periods was in Blaenau Gwent county, while the highest during the 1997-2007 period was in Wrexham, and in 2007-2014 period was in Denbighshire, a county in northeast Wales.

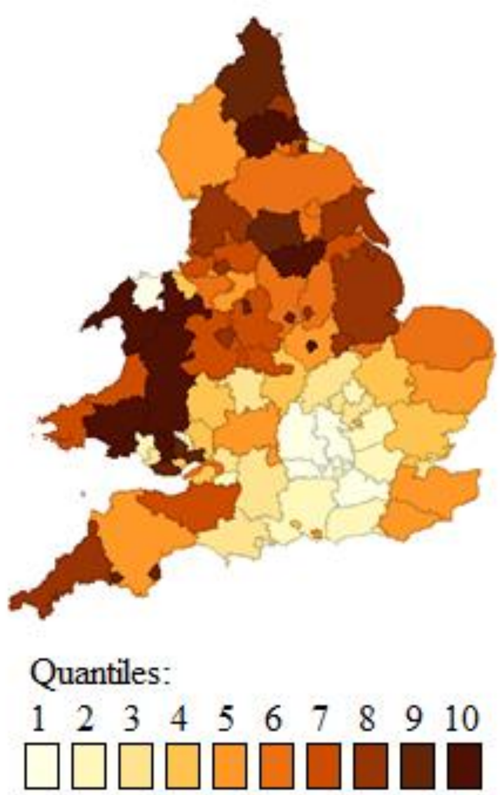


Figure 12. Market risk from 1997 to 2007

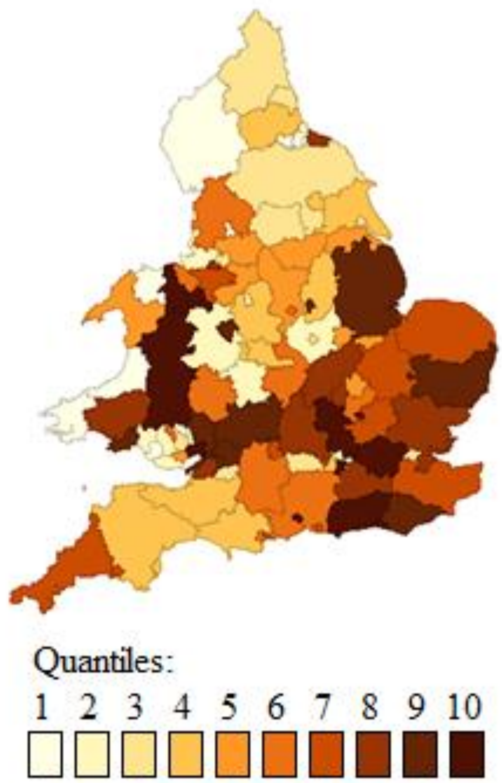


Figure 13. Market risk from 2008 to 2014

Source: author's calculations

Overall, systematic risk allows distinguishing several hosing markets in the country: London and surrounding areas, peripheral areas of England and Wales. While London with the surrounding areas and the rest of English counties and unitary authorities appeared to oppose each other, Wales made an impression that it is the most sensitive to house market movements in the country.

Idiosyncratic risk, which is measured in two different ways (see Methodology section in Chapter IV), allows tracking how well dynamics of English and Welsh housing market could explain a housing market in a particular county or unitary authority. The two measures seem to differ only marginally. If ranked from lowest to highest risk according the two idiosyncratic risk indicators, the lists of areas differ very little. This is also visible in maps that contain idiosyncratic risk information (figure 14, figure 15).

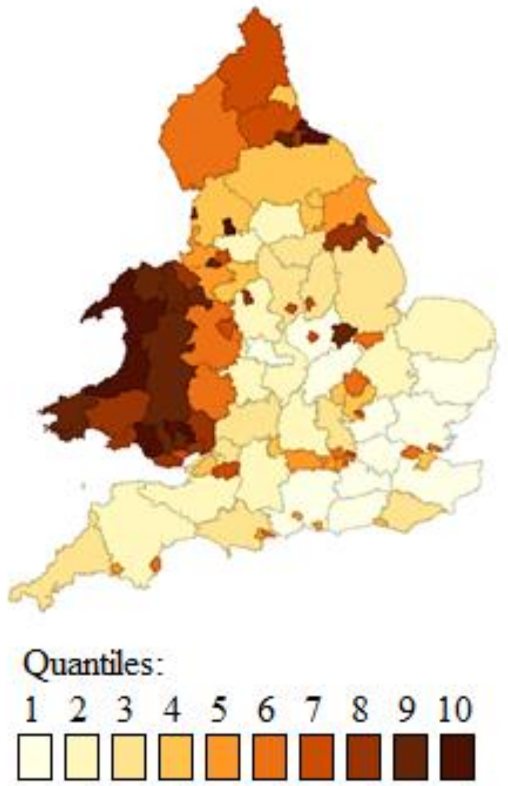


Figure 14. Idiosyncratic risk

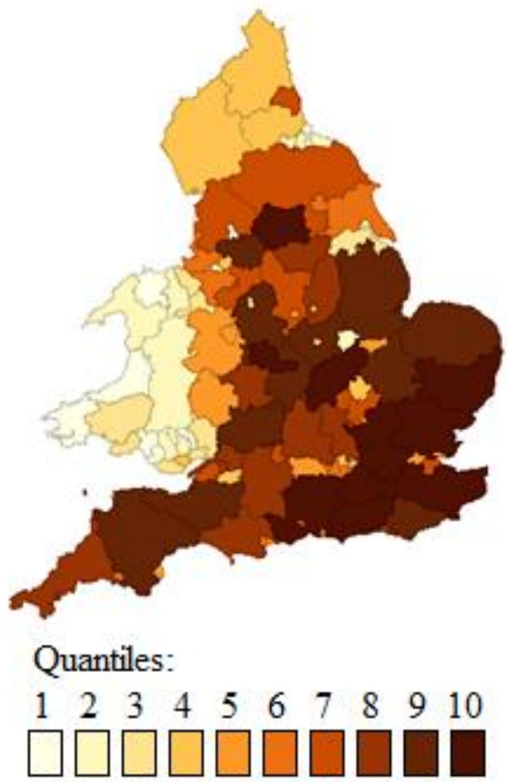


Figure 15. Idiosyncratic (2) risk

Source: author's calculations

Contemporary house price movements in the country could explain a bit over a quarter of housing markets dynamics (0.28) in an average county or unitary authority. The range started from 0.00 in a county of Blaenau Gwent to 0.77 in London (the lower the number means higher idiosyncratic risk, which in the tables is indicated as idiosyncratic risk 2).

Idiosyncratic risk appears to be lowest in London, East of England, and South East regions. It gradually increased if going to the north or west of England; except Wales, which in contrast to the neighbouring regions, had notably high idiosyncratic risk. This indicates that housing markets in Wales are affected very little by current housing market trends in the country. In addition, smaller, more densely populated areas also seemed to have higher idiosyncratic risk. This could be because more urbanized areas were more driven by local city or town level dynamics, whether it would be economic, demographic, or planning.

The idiosyncratic risk does not change much in time. Wales remained the region where returns of the housing markets in counties and unitary authorities explained the least by national house price movements were clustered in both high and low growth periods; while the most explained areas were clustered around London. Yet a low growth period seems to be clustered more neatly (this is not confirmed by Moran's I calculations, but on the other hand, Moran's I in this analysis accounts only neighbouring regions).

The area explained least by national house price movements during high and low growth periods was Blaenau Gwent. The movements in the county were not explained at all by contemporary nationwide housing market dynamics (idiosyncratic 2 indicators were 0.00 in both periods). During high growth period, the nationwide house price dynamics had the highest impact on the housing market in a county of West Midlands (0.59), which is the second most populous county in the sample (and in the country). During low growth period, the most explained area was London (0.84). It is interesting that idiosyncratic measures of West Midland have remained almost the same (0.56).

Of course, at least partly idiosyncratic risk coincides with a houses sales volume in a particular county or unitary authority, because volume has an effect on how much a particular housing market impacts total English and Welsh housing market. Yet London, which has the biggest house sales volume, constitutes only 13.15 percent of total volume in the English and Welsh housing market.

Sharpe ratio, which measures returns above a risk-free rate relative to risk, was 4.68 in the English and Welsh nationwide housing market. However, Sharpe ration in an average county or unitary authority was only 1.69 and ranged from -0.29 to 9.34 respectively in Middlesbrough, an industrial unitary authority in North East region, and London. The ratio was clearly higher in the south in the regions of East of England, London, South East, and South West (figure 16). The ratio was a bit lower in the middle of the country in the regions of West Midlands, East Midlands, and Yorkshire, and the Humber; while it was even lower in Wales, North West, and North East regions.

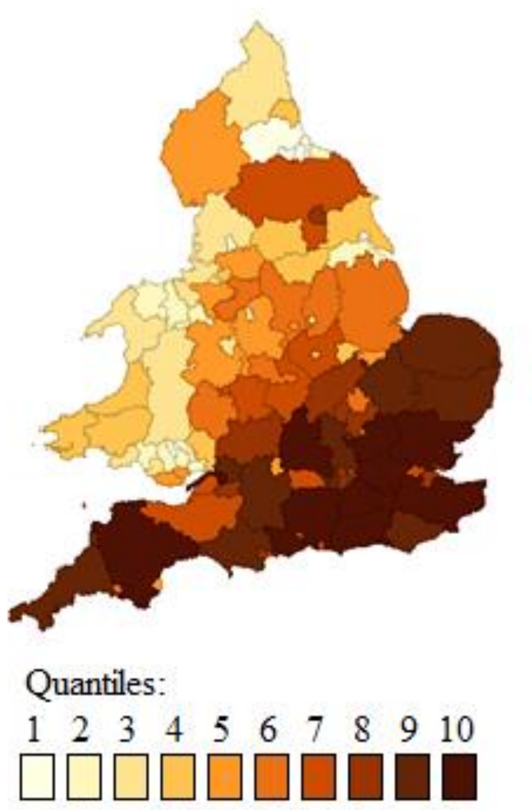


Figure 16. Sharpe ratio

Source: author's calculations

While the ratios are not directly comparable across time, the ranks according to the ratio may be compared. In the period from 1997 to 2007, according to Sharpe ratio, counties and unitary authorities in Wales were underperforming compared to the rest of the country; while counties in the south of the country were leading, and the rest of the counties landed somewhere in the middle (figure 17). In a dissed period, the highest Sharpe ratio was in London (17.73) and the lowest ratio was in Merthyr Tydfil.

The ranks have changed in a period from 2008 to 2014 (figure 18). Welsh counties had relatively high Sharpe ratio. Southern counties separated into London with surrounding areas that had relatively high Sharpe ratio and into other, more distant from London counties that - together with the rest of the country - were underperforming. The highest Sharpe ratio was again in London (2.62) and the lowest was in a county of West Yorkshire (-2.25) in Yorkshire and the Humber region, which is one of the most populous counties and which is dominated by the service industry. Overall, once again, the risk indicator distinguishes the country into three separate markets: London with the neighbouring areas, Wales, and the rest of the country.

Figure 17. Sharpe ratio from 1997 to 2007

Figure 18. Sharpe ratio from 2008 to 2014

Source: author’s calculations

House sales volumes also distinguish the country, yet into two visibly different markets: England and Wales. Less populous Wales stands out from the rest of the country with much lower house sales volumes. The sales volumes in the rest of the country are visibly higher, especially in and around large metropolitan areas (figure 19, figure 20). The sales volumes are also not clustered in one region (London has around three times larger house sales volume compared to Greater Manchester, which has the second largest sales volume; however, for this comparison, it is not excluded from the other large markets). County and unitary authority clusters of high house sales volume were distributed around England. They were located in London and its surrounding areas, as well Northern metropolitan surrounding areas (Greater Manchester, Merseyside, Lancashire, South Yorkshire, and West Yorkshire). Also, West Midlands county, and Tyne and Wear county in North East region are among largest housing markets in the country in terms of house sales. The largest amount of houses was sold in London, on average 10,777 per month. The lowest amount of houses, on average fifty-nine per month, was sold in Rutland, a county in East Midlands. London and Rutland are respectively the largest and the smallest areas in the sample in terms population. Overall, on average, there were 81,985 houses sold in the English and Welsh market per month.

The structure of counties having highest and lowest sales volume have not changed significantly when compared with high growth and low growth periods. Yet, during the high growth period, the lowest average of sold houses per month was in Merthyr Tydfil (sixty-eight), which was the second least populous area. During the second period, the lowest amount of houses was sold in Rutland (fifty). In both periods, London was the leader by a large margin with on average 12,467 and 9,088 houses sold per month during the first and the second period respectively. For comparison, the second in the top areas with the largest house sales volume, Greater Manchester had 4,234 and 2,941 houses sold on average per month. The total average number of houses sold has declined from 95,282 in the high growth period to 68,689 in the low growth period. On the other hand, house sales growth was relatively higher in the northern parts of the country during the growth period, while during a slowdown period house sales growth was relatively higher in the south.

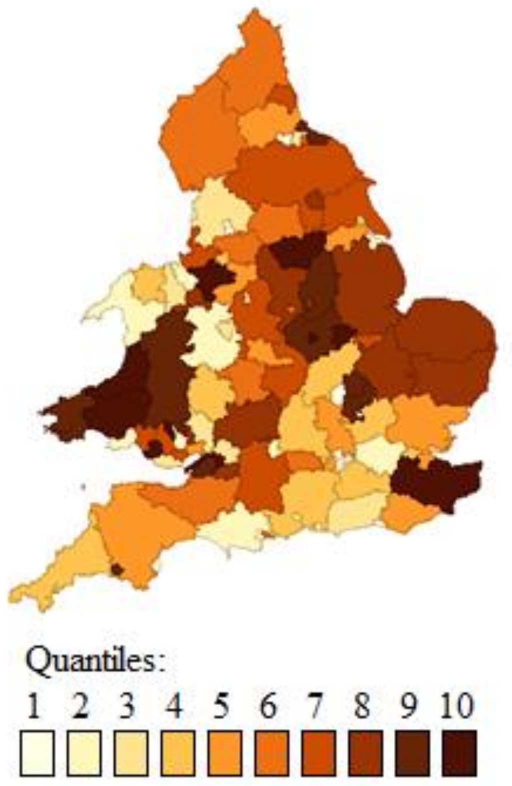


Figure 19. House sales growth

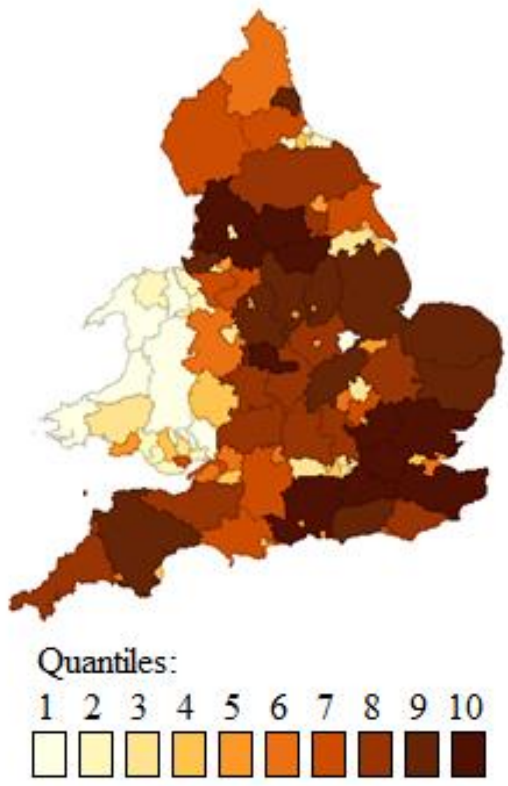


Figure 20. House sales

Source: author's calculations

From the houses sales volume numbers above and population statistics, house market turnover rates were calculated for each county and unitary authority, which is called liquidity ratio in this study. The liquidity ratio measures how many houses per 10,000 persons were sold on average per month, thus eliminating population size factor from the volume statistics. It is expected that liquidity ratio could help to distinguish more attractive housing markets adjusted to their population size.

In England and Wales, for every 10,000 persons, there were 15.17 houses sold on average per month, which was almost equal as in an average county or unitary authority (15.30). The difference of houses sold in the most liquid and the least liquid markets was 11.87 houses per 10,000 persons. The most liquid market when adjusted to population was a

Bournemouth unitary authority (21.41), a coastal resort area with a strong financial industry. The least liquid market was Blaenau Gwent in Wales (9.54).

When compared across the country, the liquidity ratio was slightly higher in the coastal areas in South West, South East, the East of England, and East Midlands regions. The higher liquidity ratio in these areas could have been boosted by the sales of second homes, due to attractive close distances to the sea. The least liquid areas were in Wales, especially in counties and authorities that are landlocked or have a short coastal line. It is interesting that London stands out from the neighbouring areas as having low house sales volume per population. This could be due to several reasons: a lack of new developments relative to the population size, unaffordable house prices, and unwillingness to sell due to relatively good capital gains and low risk (we are going to expand on this topic below in our study).

Comparing the high growth and low growth periods, the liquidity had dropped from 18.42 to 12.35 average houses sold per 10,000 persons per month in an average county or unitary authority. The country-wide result was very comparable with 18.17 and 12.33 houses respectively during the first period and the second period. The range between the most liquid and least liquid areas had also decreased from 15.14 in the economic boom period to 9.04 in the crisis and post crisis period. Bournemouth and Blaenau Gwent shared the most liquid and the least liquid housing market positions in both periods. The liquidity ratio for the first area decreased from 26.20 in the high growth period to 17.05 houses in the low growth period, while the liquidity ratio for the second area decreased from 11.06 to 8.00 houses. The liquidity ratio in London remained below country-wide average in both periods, respectively 11.27 and 17.13. There were no notable changes relative to other counties and unitary authorities, when comparing the liquidity ratio in two discussed periods.

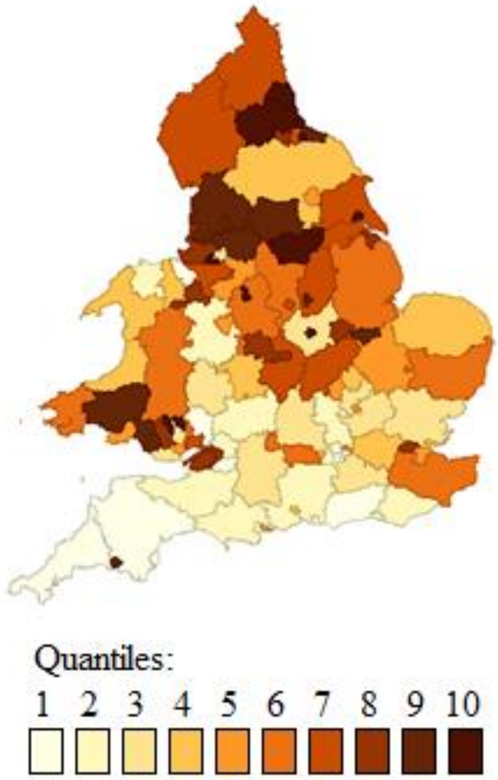


Figure 21. House sales growth from 1997 to 2007

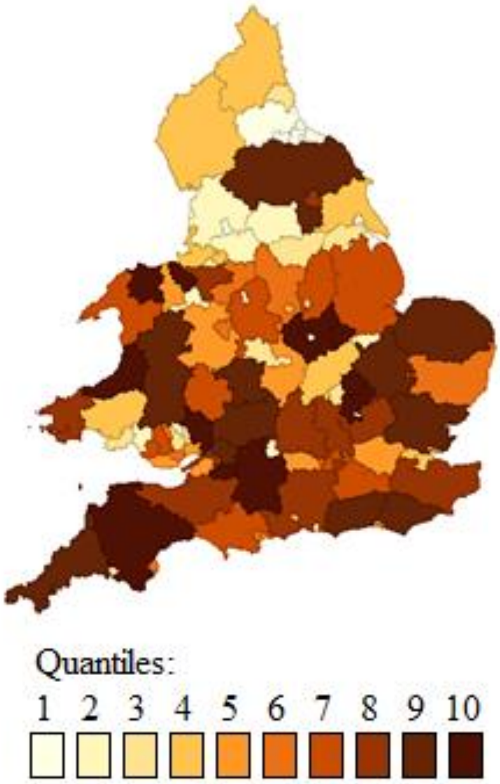


Figure 22. House sales growth from 2008 to 2014

Source: author’s calculations

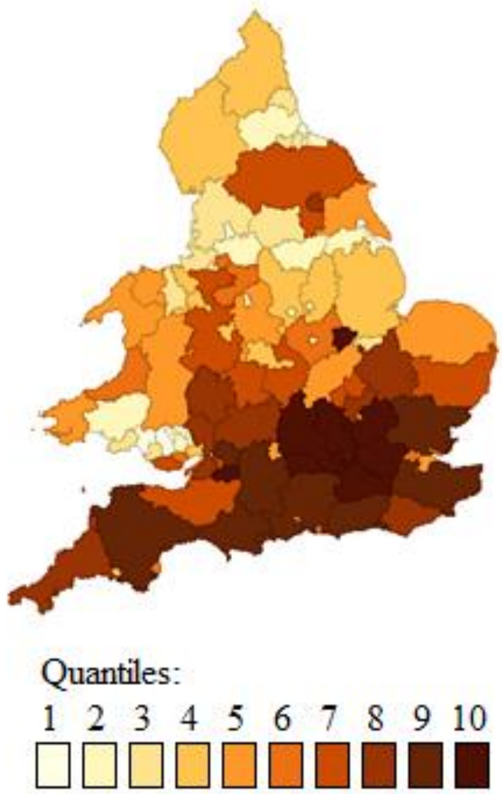


Figure 23. House price level

Source: author's calculations

From 1997 to 2014, the average house price in England and Wales was 161.00 thousand pounds (the price is adjusted to inflation). An average house price in a typical county or unitary authority was a little bit lower - 149.87 thousand pounds. The median price in an average county or unitary authority was 143.62 thousand pounds. Lower median and positive skewness (1.09) indicates that house price distribution has a longer positive tail. The range from an area with the lowest priced houses to the range of the highest priced houses was 254.51 thousand pounds. The least valued houses were in a Welsh county of Merthyr Tydfil (68.33 thousand pounds). The highest valued houses were in London (322.84 thousand pounds). The highest house prices were in London, and in the counties and unitary authorities to the east from London (figure 23). The lowest house prices were in the south of Wales. As for the rest of the country, relatively higher prices were South West and South East regions.

In the high growth period from 1997 to 2007 average house price in England and Wales was 137.77 thousand pounds. It has increased and, in a low growth period, was 184.20 thousand pounds when adjusted for inflation. The prices in an average county or unitary authority were moderately lower compared to the country-wide averages. In the first period, it was 129.25 thousand pounds, and in the second period, 170.49 thousand pounds. The price range among the highest priced housing market and lowest priced housing market increased from 224.80 thousand pounds to 301.54 thousand pounds. The lowest priced housing market in both the high growth and low growth periods was Merthyr Tydfil, with house prices respectively 56.19 thousand pounds and 80.47 thousand pounds. The highest priced houses during the first period were in Windsor and Maidenhead, a unitary authority in South East region close to London. Average house in this area cost 280.99 thousand pounds.

Figure 24. Jobseeker‘s claimants per active population

Source: author’s calculations

During the second period, the most valued houses were in London where average prices reached 382.01 thousand pounds.

A distribution across the country of the relative house prices has not changed much. The relative price level in comparison to the rest of the country increased in coastal areas of South West and South East regions.

A large effect on housing market has economic conditions, especially labour market. In a period from 1997 to 2014, Jobseeker’s allowance claimants share from active population in the country was 2.95 percent. The ratio replicates relatively well the dynamics of unemployment, yet its level is slightly lower. However, in this study, Jobseeker’s allowance claimant rate and unemployment will be used interchangeably. The share of claimant seekers in an average county or unitary authority was almost the same 2.85 percent. A country-wide hourly compensation per employee, adjusted for inflation, was 15.39 pounds. A respective rate in an average county and unitary authority was a little lower 14.15 pounds.

A relatively higher unemployment was in more densely populated metropolitan areas, including London; also in more peripheral counties and unitary authorities in the north of England and Wales (figure 24). There were significant differences among the areas with high and low unemployment. There range between area with the lowest and highest unemployment was 5.53 percent. The highest unemployment rate was in Kingston upon Hull (6.40 percent), a unitary authority in Yorkshire and the Humber with significant port activities. The lowest unemployment rate was in Rutland (0.87 percent).

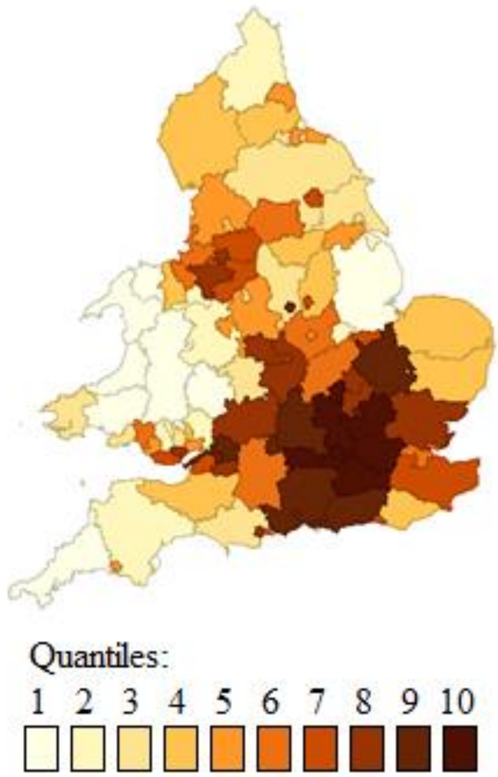


Figure 25. Hourly pay

Source: author's calculations

Oppositely, to unemployment rate, hourly wage was clustered without exceptions of densely populated areas (figure 25). The highest compensations were paid for employees in London and the surrounding areas. The lowest compensations were paid in Wales. Compensation in the rest of the country was approximately distributed according to the distance from London. The lowest wages were in Cornwall, which was dominated by fishing, agricultural, and tourism industries. The average hourly pay in Cornwall, adjusted for inflation, was 11.71 pound. The highest wages were in London, where average hourly pay was 20.93 pounds.

Comparing the high growth period and low growth period, there were only minor changes in relative unemployment. During the discussed periods, a country-wide unemployment rate increased from 2.84 percent to 3.07 percent. In an average county or unitary authority, the rate increased comparably from 2.69 percent to 3.01 percent. The peripheral areas in northern England, Wales, and Cornwall have slightly reduced relative unemployment rates, while unemployment rates have somewhat increased in counties and authorities that are located in the middle of England. From 1997 to 2007, the highest average unemployment was in Middlesbrough (6.09 percent), while the lowest was in Rutland (0.64 percent). From 2006 to 2014, the most allowance claimants proportionally to active population were in Kingston upon Hull (6.91 percent), and the least claimants were in Rutland (1.10 percent).

The average hourly pay in the country, adjusted by inflation, increased from 14.67 pounds in the economic growth period to 16.11 pounds during the lower growth period. A respective increase in an average county was from 13.50 pounds to 14.80 pounds. There were no significant changes in relative average compensation across the counties when compared to economic growth periods. From 1997 to 2007, the lowest hourly pay was in Cornwall (11.02 pounds) and the highest in London (19.99 pounds). While from 2008 to 2014 the lowest hourly pay was in Powys (12.19 pounds), the largest area in Wales (Cornwall had the second lowest pay of 12.40 pounds). The highest hourly pay was in London, which reached 21.87 pounds.

Demographic situation is another very important factor in housing markets. Intensively populated areas attract other people and stimulate housing markets. Furthermore, densely populated areas have less land to develop, thus the tighter supply forces house prices to be at a higher level. In the past eighteen years, the population in England and Wales has increased by 11.34 percent up to 57.41 mil persons. The United Kingdom has the fastest growing population among large European countries. It is expected that by 2050, the

United Kingdom will become the largest state in the European Union in terms of population (European Commission, 2014). Thus, not only that population is an important factor overall in real estate economics, but also very relevant when trying to describe housing market dynamics in the country.

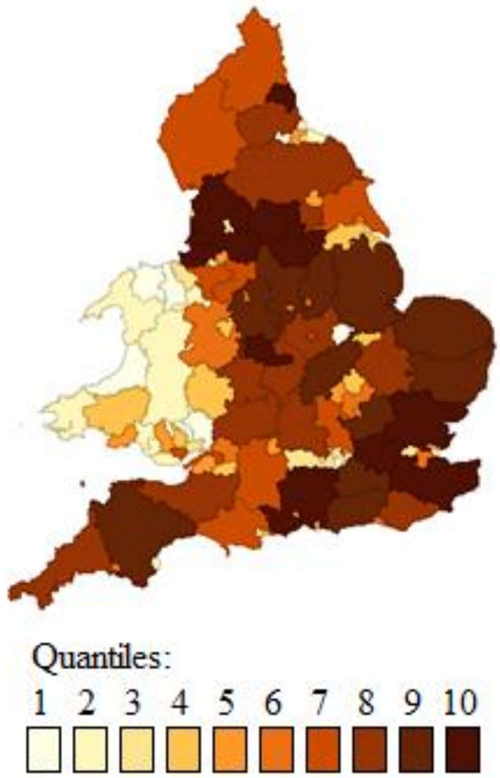


Figure 26. Population

Figure 27. Population density

Source: author's calculations

From 1997 to 2014, in England and Wales on average, the population density was 3.58 persons per hectare. In an average county or unitary authority, the density was a little bit higher and reached 11.01 persons per hectare. There were significant disparities among the areas in terms of their population. The difference between the least densely populated area and the most densely populated area was 48.54 persons per hectare. The most densely populated area was London with 48.80 persons per hectare (the second was Portsmouth with 48.52 pers./hec.). The least densely populated area was Powys that on average had four hectares per person (0.25 pers./hec). London and surrounding areas in South East and East of England regions, Midlands, North West region around Merseyside and Greater Manchester, North East region around Middlesbrough, and South of Wales around Cardiff were the among the most densely populated areas (figure 26, figure 27).

From 1997 to 2007, a population density in an average area was 10.67 persons per hectare. In the second period from 2008 to 2014, it was 11.35. During the first examined period, the most densely populated area was Portsmouth with 47.04 persons per hectare, a unitary authority with a significant port and naval industry in it. Powys was the least populated with 0.25 persons per hectare. During the second period, Powys remained the least populated area with the 0.26 person per hectare. However, London has outgrown Portsmouth and has become the most densely populated area with 51.29 persons per hectare. Neither the distribution of density neither the distribution of absolute population has changed notably across the counties.

Redcar and Cleveland, a unitary authority in North Yorkshire, have observed the biggest drop in its population (on average 0.25 percent per year). Milton Keynes a unitary authority that borders Greater London, have observed highest increase in population (on average 1.76 percent per year). Population in an average county/unitary authority was rising by 0.58 percent annually. During the high economic growth period Middlesbrough have observed -0.48 percent decrease in population, which was the lowest result among all areas . While Milton Keynes was fastest growing areas again and have observed 1.74 percent growth in population. During the low economic growth period, the worst performing area in terms of population was Redcar and Cleveland, which had observed a shrinkage of population by -0.19 percent annually. Slough, another unitary authority that borders Greater London, was the observed the highest annual population growth, which was 1.72 percent (Milton Keynes was in the second place).

Overall, from the descriptive statistics, it is seen that English and Welsh housing markets were divided into at four clustered zones where housing markets dynamics acted in a distinctive ways: London and it surrounding areas, Wales, the northern England, and the rest of the country.

The first cluster would be London and its surrounding areas in East of England and South East regions, i.e. Windsor and Maidenhead, Essex, Hertfordshire, Kent, Surrey, West Sussex, Buckinghamshire, Wokingham, West Berkshire. These areas have similar house price returns and risk dynamics, relative to rest of the country comparable house price levels and house sales volumes, large populations and higher than country-average wages. In addition to that, the areas acted in a similar way during the high growth period and the low growth period. The division of England into South and North could be more of a 'South East' and 'the rest of country.' While, more distant from London areas, South West and East of England regions (e.g. Norfolk, Suffolk, Somerset, Devon, Dorset) had higher than average returns and risks compared to the rest of the country, yet economic and demographic conditions differed. Moreover, the split data analysis revealed the differences in the levels of risk and returns in high growth period and low growth period.

The second cluster was concentrated in Wales. The region was very distinct in many ways from the rest of the country. It has significantly lower population, lower population density, and employee compensations are significantly lower compared to the average in the country. While, in terms of housing markets, the sales volumes were distinctively lower even when accounted for population, the returns and average house prices in the coastal parts of Wales (e.g. Gwynedd, Flintshire, Ceredigion, Pembrokeshire) were comparable to the middle and north of England. Yet the south of Wales stood out as a small cluster of lower house prices and lower returns (e.g. Blaenau Gwent, Caerphilly, Rhondda Cynon Taff, Merthyr Tydfil). This was expected, taking into account the labour market in the area, while resort homes and second homes-buyers possibly fostered the coastal areas.

Additionally, all risk factors indicated it as a cluster of risky housing markets, thus distinguishing Wales from the other regions. It is interesting that the region, except for the coastal areas, have maintained a high risk in the first part of analysed period and in the second.

The third zone falls under North West and North East regions. It has relatively high population, yet density is not even and varies from large counties with lower density (e.g. North Yorkshire, Cumbria, Northumberland) to densely populated metropolitan areas (e.g. Middlesbrough, Blackpool, Hampshire, Merseyside, Tyne and Wear). Moreover, the region has slightly higher unemployment rate and lower wages compared to the rest of the country. The housing market had medium and below medium returns, lower house prices, medium risk, and house sales volume and liquidity. All this distinguished the region from the rest of the group.

The fourth zone was the rest of the country, which included Yorkshire and the Humber, East Midland, West Midlands, and South West regions. The areas construct an imaginative half-circle around London and neighbouring areas. Its demographic, economic, and housing market measures are also somewhere in between London and more peripheral areas. Capital returns, house prices, risks, population densities, Jobseeker's allowance claimant rates, and compensation for employment were around average, with slightly higher numbers in the south. On the other hand, this group of areas is spread mostly geographically and appeared to be the least homogeneous.

Finally, the splitting the data set reveals interesting patterns. In the first period of high growth, all the ratios were more scattered across the country. Peripheral areas, especially the ones near the coastline and in counties or unitary authorities that have lower house price level and lower wages, observed high returns. During the second period of slow growth period, areas with similar return and risk levels appeared to be much more clustered and seemed to coincide with labour market conditions.

3. Correlation analysis

To understand the relationships among the variables, Pearson correlation coefficients were calculated for the variables (table 6). Pearson correlation coefficients show that returns were highly related with house price levels (0.81), employment compensations (0.54), and liquidity (0.50), but are oppositely related to unemployment (-0.57) and returns volatility (-0.53). Interestingly, that correlation coefficient between returns and population, density, and volume are relatively low - respectively 0.27, 0.14 and 0.32. Furthermore, house price returns were less correlated with the other variables during the high growth period from 1997 to 2007. Correlations coefficients with house price levels and liquidity were lower more than twice, respectively 0.37 and 0.24. Returns and employment compensations were not correlated at all (0.03), while opposite correlations also decreased in size significantly (unemployment to -0.29 and volatility to -0.31). Accordingly, during the low growth period, correlation coefficients were higher compared to the coefficients for the total period. Yet the differences were of much lower magnitude as the difference between complete period and the high growth period coefficients. The most significant change was an increase in correlation between returns and hourly pay to 0.72.

An inverse correlation between the returns and volatility is rather unconventional because, according to Modern portfolio theory (Markowitz, 1952), riskier investment assets should earn higher returns as investors should be compensated for risk. However, the analysed data indicates that higher volatility in English and Welsh housing markets is related to lower returns (figure 28).

Returns volatility relatively well correlates with unemployment (0.51) and oppositely correlates with house sales per population (-0.61), house price level (-0.53), house sales volume (-0.39), and population (-0.35), yet not with population density (-0.07). Pearson correlation coefficients indicate that house price returns were more volatile in smaller housing markets. This could be due to thin market effect, which states that prices tend to be more volatile in less liquid markets, as a price mismatch between supply and demand in a particular moment is more likely in shallow markets. Interestingly that correlation coefficient among volatility and the rest of the variables have changed only marginally when different growth periods were considered.

Table 6. Correlations of the variables

1997-2014	Returns	Volatility	Idiosyncratic	Systematic	Idiosyncratic 2	Sharpe	House price	Wage	Unemployment	Sales	Population
Returns	1.00										
Volatility	-0.57	1.00									
Idiosyncratic	-0.49	0.95	1.00								
Systematic	0.26	-0.30	-0.36	1.00							
Idiosyncratic 2	0.55	-0.78	-0.58	0.24	1.00						
Sharpe	0.83	-0.62	-0.46	0.16	0.79	1.00					
House price	0.60	-0.48	-0.41	0.03	0.47	0.68	1.00				
Wage	-0.02	-0.13	-0.16	-0.19	0.02	0.03	0.06	1.00			
Unemployment	-0.58	0.37	0.33	-0.07	-0.30	-0.45	-0.21	-0.08	1.00		
Sales	-0.04	-0.18	-0.12	0.02	0.28	0.02	0.04	0.02	0.15	1.00	
Population	0.25	-0.32	-0.27	0.12	0.35	0.25	0.14	-0.04	0.02	0.57	1.00

1997-2007	Returns	Volatility	Idiosyncratic	Systematic	Idiosyncratic 2	Sharpe	House price	Wage	Unemployment	Sales	Population
Returns	1.00										
Volatility	-0.10	1.00									
Idiosyncratic	-0.10	0.94	1.00								
Systematic	0.09	0.22	0.10	1.00							
Idiosyncratic 2	0.15	-0.72	-0.54	0.01	1.00						
Sharpe	0.32	-0.80	-0.61	-0.35	0.85	1.00					
House price	0.03	-0.47	-0.38	-0.54	0.23	0.52	1.00				
Wage	0.00	-0.32	-0.31	-0.24	0.08	0.20	0.37	1.00			
Unemployment	-0.54	0.11	0.15	-0.11	-0.07	-0.20	-0.03	-0.03	1.00		
Sales	-0.09	-0.18	-0.12	0.03	0.35	0.16	0.04	0.03	0.20	1.00	
Population	0.29	-0.45	-0.40	-0.16	0.35	0.48	0.36	0.16	-0.08	-0.01	1.00

Correlations of the variables (continued).

2008-2014	Returns	Volatility	Idiosyncratic	Systematic	Idiosyncratic 2	Sharpe	House price	Wage	Unemployment	Sales	Population
Returns	1.00										
Volatility	-0.64	1.00									
Idiosyncratic	-0.53	0.94	1.00								
Systematic	0.55	-0.51	-0.54	1.00							
Idiosyncratic 2	0.64	-0.77	-0.56	0.43	1.00						
Sharpe	0.53	0.12	0.12	0.18	0.06	1.00					
House price	0.81	-0.52	-0.44	0.34	0.55	0.59	1.00				
Wage	-0.33	0.21	0.18	-0.27	-0.18	-0.12	-0.32	1.00			
Unemployment	-0.37	0.33	0.22	-0.14	-0.38	-0.12	-0.28	0.02	1.00		
Sales	0.00	-0.18	-0.12	0.01	0.26	-0.29	0.01	-0.01	-0.04	1.00	
Population	0.13	-0.19	-0.14	0.10	0.22	-0.13	0.03	-0.10	-0.13	0.62	1.00

Source: author’s calculations

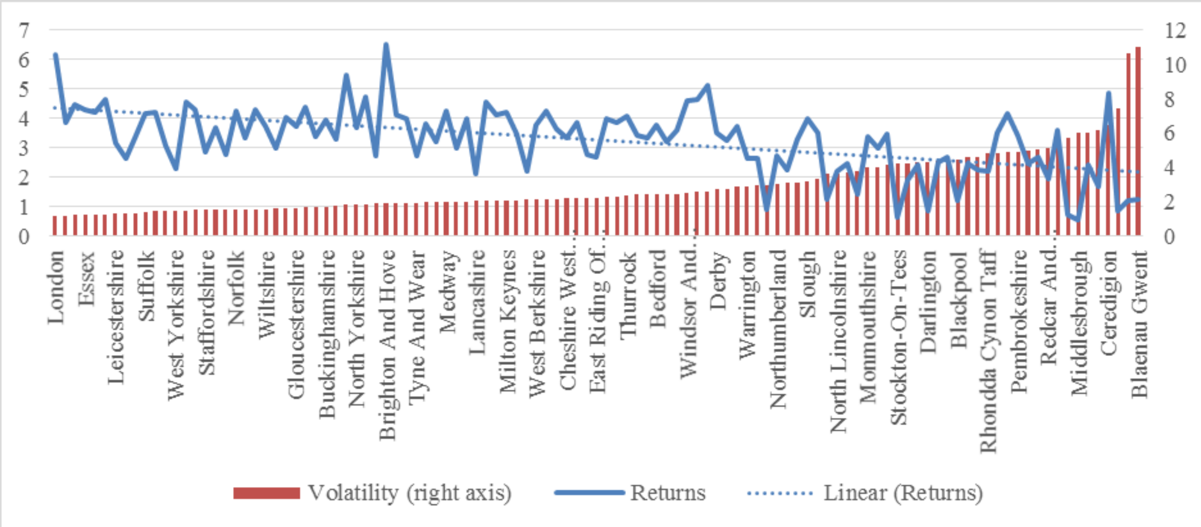


Figure 28. House price returns and volatilities in England and Wales

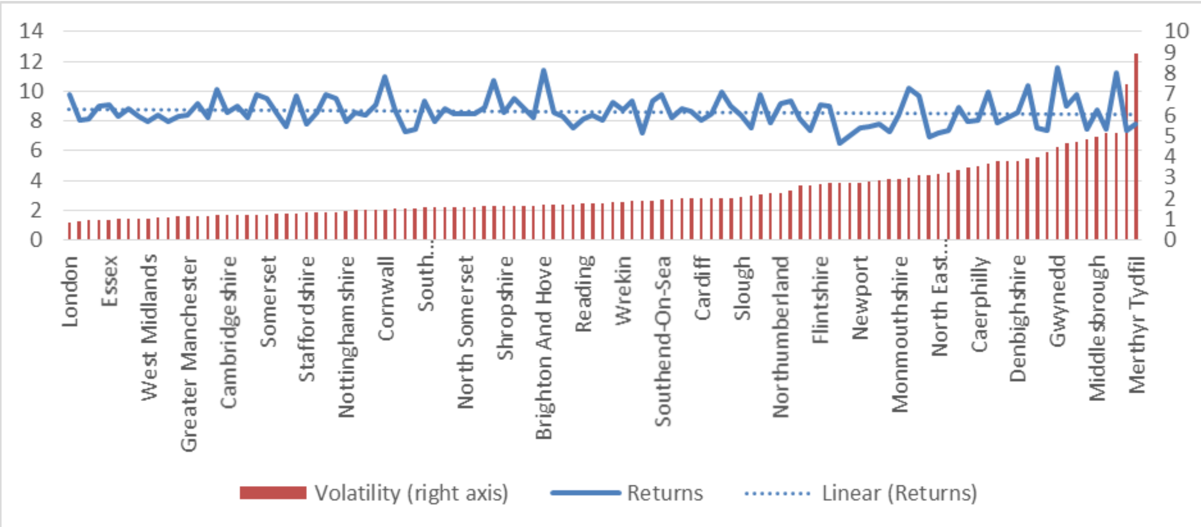


Figure 29. House price returns and volatilities in England and Wales (1997-2007)

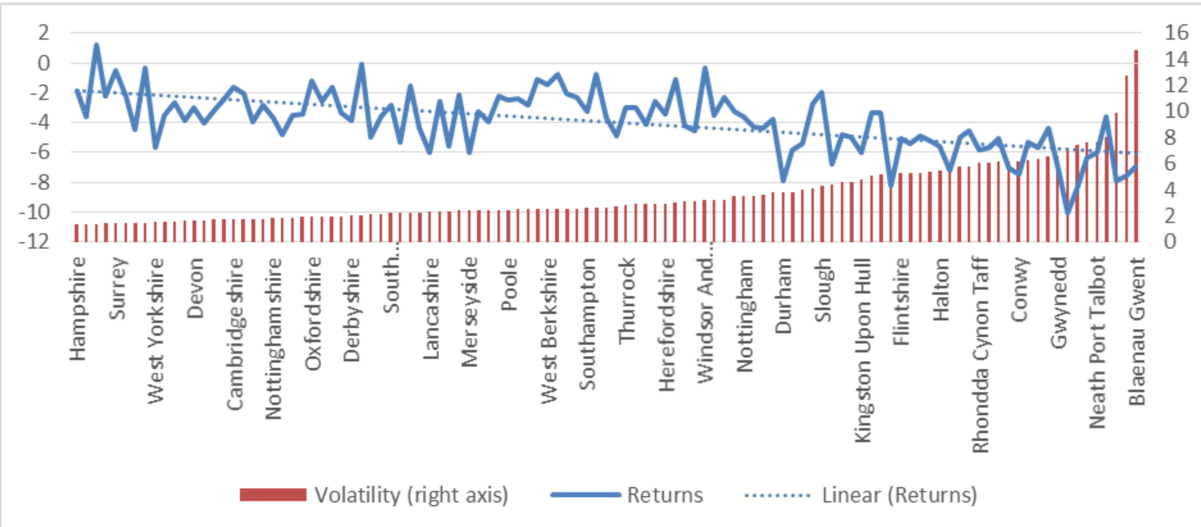


Figure 30. House price returns and volatilities in England and Wales (2008-2014)

Source: author’s calculations

Volume, population, and unemployment variables are very highly correlated. Correlation coefficients among the variables exceed 0.94, thus to prevent multicollinearity unemployment and population variables were not included in regression analysis in later sections). Volume variable was left instead of others because the data behind it is of better and more trustable quality.

4. Summary of the chapter

English and Welsh housing market experienced a long lasting housing market growth. The housing market growth was driven by favourable economic and social conditions and was led by London. More distant areas in the north and west have shown less strong housing market growth. The only house price decline in twenty years was caused by the global financial crisis. However, the market did not last to pick up a growth again a few years after the crisis. The descriptive statistical analysis indicated that English and Welsh housing markets could be divided into at a several clustered zones where housing markets dynamics acted in a distinctive ways: London and it surrounding areas, Wales, the northern England, and the rest of the country.

VI. Analysis of housing returns in England and Wales

The following chapter presents result of the regression analysis of the returns in English and Welsh housing market. In the first section, findings of the linear regression analysis are presented. In the second section, the results of spatial diagnostics and spatial regression analysis are provided. In the third section, the direct and indirect spatial impacts were calculated. In the fourth section, the analysis was repeated for two separate periods to assess robustness of the results. In the final section, summary of the chapter was provided.

1. Linear regression analysis

The returns were analysed at first, performing multiple linear regressions with fundamental factors that should describe differences of the returns in English and Welsh housing markets. We suspected that differences in housing markets' returns among the areas should be influenced by economic and labour conditions (e.g. unemployment, wages), demographic characteristics of the area (e.g. population), housing market conditions (e.g. house sales volume), and attractive locations (e.g. prime locations versus subprime, which could be captured by a price level). These influences on housing markets were intend to capture with house sales volumes, population, unemployment, employee compensation, and house prices level. Then risk variables were added to check whether they would provide any additional information.

Regression variables were checked for multicollinearity, using variance inflation factor (VIF) coefficients (table 7). If VIF coefficient of a variable was higher than five, which indicates that variables are correlated with the other independent variables, then one of the correlated variables was excluded from the regression.

The first multiple regression model (Model I) explains average return variation among the areas relatively well. The adjusted coefficient of determination of the model 0.63. The residuals of the regression are homoscedastic. Breusch-Pagan test for heteroscedasticity returned insignificant value (coefficient = 5.99, p-value = 0.31), as well as non-constant variance score test did (chi-square = 1.08, p-value = 0.30). However, unexpectedly, employee compensation coefficient was negative and insignificant, thus it was removed from the model and the regression was performed again.

Table 7. Multicollinearity test

VIF Coefficients	Model I	Model II	Model III	Model IV	Model V	Model VI
Price level	1.07	1.07	1.30	1.07	1.21	1.30
Unemployment	1.08	1.08	1.22	1.08	1.18	1.18
Wage	1.02	1.51	1.60	1.54	1.58	1.57
Population	1.52	1.52	1.53	1.52	1.52	1.58
Sales	1.53				1.39	
Volatility			1.62			
Systematic				1.02		
Idiosyncratic					1.39	
Idiosyncratic 2						1.61

Source: author's calculations

The second multiple regression model (Model II) explains average return variation among the areas with the same goodness. The adjusted coefficient of determination of the model 0.63. Yet the models efficiency marginally increased. Akaike information criterion (AIC) was marginally lower compared to the Model I. There were no insignificant independent variables at a five percent level. Constant was insignificant at ten percent level. The model also met the regression criteria of residuals homoscedasticity, as Breusch-Pagan test for heteroscedasticity returned insignificant value (coefficient = 5.07, p-value = 0.28). Non-constant variance score test also suggested the same result (chi-square = 0.83, p-value = 0.36). This model will serve as a benchmark in comparing the other models.

Table 8. Multiple Regression Results

	Returns					
	Model I	Model II	Model III	Model IV	Model V	Model VI
Price level	0.23***	0.23***	0.20***	0.23***	0.21***	0.19***
	p = 0.00	p = 0.00	p = 0.0000	p = 0.00	p = 0.00	p = 0.00
Unemployment	-0.66***	-0.65***	-0.57***	-0.63***	-0.60***	-0.57***
	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00
Wage	-0.18					
	p = 0.25					
Population	0.43***	0.44***	0.38***	0.40***	0.40***	0.38***
	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00
House sales e-04	-3.70**	-3.85**	-4.20**	-3.58**	-3.93**	-4.89***
	p = 0.05	p = 0.04	p = 0.03	p = 0.05	p = 0.04	p = 0.01
Volatility			-0.12**			
			p = 0.02			
Systematic				1.90***		
				p = 0.00		
Idiosyncratic					-0.01*	
					p = 0.08	
Idiosyncratic 2						1.27***
						p = 0.00
Constant	-0.32	-0.47	0.40	-2.23***	-0.07	-0.25
	p = 0.33	p = 0.13	p = 0.39	p = 0.00	p = 0.85	p = 0.42
N	109	109	109	109	109	109
R^2	0.63	0.63	0.65	0.66	0.64	0.66
Adjusted R^2	0.61	0.61	0.63	0.65	0.62	0.64
AIC	243.16	242.60	238.38	233.96	241.26	235.80

Note: ***p < .01; **p < .05; *p < .1

Source: author’s calculations

Model II coefficient for house price level, the rate of Jobseeker's allowance claimants, population, house sales volume were statistically significant in explaining housing returns variation at five percent level.

The results from benchmark model shows that the housing returns were negatively significantly related with the house sales volume, yet the impact was of a small scale. An increase in average house sales volume by one percent could lead to a decrease in house price returns by -3.85 percent. The negative sign of the house sales volume was unexpected. Higher house sales are usually related with raising house prices, because house sales represents economic environment in the market, not only in terms of housing but also in terms of economic development and population development (which was also partly visible from high correlation coefficient between house sales and population). Also, homeowners tend to resist selling houses and developers could be less motivated to construct new ones if prices are decreasing. Krainer (2001) showed that homeowners are resisting accepting a price that is below what they have paid themselves, thus house sales volumes are fluctuating with prices. Also, decreasing could decrease a possible down payment for the next house for not-first-time buyers (see Benito, 2006; Stein, 1995).

On the other hand, cross area comparison eliminates macroeconomic impacts to the returns (e.g. interest rates, inflation, homebuyers’ confidence, mortgage availability). Economic and demographic characteristics of the local area were controlled by other variables. Thus, higher volume sales could be negatively related with returns because of higher supply of houses in the market. So, an increase in house sales could be related with changing characteristics of the area, as economic houses are traded more frequently. Additionally, the volume and price characteristic depends on the existing rent market. Krainer (2001) showed that houses’ sales volume and prices should be less related in well-functioning rent market because the loses of not selling in a “hot market” are lower.

Jobseeker's allowance claimant rate, as expected, is negatively significantly related to housing market returns. One percent increase in claimant rate is associated with -0.65 percent lower annual house price returns. The coefficient captures the impact of economic environment across the counties and unitary authorities. Higher employment not only means that people would have money to spend on housing, but also to make the area more attractive for Jobseekers from other areas to move in, and vice versus. Böheim and Taylor (1999) noted that around 10 percent of individuals actually move house every year, and the biggest incentive to move is unemployment.

Population was positively significantly related with the housing market returns. An increase in population by one percent was related to 0.44 percent higher house price returns in the area. People are the consumers of housing; thus, by including the population variable, it was expected to capture an increased demand for housing. Also, higher population density is related to bigger scarcity of available land and housing in the area; thus, the level of population does have an impact on supply. Consequently, the positive coefficient was expected and it is very much in line with many other housing studies (see Meen 2012).

House price level was also significant and has a positive coefficient. A 10,000 pound higher house price level (accounted at the beginning of the period in order to avoid endogeneity) was associated to 0.23 percent higher returns. The variable intends to capture the effect when homebuyers are willing to pay relatively more for houses in attractive areas that have already tight supply. A significant positive coefficient of the variable could indicate English and Welsh housing market polarization. House prices were rising more rapidly in already expensive areas; thus, there was an increasing gap among expensive areas, which had expensive homes, and poor areas, where homes are cheaper. Gyourko, Mayer, and Sinai (2006) showed that some areas have higher house price returns, which were the result of a desire to move to the areas and tight supply constraints. As a consequence of the two, the areas became available for the richest segment of households.

The benchmark model was complemented with risk indicators in order to find out what the relationship between the returns and risk is, and whether risk indicators could provide additional information in explaining the return differences among the areas. The additional models have rather interesting results. Three of the four additional risk factors were significant at five percent level and one at ten percent level. All of them increased the explanatory power of the benchmark model, yet not by a large margin. Also, all of the models were slightly more efficient compared to the benchmark model.

The coefficient of volatility was significant at five percent level and negative (Model III). One standard deviation higher volatility was associated with -0.12 percent lower returns in the area. This is in line what correlation analysis was indicating.

Systematic risk has a positive significant at five percent level impact on returns (Model IV). One beta higher systematic risk was associated with 1.90 percent higher returns in the area. The sign is expected but the impact was rather small. As one beta is equal to market risk, thus one additional beta would indicate returns sensitivity twice to that of a market.

Idiosyncratic risk has a negative sign and is significant at ten percent level (Model V). The negative sign indicate lower returns of the areas with more influential local housing market factors and less correlated with national housing market. This is confirmed by idiosyncratic risk 2, which was positive and significant at five percent level (Model VI).

It is not yet completely clear why standard deviation is negatively related with the returns, yet it seems to have been highly significant. It could be that volatility may be positively related to other negative housing market characteristics - for example liquidity or thin market effect. Moreover, houses are primarily consumptions good, not an investment asset; thus, Modern portfolio theory (Markowitz, 1952) may not be directly applicable. Furthermore, returns from rent are not included in the assessment, thus it could have disturbed the analysis. Including rents in the returns may alter the results. On the other hand, an average compensation per employee for work, which could be a proxy for an average rent in the area, also negatively correlates with the volatility. Finally, the observed period has a long streak of house price growth, which could distort results. Taking longer periods into account or checking the robustness of the results may be necessary to support the results. In addition, the analysed data appears to have two very different periods of high and low growth, which may have an effect on the coefficients.

2. Spatial diagnostics and spatial regression analysis

We proceed to examine the returns using spatial regression analysis. In the beginning, spatial diagnostics must be performed to find whether returns of house prices have spatial patterns. For this purpose, Global Moran's I coefficient was calculated and plotted (figure 31).

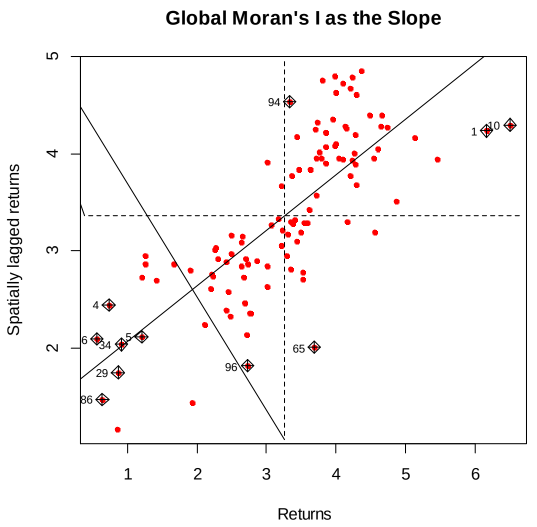


Figure 31. Global Moran's for the housing returns

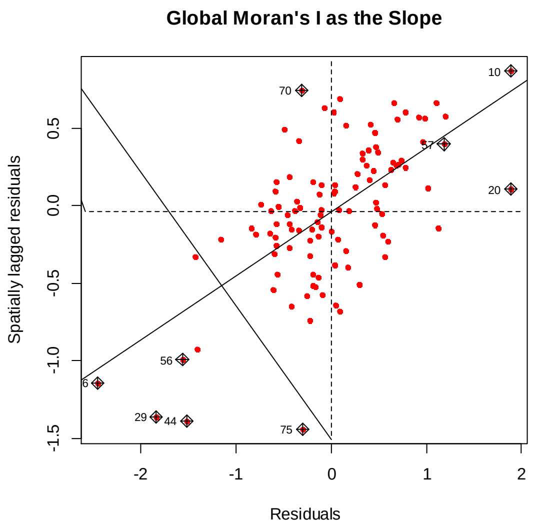


Figure 32. Global Moran's for the residuals of the benchmark regression

Source: author's calculations

Table 9. Lagrange Multiplier diagnostics for spatial model

Model	Coef.	p-value
Spatial Error	35.50	0.00
Spatial Lag	36.69	0.00
Robust Spatial Error	5.16	0.02
Robust Spatial Lag	6.34	0.01

Source: author's calculations

Visual data points representing house price returns are distributed along the line going from a bottom left to a top right; this indicates that data is positively spatially correlated. The estimated Global Moran's I coefficient of 0.57 shows strong spatial correlation and is statistically significant at five percent level (p-value = 0.00). It is also necessary to check whether spatial correlation among the housing market returns could not be captured by independent variables. Thus, additionally, Global Moran's coefficient was estimated for residuals of the benchmark linear regression. From the plot (figure 32), it is evident that the residuals are spatially correlated. The estimated coefficient is positive 0.41 and statistically significant at five percent level (p-value = 0.00). The existing spatial structure reveals that spatial models for the estimation of average returns could be performed (more about Moran's I, please see: Cliff & Ord, 1981).

In order to identify the most appropriate spatial model, Lagrange multiplier test for spatial dependence was executed[11]. Both tests show spatial dependency of the data. Lagrange multiplier coefficient for spatial lag model is positive (39.94) and statistically significant at five percent level, while Lagrange multiplier coefficient for spatial error model is also positive (37.33) and statistically significant at five percent level. Robust Lagrange multiplier tests were performed to complement the results. The tests returns a positive (2.40) and significant coefficient for spatial error model at five percent level, while spatial lag model has positive (5.00) and statistically significant coefficient at five percent level. However, the lag model was marginally more significant in both tests; thus, this indicates that spatial lag model is more suited for the returns data.

The spatial analysis of the average returns is preceded by performing spatial lag regression. The first spatial model (Model I) is a spatial autoregressive model that includes all

[11] More about Lagrange multiplier diagnostics, please see Anselin (1988) and Anselin *et al.* (1996).

independent variables from the benchmark model (table 8). The results indicate that spatial residual autocorrelation was not eliminated by spatially lagged returns. Lagrange multiplier coefficient (4.65) was statistically significant at five percent level (p-value = 0.03). Yet, the efficiency of the model was highly improved by the spatial structure. AIC of the spatial lag model compared to linear model was considerably lower, respectively 202.47 and 242.6.

Further, to tackle the spatial autocorrelation, Spatial Durbin model was introduced. Spatial-Durbin model was estimated to check whether spatial dependence is caused by spill-over of explanatory and dependent variables. The spatial analysis of the average returns is preceded by performing spatial lag regression.

The first Spatial Durbin model (Model II) includes all independent variables from the benchmark model (table 10). The results indicate that spatial residual autocorrelation was eliminated by spatially lagged returns and spatially lagged explanatory variables. Lagrange multiplier coefficient (0.01) was statistically insignificant at ten percent level (p-value = 0.91). The efficiency of the model compared to spatial lag model was also improved. AIC of Spatial Durbin model compared to spatial autoregressive model decreased from 202.47 to 197.23. Moreover, house sales volume explanatory variable was no longer significant at ten percent level, thus it was removed from the model (also spatially lagged house sales variable was not significant at ten percent level).

The final spatial model variant (Model III) included house price level, unemployment, and population as explanatory variables. All of which were statistically significant at five percent level. The removal of house sales variable has increased models efficiency from 197.23 to 194.78. The model also includes the spatially lagged explanatory and independent variables.

Table 10. Spatial Regression Results

	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII
Price level	0.15***	0.14***	0.14***	0.11***	0.14***	0.12***	0.13***
	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00
Unemployment	-0.50***	-0.63***	-0.65***	-0.60***	-0.63***	-0.61***	-0.63***
	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00
Population	0.25***	0.24***	0.17**	0.13*	0.16**	0.14**	0.15*
	p = 0.01	p = 0.01	p = 0.02	p = 0.07	p = 0.03	p = 0.05	p = 0.06
House sales	-2.49*	-1.65					
	p = 0.09	p = 0.24					
Volatility				-0.11**			
				p = 0.02			
Systematic					1.40***		
					p = 0.00		
Idiosyncratic						-0.01**	
						p = 0.02	
Idiosyncratic 2							0.38
							p = 0.29
Lag Price level		-0.05	-0.05	-0.04	-0.03	-0.04	-0.05
		p = 0.24	p = 0.28	p = 0.41	p = 0.45	p = 0.39	p = 0.26
Lag Unemployment		0.43***	0.47***	0.49***	0.42***	0.49***	0.49***
		p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00
Lag Population		0.28	0.25	0.14	0.20	0.18	0.12
		p = 0.22	p = 0.26	p = 0.54	p = 0.35	p = 0.41	p = 0.64
Lag House sales		-0.65					
		p = 0.85					

Lag Volatility				0.07			
				p = 0.29			
Lag Systematic					1.58		
					p = 0.15		
Lag Idiosyncratic						0.01	
						p = 0.28	
Lag Idiosyncratic 2							0.14
							p = 0.78
Lag Returns	0.55^{***}	0.65^{***}	0.67^{***}	0.69^{***}	0.60^{***}	0.69^{***}	0.67^{***}
	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00
Constant	-1.14^{***}	-0.41	-0.39	0.03	-3.26^{***}	-0.17	-0.26
	p = 0.00	p = 0.21	p = 0.23	p = 0.96	p = 0.01	p = 0.70	p = 0.46
N	109	109	109	109	109	109	109
Log Likelihood	-94.23	-87.61	-88.39	-85.47	-82.73	-85.25	-87.62
Wald Test	70.67^{***}	66.27^{***}	74.14^{***}	83.39^{***}	51.31^{***}	85.70^{***}	71.88^{***}
LR Test	42.14^{***}	33.64^{***}	38.48^{***}	41.34^{***}	27.42^{***}	41.38^{***}	38.58^{***}
AIC	202.47	197.23	194.78	192.95	187.45	192.50	197.24

Note: $^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$

Source: author's calculations

House price level was positively significantly at five percent level related with higher house price returns. 10,000 pounds more expensive average house in the area meant that house price returns could be higher by 0.14 percent. Slightly less compared to linear model. Yet, higher house price levels in surrounding areas were not enough to have higher returns. The spatially lagged coefficient was negative and insignificant.

Unemployment was negatively significantly at five percent level related with higher house price returns. One percent increase in unemployment was related to 0.65 percent lower capital returns on houses, exactly the same impact as in a linear regression. However, unexpectedly, spatially lagged unemployment was significantly at five percent level positively related with the returns. One percent higher average unemployment rate in the neighbouring areas was related with 0.47 percent higher returns in the observed market. It is difficult to interpret the positive sign of the parameter. This could due to other unobserved variables that spatially lagged unemployment captures, e.g. segregation of richer and poorer areas.

Population was positively and significantly at five percent level related with returns. One percent increase in population was related with 0.17 percent higher returns in a housing market, which is almost three times lower impact compared to the coefficient obtained in the linear regression. Spatially lag population had a positive sign, yet it was statistically insignificant. One would expect that the population of the surrounding areas should have an influence, yet it could be captured by other spatially lagged variables, such as returns.

The coefficient of spatially lagged returns was positive and statistically significant at five percent level. One percent higher average neighbourly returns were associated with 0.67 percent higher returns in an observed area. This shows that house price returns spill over the other areas either due to commuting, sharing the common knowledge, experience similar characteristics, etc.

Model III was complemented with risk variables (Model IV, Model V, Model VI, and Model VII). The basic coefficients and their significance have changed only a little. However, the risk coefficient provided some additional information that resulted in a higher efficiency. It appears that spatial structure did not change the magnitude and significance of the risk variables. Only one risk variable was statistically not significant anymore. Statistical significance of the idiosyncratic 2 risk had diminished after introducing spatial structure. The rest of the risk variables had very comparable coefficients to that in a linear model.

To sum up, the spatial lag model appears to be superior to the linear model in explaining house price returns variation among the counties and unitary authorities in England and

Wales. The spatial structure considerably improves the efficiency of the models. However, spatial lag by itself failed to eliminate all the spatial autocorrelation in the data. The spatial structure of the data was captured by Spatial Durbin model, i.e. the spatial autoregressive model was complemented by spatially lagged explanatory variables. This has helped to eliminate spatial autocorrelation in the data. On the other hand, only one spatially lagged explanatory variable was statistically significant. The existing spatial lag suggests a possible diffusion process in the data. It is completely possible, considering all the socioeconomic processes that are happening in the housing markets.

Further, the statistically significant spatially lagged unemployment variable had an economic sign that contradicted immediate economic logic. Finally, introducing spatial structure in the model had reduced the impacts of some coefficients. In other words, the multiple linear regression model suggested that the effects of the explanatory variables were larger than they actually were, because it has not accounted for the returns' spill-over effect from the neighbouring areas.

3. Direct, indirect, and total spatial impacts

In order to better understand spatial relationships among the areas, spatial analysis is continued by decomposing the results of Spatial Durbin model into direct, indirect, and total spatial effects (more about direct and indirect impacts please see: LeSage & Pace, 2009). The measures of direct and indirect impacts are needed due to feedback loops among neighbours, which could have affected coefficients in the spatial autoregressive model. Spatial impacts are affecting neighbours, then return back and affect the area itself. The total impact could be decomposed into direct and indirect impacts. For the calculation of the impacts measures, a simulation of Markov chain Monte Carlo (MCMC) process with a sequence of 1,000 draws is used for sample distribution. After that, in order to see that the spatial coefficient remained within its valid interval, the simulated values of the coefficients were checked. All three impacts are presented in table 11.

Table 11. Impact measures

	Direct	p-value	Indirect	p-value	Total	p-value
Price level	0.14	0.00	0.12	0.19	0.27	0.00
Unemployment	-0.64	0.00	0.09	0.79	-0.55	0.11
Population	0.25	0.01	1.02	0.14	1.27	0.09

Source: author's calculations

A direct unemployment impact coefficient was negative and highly significant. One percent increase in unemployment was associated with -0.64 percent lower average house price returns. An indirect effect was positive and not significant. The total impact of unemployment was also not significant. This partly contradicts the results that were obtained by Spatial Durbin regression that indicated a significant influence of neighbouring counties and unitary authorities.

Population had a positive direct impact, which was significant at ten percent level. One percent larger population was associated with 0.25 percent direct impact on return in housing markets in an observed area. However, the indirect impact of population was statistically not significant at ten percent level, while the total impact was significant at ten percent level and was 1.27. The insignificance of indirect impact of population indicates that the there was no population spill-over effect on returns among neighbouring areas, which seems hard to believe, as commuting to work in neighbouring areas is a common practice. However, population coefficient overall has lower significance, thus it could be that other variables have captured its effect. Additionally, the same result was obtained in the spatial regression.

A 10,000 pound higher house price level had 0.14 percent significant direct impact on returns in the area. An indirect impact of the price level was statistically insignificant. A total impact of the house price level was 0.27, which is almost twice as large compared to the coefficient in the spatial model, and was statistically significant at five percent level. A larger total impact is caused by spill-over among the areas and indirect spatial response to the changes in explanatory variables.

Overall, the direct impacts were marginally lower compared to the coefficients estimated by a spatial model before. The total impacts of the explanatory variables were larger, yet only one of them was statistically significant.

4. Robustness check for housing price returns analysis

In this section of the study, regression analyses were performed on two sets of data. The data sets were produced by splitting complete data set into two periods. The analysis is going to serve in observing whether the explanatory variables are permanent and hold out in time, or whether the significance of the variables was influenced by events in one particular period. In addition to performing a robustness test for the models produced in the previous sections, this analysis is also relevant because it examines opposite stages of the housing market. The first period lasts from 1997 to 2007 and the second period lasts from 2008 to 2014. The two periods, as was mentioned in the diagnostic analysis section, have very different qualities. The qualities differ because the first data set covers uninterrupted period of high economic growth and raising house prices. The second period covers the biggest financial crisis of the century, large reduction in house prices, and economic stagnation after.

The analysis was executed based on Model II linear model and Model III Spatial Durbin model. Spatial diagnostics was also carried out to examine whether the spatial structure has changed over time. The results indicate that the fit of models was worse for the high growth period, yet better for the low growth period. The explanatory power of linear model was 46 percent lower for the first data set, compared to how it fitted for complete data set. Adjusted R squared coefficients were respectively 0.33 and 0.61. However, the goodness of fit for the second data set was 0.68, which was 12 percent more. Furthermore, two of the four explanatory variables were not statistically significant anymore in the first period, while in the second period, one variable was had lost the statistical significance. In both periods, all the variables had VIF coefficient that were lower than five (table 13), which indicates that there was no multicollinearity problem among the explanatory variables.

Table 12. Regression Results

	High growth period		Low growth period	
	OLS Model II	Spatial- Durbin Model III	OLS Model II	Spatial-Durbin Model III
Price level	-0.03	-0.03	0.26^{***}	0.17^{***}
	p = 0.33	p = 0.50	p = 0.00	p = 0.00
Unemployment	-0.43^{***}	-0.35^{***}	-0.12^{**}	-0.14^{***}
	p = 0.00	p = 0.00	p = 0.02	p = 0.00
Population	0.67^{***}	0.37^{*}	0.23^{**}	0.07
	p = 0.00	p = 0.08	p = 0.03	p = 0.25
House sales	0.38		-5.87	
	p = 0.80		p = 0.12	
Lag Price level		0.01		-0.03
		p = 0.91		p = 0.37
Lag Unemployment		0.17		0.23^{***}
		p = 0.21		p = 0.00
Lag Population		0.33		0.37
		p = 0.35		p = 0.11
Lag Returns		0.50^{***}		0.61^{***}
		p = 0.00		p = 0.00
Constant	6.26^{***}	3.02^{***}	-9.09^{***}	-4.91^{***}
	p = 0.00	p = 0.00	p = 0.00	p = 0.00
N	109	109	109	109
R^2	0.35		0.69	
Adjusted R^2	0.33		0.68	
Log Likelihood		-118.8		-138.33
Wald Test		26.90^{***}		54.39^{***}
LR Test		16.20^{***}		35.11^{***}
AIC	269.34	255.6	345.68	294.65

Note: $^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$

Source: author's calculations

The results from the split data indicate a lower impact of house sales volume. While overall coefficient was -3.70 and was significant at five percent level, the coefficient for the high growth period was only 0.38 and was highly insignificant. It appears that the significance of the house sales volume variable could be driven by the second period. Yet, in the second period, the variable was also insignificant at ten percent level and the coefficient was -5.87. The importance of the house sales value is discussable. An insignificance of the house sales volume during the first period could be caused by raising housing prices in the peripheral areas that had small housing markets. While during the second period, the crisis caused house price increases (or a price decline of a smaller scale) in larger markets with stronger economic fundaments for house price increase. In other terms, the insignificance could have been caused by "homebuyers fly to safety" as the equivalent effect in commercial real estate market or finances. However, it was also seen that house sales had lost the statistical significance in a model for complete period, when spatial structure of the model was introduced.

Table 13. Multicollinearities test: VIF coefficients

	1997-2007	2007-2014
Price level	1.16	1.08
Unemployment	1.05	1.11
Population	1.15	1.66
House sales	1.05	1.63

Source: author's calculations

From 1997 to 2007, the impact of unemployment on housing market returns was about one third smaller compared with a coefficient for a complete data. Jobseeker's allowance claimant's rate had a negative coefficient of -0.43, which was significant at five percent level. Interestingly, from 2008 to 2014 the coefficient was negative, yet several times smaller and insignificant at five percent level. This is interesting as it shows that the impact of unemployment decreased in a harsher economic environment. It could be that in high growth period, higher unemployment was indicating only most troublesome areas. However, in a period of economic decline when the unemployment had become more common, the importance of it in distinguishing the better and worse performing markets decreased. Also, the effect could be caused by larger unemployment rates in more populated areas, which seems to have higher long-term growth. Thus, it could make sense to analyse metropolitan and rural or otherwise less populated areas separately. Finally, people who had lost their jobs could have moved to more perspective areas in pursuit of finding employment, thus balancing unemployment ratio among the areas.

The variable of population was positive and significant at five percent level in both periods. It seems that the variable is relatively stable, yet the coefficient varies greatly. For the high growth period, it was 0.67 and was larger compared to 0.44 gotten for the complete period. During low growth period, it had shrunk to 0.23. The significance and positive signs are expected and have economic logic. A decrease of the coefficient in the second period could be caused by overall smaller variation of returns among the counties. As it was noted in the descriptive analysis, the range of returns was smaller in the second period.

The coefficient of house price level was negative (0.29) but not significant in explaining housing market returns variation during the high growth period. For the second period, it was positive and significant at five percent level. In a low growth environment, the impact of house price level was comparable to what it was for the complete period. The coefficients were respectively 0.26 and 0.23. The insignificance of the coefficient in the first period and its significance in the second again could be due homebuyers “fly to safety,” when interest in less attractive areas decreased in declining market.

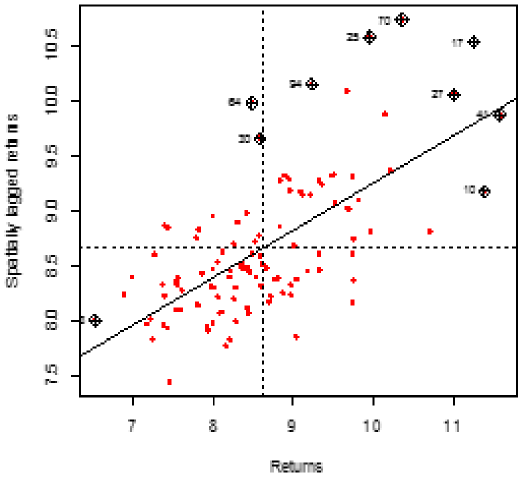
Overall, it appears that population and unemployment that represent two major fundamentals, economics and demographics, hold the significance when they are applied on a split data and different economic environment. The house sales do not seem to be significant in either of the periods, thus it could be that variable’s statistical significance was accidental. The price level was significant in the second period, yet not in the first, which could be due to buyers being more selective in a declining period and thus picking only most attractive locations, even if they are already expensive. However, please mind that the significance of some variables may change if some insignificant variables would be removed.

We further analysed the spatial structure in two different periods. As in the section, spatial diagnostics was performed to find whether returns of house prices have spatial patterns. For this purpose, Global Moran’s I coefficient was calculated and plotted in both periods (figure 33 and figure 34).

For 1997-2007 period, visual data points representing house price returns were distributed along the lines going from a bottom left to a top right in both periods; this indicates that data was positively spatially correlated. Global Moran's I coefficient was 0.43 and is statistically significant at five percent level. For 2007-2014, the coefficient was 0.67 and it was significant at five percent level. Thus, housing market returns in both periods show strong spatial correlations.

Global Moran’s I was also calculated for the residuals of the linear models. This was done in order to check whether spatial correlation among the housing market returns could be captured by independent variables. If it was spatial correlation that could be captured, then spatial structure of the models could be avoided. From the plots of the returns in high growth period and low growth period (figure 35 and figure 36), it is seen that the residuals were spatially correlated. Global Moran’s I coefficient in the first period was positive (0.26) and statistically significant at five percent level. For the second period, it was also positive (0.39) and statistically significant at five percent level. Thus, it is evident that independent variables did not capture spatial effects.

We also check whether it would be appropriate to use the same spatial model structure for different periods. As in previous section likewise, in order to identify the most appropriate spatial model, Lagrange multiplier test for spatial dependence was executed (Table 14).



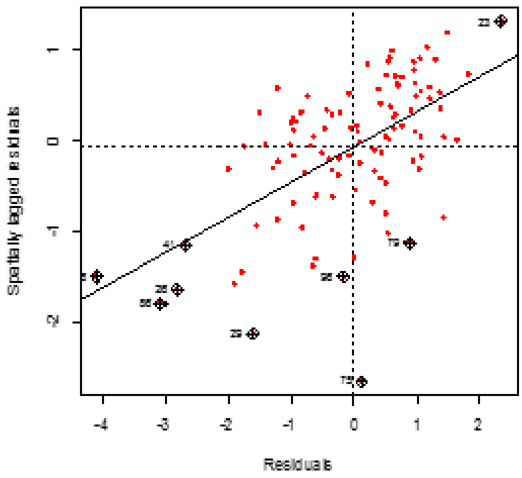
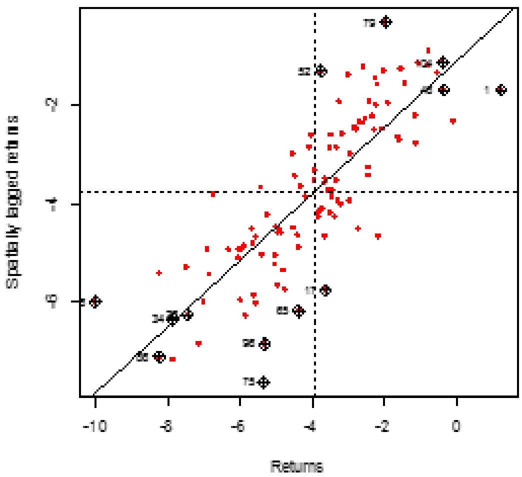


Figure 33. Global Moran's I as the slope. Returns (1997-2007)

Figure 34. Global Moran's I as the slope. Residuals of the regression (1997-2007)

Source: author's calculations



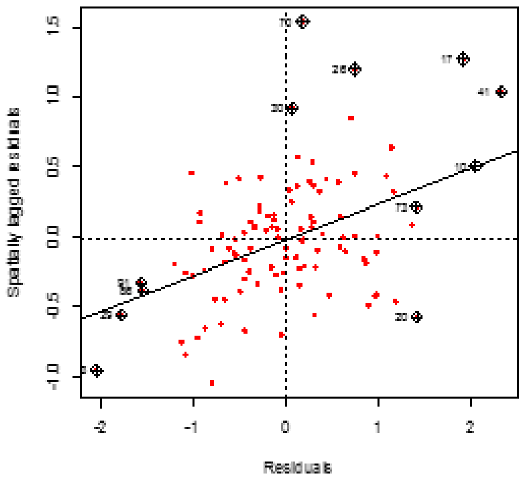


Figure 35. Global Moran's I as the slope. Returns (2008-2014)

Figure 36. Global Moran's I as the slope. Residuals of the regression (2008-2014)

Source: author's calculations

Table 14. Lagrange Multiplier test for spatial dependence

	1997-2007		2008-2014	
	Coef.	p-value	Coef.	p-value
Spatial Error	13.54	0.00	31.57	0.00
Spatial Lag	14.58	0.00	39.31	0.00
Robust Spatial Error	0.22	0.64	4.04	0.04
Robust Spatial Lag	1.26	0.26	11.80	0.00

Source: author's calculations

Both tests for both periods indicate spatial dependency of the data. For the high growth period, Lagrange multiplier coefficient for spatial lag model was positive (14.58) and statistically significant at five percent level, while Lagrange multiplier coefficient for spatial error model was also positive (39.31) and statistically significant at five percent level. Robust Lagrange multiplier tests were performed to complement the results. The tests return a positive (0.22), yet statistically not significant coefficient for spatial error model. Spatial lag model had also positive (1.26) and statistically insignificant coefficient, yet its significance was relatively higher. This indicates that spatial lag model was superior in analysing returns in the first period.

For the low growth period, Lagrange multiplier coefficient for spatial lag model was positive (39.31) and statistically significant at five percent level, while Lagrange multiplier coefficient for spatial error model was positive (31.57) and statistically significant at five percent level. The robust tests show positive (4.04) and statistically significant coefficient for spatial error model, and positive (11.80) and statistically significant coefficient for spatial lag model. However, the significance is marginally better for the spatial lag model. This indicates that spatial error dependence disappears if lagged dependent variable is included for the model applied on the second data set. Consequently, spatial lag model is suited for the average returns data in both periods.

Introducing spatial structure in the models on the split data had positive impacts on the efficiency in explaining housing market returns. In the first period, the AIC coefficient decreased from 269.8 in a linear model to 25.6 in spatial autoregressive model. In the second period, AIC coefficient has changed from 294.65 to 327.77. Thus, in both cases, the improvements were relatively high. Also, the spatial structure of the models had eliminated the spatial autocorrelation in the returns data in both periods. For the high growth period, Spatial Durbin model Lagrange multiplier test returned an insignificant coefficient at ten percent level (p-value = 0.50). For the low growth period, the coefficient was also highly insignificant (p-value = 0.99).

The coefficients of spatially lagged returns were highly significant in both cases. For the high growth period the coefficient was 0.50 (p-value = 0.00); for the low growth period, the coefficient was 0.61 (p-value = 0.00.) Both coefficients are comparable, yet smaller than the spatially lagged returns coefficient from the model on the complete data set (0.67); thus, returns spill-over also proved to be a consistent explanatory variable.

Spatially lag explanatory variables were mostly insignificant at ten percent level in both periods, with the exception of unemployment, which was positive and significant at five percent level in the second period. The relationship of spatially lagged unemployment in the second period could have influenced statistical significance in the model for the complete period, though it is difficult to explain why the sign is positive.

Overall, spatial autoregressive structure of the equation compared to the linear improved the model in both periods. The spatially lagged returns had been highly significant and positive in both cases. Thus, as the significance of some other variables changed when applied in different periods, the remaining sign and significance of spatially lagged returns could indicate that spatial structure is the a robust explanatory factor.

5. Summary of the chapter

The spatial lag structure of the data indicated an existing diffusion process among the housing areas. Considering all the socioeconomic processes that could be happening in the housing markets, this finding is completely expected. Further, the statistically significant spatially lagged unemployment variable had an economic sign that contradicted immediate economic logic. Finally, introducing spatial structure in the model had reduced the impacts of some coefficients. In other words, the multiple linear regression model suggested that the effects of the explanatory variables were larger than they actually were, because it has not accounted for the returns' spill-over effect from the neighbouring areas.

Additionally, the direct impacts of the returns explanatory factors were marginally lower compared to the coefficients estimated by a spatial model. Moreover, spatial autoregressive structure of the equation compared to the linear improved the model in both periods. The spatially lagged returns had been highly significant and positive in both cases. Thus, as the significance of some other variables changed when applied in different periods, the remaining sign and significance of spatially lagged returns could indicate that spatial structure is the a robust explanatory factor.

Overall, the spatial lag model appears to improve the linear model in explaining house price returns variation among the counties and unitary authorities in England and Wales. The spatial structure considerably improves the efficiency of the models, reduces coefficient bias, and helps not to violate regression assumptions.

VII. Analysis of volatility in England and Wales

The following chapter presents result of the regression analysis of the return volatilities in English and Welsh housing market. In the first section, findings of the linear regression analysis are presented. In the second section, the results of spatial diagnostics and spatial regression analysis are provided. In the third section, the direct and indirect spatial impacts were calculated. In the fourth section, the analysis was repeated for two separate periods to assess robustness of the results. In the final section, summary of the chapter was provided.

1. Linear regression analysis

The volatilities of house price returns are analysed in the similar style as the returns themselves. Regressions with fundamental factors that should describe differences of the returns volatilities in English and Welsh housing markets were performed. We suspected that volatilities could be explained by similar variables as returns. The insignificant or high correlated factors with other variables that caused multicollinearity problems were excluded from the model.

The first multiple regression model (Model I) explains close to 0.36 percent average return volatility variation across England and Wales. The model includes five explanatory variables representing house price level in the area, unemployment, population, house sales volume, and employment compensation. Once again, employment compensation and house sales volume fail in significantly describing housing markets. The two variables were excluded and the regression was calculated again. Model III describes the return volatility with the same fit; the adjusted R squared was equal to 0.36. However, the efficiency of the model has slightly increased (from 393.85 to 392.09). All explanatory variables and constant were significant at five percent level. This model will serve as a benchmark in spatial model comparison.

Table 15. Multiple Regression Results of volatilities

	OLS			Spatial autoregressive
	Model I	Model II	Model III	Model IV
Price level	-0.28***	-0.28***	-0.29***	-0.19***
	p = 0.00	p = 0.00	p = 0.00	p = 0.00
Unemployment	0.65***	0.63***	0.64***	0.51***
	p = 0.00	p = 0.00	p = 0.00	p = 0.00
Population	-0.60**	-0.70***	-0.68***	-0.42***
	p = 0.02	p = 0.00	p = 0.00	p = 0.01
House sales	-2.74			
	p = 0.46			
Wage	-0.37	-0.39		
	p = 0.24	p = 0.21		
Lag Volatility				0.57***
				p = 0.00
Constant	7.66***	7.65***	7.34***	4.57***
	p = 0.00	p = 0.00	p = 0.00	p = 0.00
N	109	109	109	109
R^2	0.39	0.39	0.38	
Adjusted R^2	0.36	0.36	0.36	
Log Likelihood				-173.35
Wald Test				52.57***
LR Test				35.38***
AIC	393.85	392.43	392.09	358.71

Note: ***p < .01; **p < .05; *p < .1

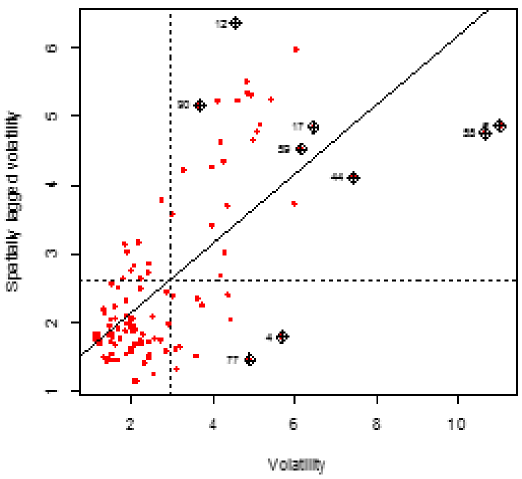
Source: author's calculations

Unemployment rate was a statistically significant and positive explanatory variable. One percent higher unemployment rate was associated with 0.64 standard deviation higher volatility of house price returns. If volatility represents riskier assets, then it makes economic sense, as higher unemployment indicates potentially lower cash flows in housing market in the future and, thus, is not a desirable characteristic of a market from an investor's perspective. Moreover, it could be that higher unemployment indicates weaker economic environment and, consequently, less stable rents or other expenses allocated for housing. Rent that is more volatile would make prices more volatile as well; however, this is only assumption, because the study does not have rent data, which would confirm the assumption.

Population was statistically significantly negatively correlated with the volatility variable. One percent higher population in an area was related to -0.68 standard deviations lower volatility of the housing returns in the area. This suggests that more intensively populated counties tend to have less volatile housing markets. The sign of the coefficient is rather unexpected, because population increase is related to the slope of the demand curve, and steeper slopes should indicate larger sensitivity price to the changes in housing supply. The high significance of the variable could be explained that volume variable does not capture all housing market size effect for the volatility. Growing population would indicate a lower thin market effect, which cause higher price volatility due to absence of buyers and seller at a particular moment.

In total, it appears that volatility is related to the size of the house price level, demographics, and economic conditions of the area. Price level, population, and unemployment were the only significant variables at five percent level. Also, all significant coefficients appear to be in line with the economic expectations. Still, the explanatory power of the model is not very high, thus there should be other explanatory variables that could improve explanation of the volatile areas.

2. Spatial diagnostics and spatial regression analysis



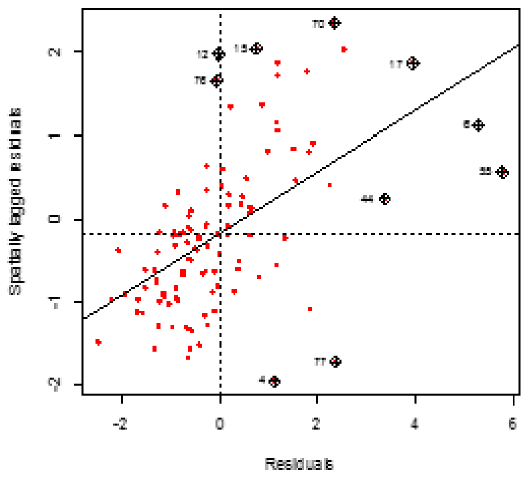


Figure 37. Global Moran's I as the slope of volatility

Figure 38. Global Moran's I as the slope of residuals of the regression

Source: author's calculations

As in the analysis of the returns, spatial diagnostics for the volatility data was performed for the purpose to identify spatial patterns. According to visual analysis of Moran's I plots (figure 37), data were positively spatially correlated. The data points distributed along the line from the bottom left corner to the top right one indicate a positive spatial autocorrelation. This is confirmed by Global Moran's I coefficient for volatility. The coefficient was positive and significant 0.50, and statistically significant at five percent level, which suggests a strong spatial autocorrelation. The models residuals were also examined for spatial autocorrelation characteristics. It was done because spatial structure of housing returns volatility could have been captured by explanatory variables. In that case, spatial structure of the models could be avoided. Moran's I plot, and positive (0.37) and at five percent level statistically significant coefficient indicated that explanatory variables were not able to eliminate spatial autocorrelation. Thus, spatial models could be applied to exploit information in the spatial structure of the data.

With a purpose to identify the most appropriate spatial model. Lagrange multiplier tests for spatial dependence were applied for the linear regression's results (table 16). The results showed that spatial lag and spatial error models both have highly significant and positive coefficients - respectively 36.60 and 28.54. Thus, to indicate a more appropriate model, robust Lagrange Multiplier tests were performed. The robust tests were in favour of spatial lag model that has a positive coefficient of 8.07 that was statistically significant at five percent level, while the coefficient of spatial error model was almost equal zero and not statistically significant. Consequently, spatial lag model was more suited for the housing returns volatility data.

Table 16. Lagrange multiplier tests for spatial dependency

	Coef.	p-value
Spatial Error	28.54	0.00
Spatial Lag	36.60	0.00
Robust Spatial Error	0.01	0.91
Robust Spatial Lag	8.07	0.00

Source: author's calculations

The analysis was continued by applying spatial lag regression in order to explain house price returns volatility variation among counties and unitary authorities in England and Wales. Spatial lag variable eliminates spatial autocorrelation. Lagrange multiplier coefficient (0.11) was statistically insignificant at ten percent level (p-value = 0.74). The spatial equation compared to the linear with the same explanatory variables was more efficient (table 15). AIC coefficient of the spatial regression was 358.71 and was lower compared AIC (392.09) of the linear regression. This suggests that the spatial model fits the data better compared to the linear one.

All the explanatory variables present in the benchmark mode except one remained significant at five percent level. Introducing spatial structure has retained the significance of all the explanatory variables at 5 percent level.

The coefficient of spatially lagged volatility was positive and statistically significant at five percent level. An increase of average returns volatility in neighbouring areas by one standard deviation leads to 0.57 standard deviation higher house price returns volatility in the area. This shows that volatility could spread to other counties or unitary authorities.

The spatial structure of the model made the coefficients of all the explanatory variables smaller (in terms of magnitude). The coefficient of house price level had shrunk 34.48 percent from -0.29 to -0.19; the coefficient of unemployment had shrunk 20.31 percent from 0.64 to 0.51; the impact of population had shrunk 38.24 percent from -0.68 to -0.42; and constant had decreased 37.74 percent from 7.34 to 4.57.

Overall, spatial autoregressive model of the equation compared to the linear one reduced the size of the most coefficients but has not changed any signs. In other words, the multiple linear regression model suggested that the effects of the explanatory variables were larger than they actually were, because it has not accounted for the volatility spill-over effect from the neighbouring areas. In addition, density was no longer significant, thus it made the explanation of the results easier as the sign of the variable being harder to interpret.

3. Direct, indirect, and total spatial impacts

The analysis was preceded by decomposing the results of spatial autoregressive model into direct, indirect, and total spatial effects in order to improve explanation of the results from spatial volatility analysis. The decomposition of the impacts allows accounting for feedback loops among neighbours. The results are presented in table 17. All the direct, indirect, and total coefficients are statistically significant at 5 percent level. Total impacts of the explanatory variables were approximately 70 percent bigger than direct impacts.

Table 17. Direct, indirect, and total impacts of the volatility explanatory factors

	Direct	p-value	Indirect	p-value	Total	p-value
Price level	-0.21	0.00	-0.23	0.00	-0.44	0.00
Unemployment	0.56	0.00	0.62	0.01	1.18	0.00
Population	-0.46	0.00	-0.51	0.03	-0.97	0.01

Source: author's calculations

A direct impact of house price level volume was statistically significant and negative. 10,000 pounds more expensive average house in the area was associated with a decrease in volatility in an observed area by -0.21 standard deviations, the indirect impact was also statistically significant and the sales increase would lower average neighbours volatility by -0.23 standard deviations. The total impact of house sales volume was -0.44. This suggests that volatility was lower in areas with higher house price level and that volatility, due to house price level, also had an effect on the neighbouring areas.

A direct impact of population was statistically significant and negative. One percent increase in population was associated with -0.46 standard deviation lower volatility in an observed area.

An indirect impact of population was also significant and negative. It would result in -0.51 lower standard deviation of the average neighbours' volatility in case of the respective population increase. While the total impact of population was -0.03.

A direct impact of 1 percentage point increase in unemployment was statistically significantly associated with higher volatility by 0.56 standard deviation, while the statistically significant effect on neighbouring areas was on average 0.62 standard deviation. Thus, the total impact of one percentage point higher unemployment was 1.18 standard deviation.

Overall, all the direct and indirect impacts were statistically significant. Indirect impacts had relatively large impacts compared to direct impacts, which corresponds with the results in house price returns analysis. While the direct impacts had only minor differences compared to the coefficients in the last spatial model.

4. Robustness check of the volatility analysis

In this section of the study, analysis of the return volatilities was performed on two sets of data. This was done to check the robustness of the model and it also provides an insight how housing returns volatility have changed under different economic circumstances. The two data sets that are obtained by splitting the complete data: from 1997 to 2007 and from 2008 to 2014.

The first period observed relatively high economic growth and raising house prices, while economic growth stagnated during the second period and the house prices have decreased.

The analysis was executed based on benchmark model and spatial autoregressive model. Spatial diagnostics was also carried out to examine whether the spatial structure has changed over time.

The results showed that explanatory power of the model is very similar and relatively high during both periods. Adjusted coefficients of determination in the first period were 0.30 and 0.31 for the second. Thus, the model explains the variation of volatility in the first period almost as good as for the complete period, while the explanatory power is only fractionally worse compared to the coefficient for the whole data. In addition, all the variables, except population in the first period, were significant at five percent level, while density in the first period was not significant at ten percent level. Furthermore, the sign of the coefficients have not changed.

The size of the coefficients have changed, yet not by large. Population variable had a more sizeable impact during the second period; however, as it was noted in the previous sections, the average volatility was also higher during the second period. Overall, the linear model appears to be robust in explaining the housing market volatility, but it explains only 30 percent of the volatility variation across counties and unitary authorities.

The analysis was preceded by analysing the spatial structure of the two periods. Likewise, in the returns analysis, spatial diagnostics was performed to check whether spatial structure was comparable in the first and in the second periods.

The results of Global Moran's I indicated that housing price volatility was highly spatially correlated in both time streaks. Both plots of Global Moran's I have right leaning curves.

The calculated slope, which represents Moran's I, for the first period was 0.49 and was statistically significant at five percent level. The slope for the second period was 0.51 and was statistically significant at five percent level. Thus, housing market volatilities in both periods show strong spatial correlations. Additionally, the correlations are of a very similar size.

Table 18. Regression Results of volatilities in a split periods

	1997-2007		2007-2014	
	OLS	Spatial autoregressive	OLS	Spatial autoregressive
	Model I	Model II	Model I	Model II
Price level	-0.21^{***}	-0.13^{***}	-0.18^{***}	-0.13^{***}
	p = 0.00	p = 0.00	p = 0.00	p = 0.00
Unemployment	0.09	0.16^{**}	0.19^{**}	0.03
	p = 0.34	p = 0.04	p = 0.04	p = 0.66
Population	-1.04^{***}	-0.69^{***}	-0.26^{*}	-0.16
	p = 0.00	p = 0.00	p = 0.06	p = 0.15
Lag Volatility		0.60^{***}		0.59^{***}
		p = 0.00		p = 0.00
Constant	5.10^{***}	3.40^{***}	7.01^{***}	4.53^{***}
	p = 0.00	p = 0.00	p = 0.00	p = 0.00
N	109	109	109	109
R^2	0.32		0.33	
Adjusted R^2	0.30		0.31	
Log Likelihood		-147.36		-207.27
Wald Test		62.87^{***}		56.68^{***}
LR Test		36.86^{***}		33.92^{***}
AIC	341.58	306.72	458.46	426.53

Note: $^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$

Source: author's calculations

Global Moran's I also calculated for the residuals of the linear models, in order to check whether spatial structure of the volatilities could diminish when in the linear model. From the plots of the volatility in high growth period and low growth period (figure 39 and figure 41), it is seen that the residuals were spatially correlated. Global Moran's I coefficient of the residuals in the first period was positive (0.38) and statistically significant at five percent level. For the second period, it was also positive (0.37) and statistically significant at five percent level. Thus, it is evident that independent variables did not capture spatial effects. The findings for both periods are in line with the previous findings for the whole data, and suggest using spatial models for the volatility analysis.

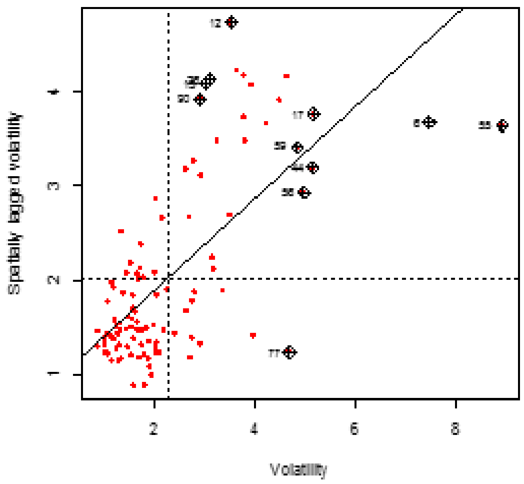


Figure 39. Global Moran’s I as the slope of volatility (1997-2007)

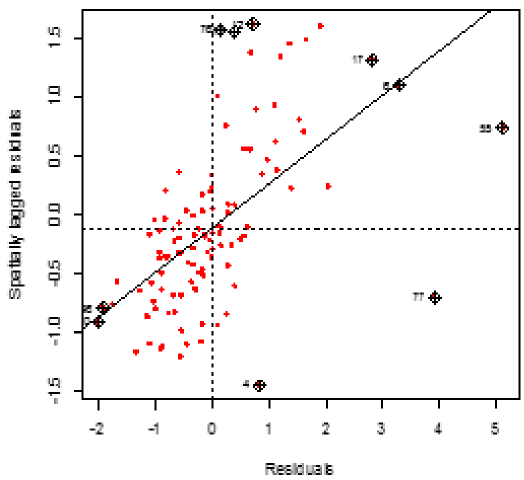


Figure 40. Global Moran’s I as the slope of residuals of the regression (1997-2007)

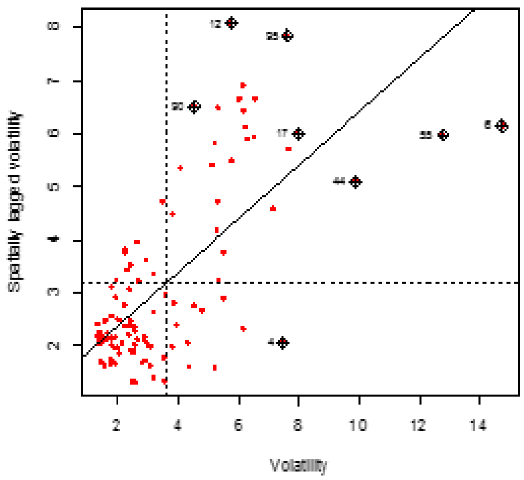


Figure 41. Global Moran’s I as the slope of volatility (2008-2014)

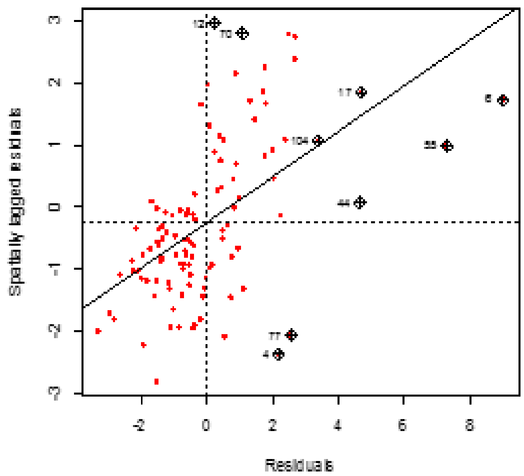


Figure 42. Global Moran’s I as the slope of residuals of the regression (2008-2014)

Source: author’s calculations

Table 19. Lagrange multiplier tests for spatial dependence

	1997-2007		2008-2014	
	Coef.	p-value	Coef.	p-value
Spatial Error	29.24	0.00	27.93	0.00
Spatial Lag	35.81	0.00	32.22	0.00
Robust Spatial Error	0.02	0.88	0.30	0.59
Robust Spatial Lag	6.60	0.01	4.59	0.00

Source: author's calculations

Lagrange multiplier test for spatial dependence is performed to find whether previously chosen spatial lag model withstands as more appropriate after data is split into two sets. At first, the test is performed on the data for the period from 1997 to 2007. Lagrange multiplier coefficient for spatial lag model is positive (35.81) and statistically significant at five percent level; the tested coefficient for spatial error model is also positive (29.24) and statistically significant at five percent level. Both tests show ability to capture spatial dependency of the data, thus robust Lagrange multiplier test is performed for further estimation. The test returns a positive coefficient (6.60) for spatial lag model, which is statistically significant at five percent level. However, the coefficient for the spatial error model while positive (0.02) was highly statistically insignificant. Thus, the test suggests that spatial lag model would more appropriate for the period from 1997 to 2007.

The situation is very similar when the test was applied for the data for the period from 2008 to 2014. Lagrange multiplier coefficient for spatial lag model is positive (32.22) and statistically significant at five percent level. Lagrange multiplier coefficient for spatial error model was also positive (27.93) and statistically significant at five percent level. Both tests show models' ability to capture spatial dependency of the data, thus robust Lagrange multiplier test was performed for further estimation. The robust test shows that the coefficient of spatial lag model is positive (4.59) and statistically significant at five percent level, while the coefficient of spatial error model was positive (0.30) but statistically insignificant. Thus, the results indicate that spatial lag model is more suitable compared to spatial error model.

In general, it seems that spatial structure of the volatility was not very different in the two periods analysed. Also, the spatial lag model appears to be a better choice compared to spatial error model in tackling spatial autocorrelation. Thus, the spatial model structure was applied for the two period analyses.

Introducing spatial structure in the models on the split data had positive impacts on the efficiency in explaining returns volatility. The efficiency of spatial model was higher compared to the linear model in both periods. AIC have decreased from 341.58 to 306.72 in the first period, and from 458.46 to 426.53 in the second period. Thus, in both cases, the improvement because of spatial structure was relatively high. Furthermore, the spatial lag models have eliminated spatial autocorrelation in the data. Lagrange multiplier coefficients in the first period were 0.01 and not significant at ten percent level (p-value = 0.93). While the coefficients in the second period was 0.08 and not significant at ten percent level (p-value = 0.78).

Spatial autocorrelation coefficients are both statistically significant at five percent level and positive. This indicates that volatility in neighbouring areas was positively correlated with volatility of the observed area. The coefficient in the first period was 0.60 and for the second 0.59. Both values appear to be very similar to conclude that spatial spill-over effect of the volatility has changed a little over the two periods.

The impacts of the most explanatory variables have slightly decreased in magnitude, but all signs of the other variables remained the same as in the results from the linear model. However, spatial structure of the models had different effects on the statistical significance of the models. In the high growth period, including spatially lagged volatility, variables had increased the significance of unemployment, which was not significant in a linear model. Yet on the second period, in a low growth environment, spatially lagged volatility had reduced the significance of two explanatory variables. Unemployment rate and population were no longer significant at ten percent level. Furthermore, the signs were the same in both periods and the same as from the model on the complete data.

Overall, it seems that spatial structure has decreased the impact of the linear coefficients in the model in both analysed periods, which is also in line with what was found in the analysis on the complete period.

5. Summary of the chapter

Spatial autoregressive model of the equation compared to the linear one reduced the size of the most coefficients but has not changed any signs. In other words, the multiple linear regression model suggested that the effects of the explanatory variables were larger than they actually were because it has not accounted for the possible volatility spill-over effect from the neighbouring areas, which is suggested by spatial lag structure. Indirect impacts had relatively large impacts compared to direct impacts, which corresponds with the results in house price returns analysis. While the direct impacts had only minor differences compared to the coefficients in the last spatial model. The spatial structure also was robust in two separate periods.

VIII. Descriptive analysis of housing data of London

London clearly distinguishes itself from other housing markets by size, performance, and other characteristics, thus it deserve to be analysed as a special case. In section one, housing markets at a borough level are described, including descriptive analysis of the variables and characteristics of the markets, and spatial distribution of the variables and characteristics. Section two, compares correlations among the variables. Section three, provides a summary of the chapter.

1. Descriptive analysis

In this section, the data used in the London housing market analysis is described using simple statistical measures, such as averages, means, ranges, minimum and maximum values, frequency distributions, and data distributions. Geographically the areas are separated into boroughs. The data lasts from eighteen years from 1997 to 2014, we also split the data into two periods from 1997 to 2007 and from 2008 to 2014, and analysed the differences and changes over time.

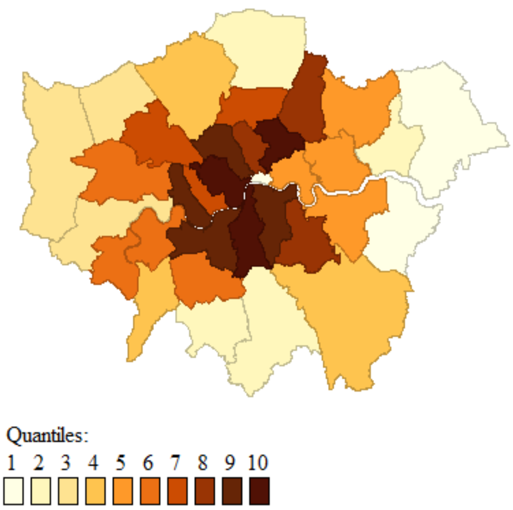


Figure 43. Returns in London

Source: author’s calculations

During 1997-2014, annual capital returns on houses in an average borough in London adjusted for inflation were 6.25 percent. Slightly lower median 6.04 percent, close to zero skewness and low kurtosis show that the values are flat distributed. The difference between least appreciated and the most appreciated areas was 4.12 percent. The highest capital returns on housing were in Hackney (8.68 percent), a borough in the northern eastern part of Inner London, while the lowest returns were Havering (4.57 percent), a borough in the eastern part of Outer London. As it is seen from the mapped returns, there was a visible difference between Inner London and Outer London in terms of house value appreciation. Boroughs closer to the centre of London observed the highest increase in house prices, while the returns gradually decreased when going further from the centre, with the most eastern parts of the city having multiple counties that were among the lowest capital gainers (figure 43).

Table 20. Descriptive statistics

1997-2014	*Returns*	*Volatility*	*Idiosyncratic*	*Systematic risk*	*Idiosyncratic 2*	*Sharpe ratio*	*Price level*	*Wage*	*Unemployment growth*	*Sales*	*Population*	*Wage level*	*Unemployment rate*
Mean	6.25	2.56	5.60	0.96	0.29	3.22	329256	0.75	-3.18	-1.19	1.28	17.96	3.58
Median	6.04	2.52	5.05	0.97	0.29	3.22	295707	0.72	-3.14	-1.53	1.29	16.86	3.25
Standard Deviation	1.04	0.52	2.73	0.11	0.08	0.56	115414	0.74	0.65	1.06	0.52	3.14	1.32
Kurtosis	-0.71	0.64	1.57	-0.16	0.71	-0.35	6.43	2.44	0.28	3.36	2.31	2.03	-1.11
Skewness	0.30	0.85	1.32	0.38	0.47	0.42	2.31	0.83	0.71	1.71	1.06	1.43	0.33
Range	4.12	2.22	11.49	0.46	0.38	2.24	552123	3.85	2.60	4.56	2.44	13.79	4.61
Minimum	4.56	1.67	1.66	0.77	0.13	2.32	219743	-0.75	-4.20	-2.51	0.48	14.13	1.55
Maximum	8.68	3.89	13.15	1.23	0.51	4.57	771866	3.10	-1.60	2.05	2.92	27.92	6.17
Count	32	32	32	32	32	32	32	32	32	32	32	32	32

1997-2007	*Returns*	*Volatility*	*Idiosyncratic*	*Systematic risk*	*Idiosyncratic 2*	*Sharpe ratio*	*Price level*	*Wage growth*	*Unemployment growth*	*Sales*	*Population*	*Wage level*	*Unemployment rate*
Mean	9.84	2.07	3.70	0.95	0.19	4.86	287571	2.83	-5.24	0.45	1.00	17.68	3.68
Median	9.75	2.05	3.47	0.95	0.18	4.82	266716	2.72	-5.41	0.25	0.95	16.59	3.16
Standard Deviation	0.90	0.45	2.00	0.15	0.08	0.92	82910	1.05	0.85	1.08	0.23	3.07	1.55
Kurtosis	-0.11	1.71	5.50	2.07	-0.39	-0.93	6.05	1.21	0.72	1.94	0.52	0.91	-1.04
Skewness	0.68	0.81	1.86	0.82	0.03	0.08	2.23	-0.54	0.87	1.10	0.69	1.11	0.46
Range	3.50	2.13	10.01	0.78	0.32	3.53	395617	4.96	3.64	5.10	2.02	13.43	5.28
Minimum	8.77	1.35	1.24	0.65	0.04	3.01	206451	-0.27	-6.46	-1.45	0.17	12.92	1.58
Maximum	12.27	3.47	11.25	1.43	0.37	6.54	602068	4.69	-2.82	3.65	2.19	26.35	6.86
Count	32	32	32	32	32	32	32	32	32	32	32	32	32

Descriptive statistics (continued)

2008-2014	*Returns*	*Volatility*	*Idiosyncratic*	*Systematic risk*	*Idiosyncratic 2*	*Sharpe ratio*	*Price level*	*Wage growth*	*Unemployment growth*	*Sales*	*Population*	*Wage level*	*Unemployment rate*
Mean	1.34	2.94	7.56	0.95	0.28	0.64	394761	-1.73	-0.55	-1.61	1.52	18.40	3.42
Median	1.25	2.87	6.72	0.94	0.28	0.48	347145	-1.70	-0.67	-1.51	1.56	17.04	3.30
Standard Deviation	1.71	0.64	4.01	0.13	0.08	0.73	167190	0.87	1.90	0.63	0.77	3.34	1.05
Kurtosis	-0.91	1.94	4.62	0.45	0.25	1.35	6.59	1.88	0.68	3.59	1.51	4.11	-1.20
Skewness	0.17	1.11	1.84	0.58	0.51	1.04	2.34	-0.12	0.10	-1.22	-0.19	1.84	0.10
Range	5.85	3.09	19.97	0.59	0.38	3.34	798060	4.71	9.06	3.40	3.88	15.42	3.56
Minimum	-1.59	1.86	2.11	0.72	0.12	-0.53	240629	-4.14	-4.85	-3.74	-0.64	14.97	1.52
Maximum	4.25	4.95	22.09	1.30	0.50	2.81	1038689	0.57	4.21	-0.34	3.24	30.40	5.09
Count	32	32	32	32	32	32	32	32	32	32	32	32	32

Source: author's calculations

Looking at the returns in the split data series, a gap was observed between the first period from 1997 to 2007 and the second period from 2008 to 2014. The first period generated 9.84 percent compounded annual return after adjusting for inflation in an average administrative area. However, during the second period, real house values have decreased by -1.34 percent in an average county or unitary authority. The average range between highest and lowest performing counties have increased from 3.50 percentage points during the first period to 5.85 percentage points during the second period, indicating that differences in price developments among the markets were milder in the first period.

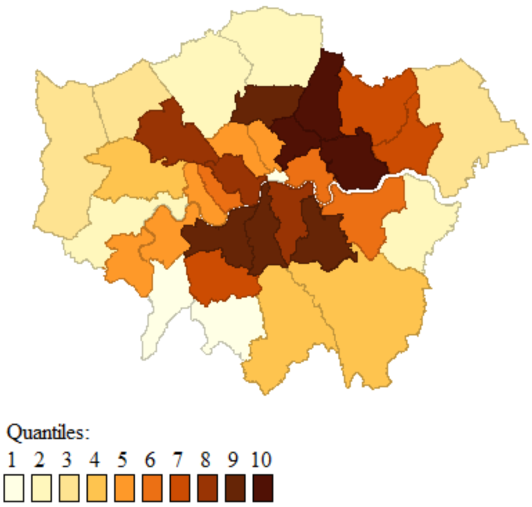


Figure 44. Returns in London from 1997 to 2007

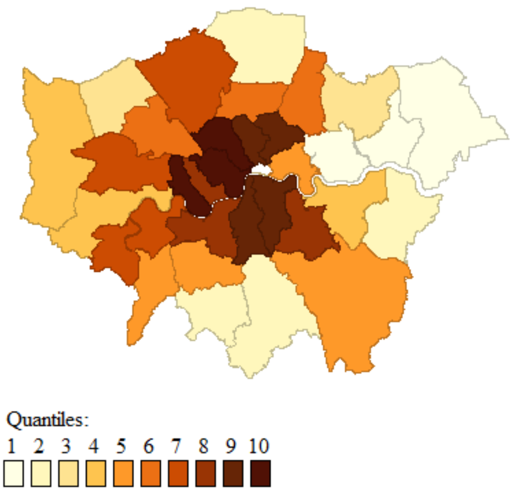


Figure 45. Returns in London from 2008 to 2014

Source: author's calculations

The best performing area during the first period was Hackney (12.27 percent); while the lowest capital gains were in Kingston upon Thames (8.77 percent), a southwest borough of Outer London. Thus, during the high growth period, even the worst-performing areas have generated relatively high inflation adjusted annual returns. During the slowdown period, Camden, a northern western borough of Inner London, that borders the City of London and is part of the city centre, was on the top of all areas in house price increase. The prices in Camden have increased by 4.25 percent, which was a considerable raise at a country level. The biggest decrease was observed in Barking and Dagenham, an eastern borough of Outer London and one of the cheapest housing markets in London (-1.59 percent).

From the returns quantiles in the maps, it is seen that during the high growth period, high returns were concentrated around the centre of London, yet some northern and eastern boroughs were also observing relatively high returns (figure 45). During the slowdown period, the concentration of the high house price returns around the City of London intensified (figure 44). Additionally, the relative performance of western boroughs compared to eastern boroughs improved.

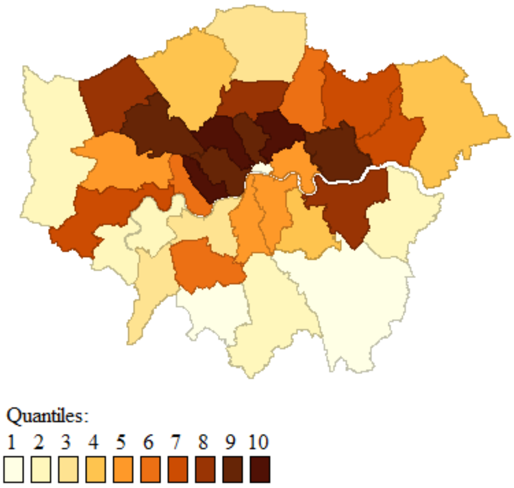


Figure 46. Volatility in London

Source: author's calculations

Volatility in an average borough was 2.56 standard deviation. The range of the volatility was 2.22. The volatility was lower in a high growth period when it sought 2.07 standard deviations; while in a low growth environment the volatility increased to 2.94 standard deviations. The range also widened from 2.13 to 3.09 standard deviations. The highest volatility was observed in Kensington and Chelsea, a small densely populated borough in the Inner London to the west from the centre (3.89 standard deviation). The lowest volatility was observed in Bromley, the largest by area borough of London in southern part of the city (1.67 standard deviation). It is interesting that the phenomenon observed at a country level, when returns correlated negatively with the volatility, was absent in London at borough level.

During the first period the most volatile borough was Hackney (3.47 standard deviation), which also observed the highest returns. The least volatile borough was Bexley, a borough in the south east of Outer London (1.35 standard deviation). During the second period the most volatile borough was Kensington and Chelsea (4.95 standard deviation); while the least volatile was Bromley (1.86 standard deviation).

From the mapped data, it is seen that the northern boroughs were relatively more volatile to the southern boroughs of the city (figure 46). The mapped data from the high economic growth and low economic growth periods indicates that volatility distribution remained geographically similar in different economic environments, i.e. the northern boroughs were relatively more volatile.

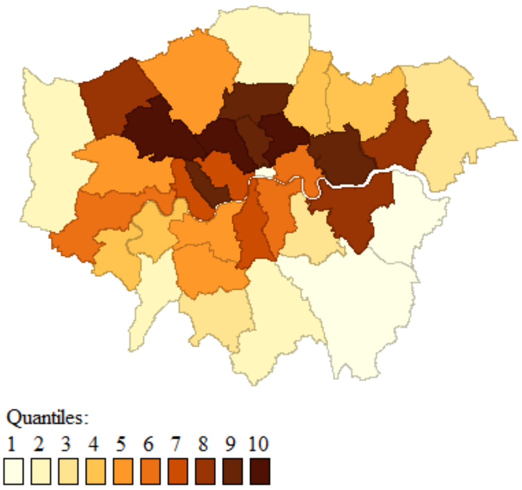


Figure 47. Volatility in London from 1997 to 2007

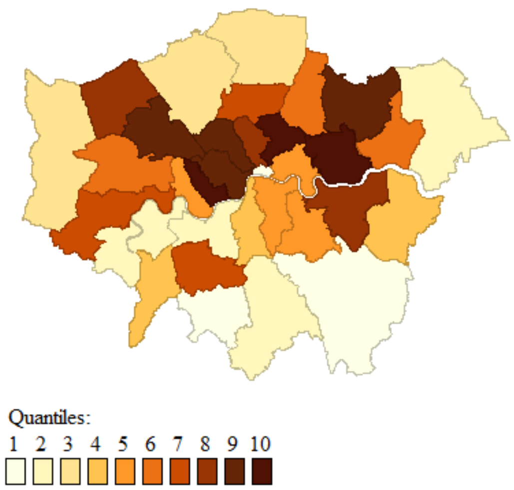


Figure 48. Volatility in London from 2008 to 2014

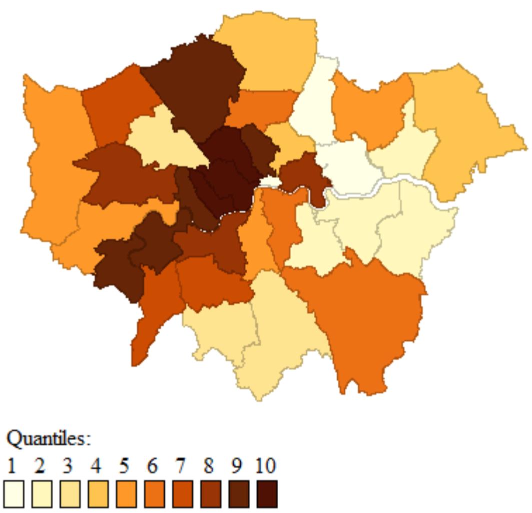


Figure 49. House price level in London

Source: author's calculations

Housing markets in the central western part of London were relatively more expensive. The most expensive housing market was Kensington and Chelsea. An average house price in 1997 was 363.6 thousand pounds in current prices. The eastern peripheral boroughs were the least expensive. Newham was the least expensive housing market in 1997 with an average house price 100.6 thousand pounds in current prices.

The highest wages were clearly concentrated around the City of London. The highest wages were in Tower Hamlets, were an average hourly wage was 27.92 pounds when adjusted to inflation (the City of London was not included in the statistics because it does not possess a significant housing market). The borough distinguishes itself because it hosts many financial institutions and large company headquarters. The borough retained the top position in an hourly wage list even when considering split periods. During the high economic growth period, an average hourly wage was 26.35 pounds; while during low economic growth period an average hourly wage was 30.40 pounds.

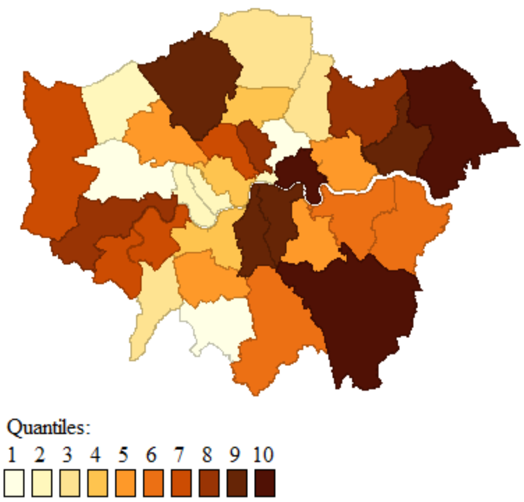


Figure 50. Wage growth in London

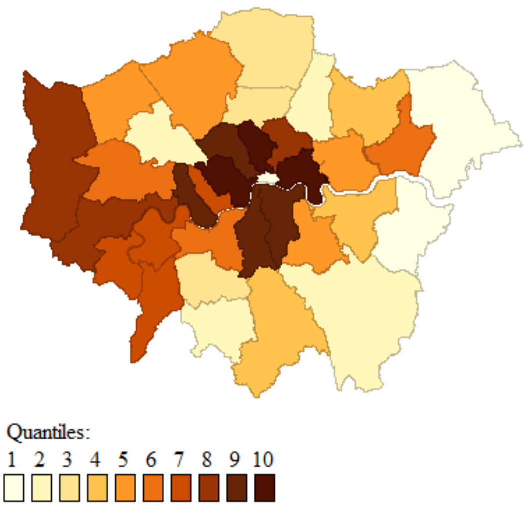


Figure 51. Wage level in London

Source: author's calculations

If not considering the centre of the city, the western boroughs were observing higher wage levels compared to the eastern part of the city (figure 50, figure 51). The lowest wage level was in Havering with an average hourly wage of 14.13 pounds. Havering had the lowest hourly wage of 12.92 pounds during the first period; while during the second period the lowest hourly wage 14.97 pounds was paid in Sutton, a southern peripheral borough in Outer London. The average wage level range was 13.79 pounds. It was lower during the economic growth period (13.43 pounds), yet it increased during economic slowdown period (15.42 pounds).

From 1997 to 2014 hourly compensation per employee in an average borough in London increased by 0.75 percentages per year. During the high economic growth period an average compensation growth was 2.83 percentages; while during the low economic growth period an average compensation decreased by -1.73 percentages per year. The mapped wage growth data shows that on average wages were relatively growing more in the eastern poorer boroughs, yet the geographical distribution was not very clear.

Since 1997, London has observed a spectacular growth in population. Population in an average borough has increased by 1.28 percentages per year. The fastest growing borough in terms of population was Tower Hamlets with 2.92 percentages annual growth. The lowest growing borough was Havering with 0.48 percentages per year. Tower Hamlets have retained the position of the fastest growing borough in the high economic growth and low economic growth periods with the respective rates of 2.19 percentages and 3.24 percentages per year. While the lowest growing borough during the first period was Havering with 0.17 percentages. During the second period, Kensington and Chelsea had the lowest population growth rate, which was negative -0.64 percentages per year.

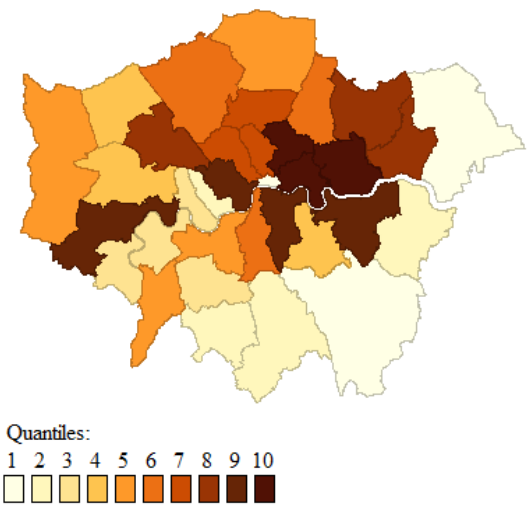


Figure 52. Population growth in London

Source: author’s calculations

From the mapped data it is seen that population was growing at a faster pace in central boroughs and the least in the southern eastern boroughs (figure 52). Interestingly the higher population growth was more concentrated in the central boroughs from 1997 to 2007; while since 2008 the growth was more even among the boroughs.

An average unemployment rate (measured as Jobseeker’s allowance claimants per active population) in London boroughs was 3.58 percentages. Interestingly, it was higher (3.68

percentages) from 1997 to 2007 when economy was growing faster and was lower (3.42 percentages) in the latter years from 2008 to 2014 when economic growth was struggling. From the mapped data, it is seen that higher unemployment levels were observed in the central and eastern boroughs. Also during the lower economic growth period, northern boroughs had observed relatively higher unemployment levels. Overall, from 1997 to 2014 unemployment was decreasing by -3.18 percentages annually. Unemployment was reduced at the fastest rate in Camden by -4.20 percentages; while slowest in Barking and Dagenham, a borough in the east of Outer London. During the high economic growth period Wandsworth, a borough in the western part of Inner London, observed the fastest decreasing unemployment by annual rate of -3.80 percentages; while Barking and Dagenham observed the lowest annual rate of -1.66 percentages. However, during the slower economic growth period Tower Hamlets was reducing unemployment at a fastest pace of -2.00 percentages per year; while during the same period unemployment in Havering increased by 1.74 percentages, which was the biggest increase in the period. From the mapped data, it is seen that unemployment was decreasing at a slowest rates in the peripheral boroughs, while at a fastest rates in the central locations. This largely remained the case in the split data maps, yet during the first period unemployment was decreasing at a lower rate in the northern boroughs compared to the southern, yet the situations turned around during the second period of struggling economic growth.

It is worth noting that relatively high increase in house prices have not translated into higher house sales. From 1997 to 2014 house sales decreased by 1.19 percentages annually. House sales shrunk the most (-2.51 percentages) in Ealing, a borough in the western part of Outer London. The difference in house sales growth between minimum and maximum was large. House sales increased the most in Tower Hamlets (2.05 percentages). During the economic growth period, house sales in an average borough were raising by 0.45 percentages annually; while during the low economic growth period house sales were decreasing by -1.61 percentages per year. The largest increase in sales during the economic growth period was observed in a borough of Barking and Dagenham (3.65 percentages).

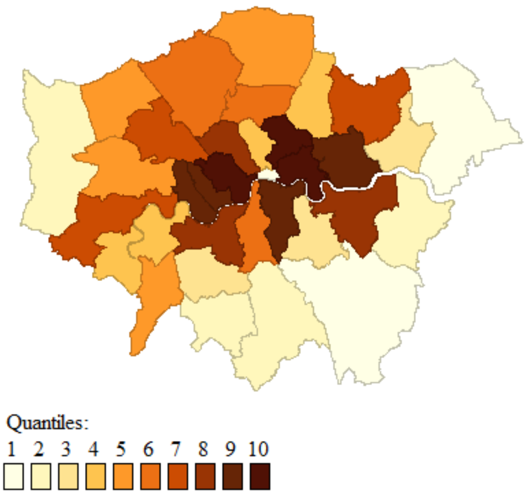


Figure 53. Population growth in London from 1997 to 2007

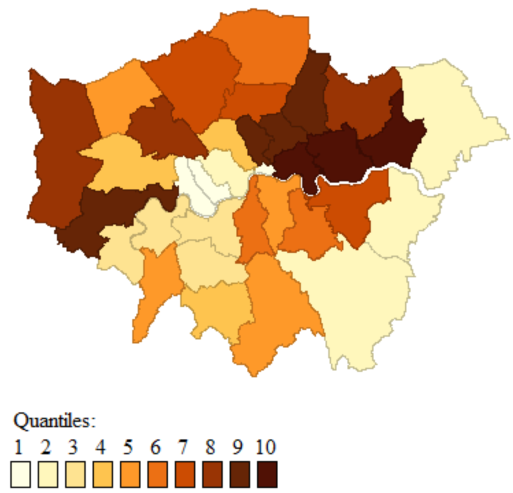


Figure 54. Population growth in London from 2008 to 2014

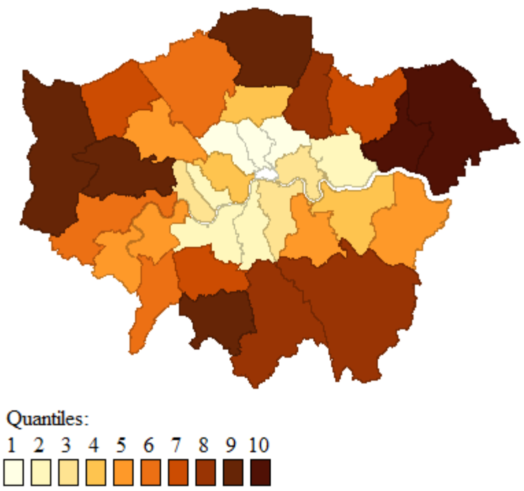


Figure 55. Unemployment growth in London

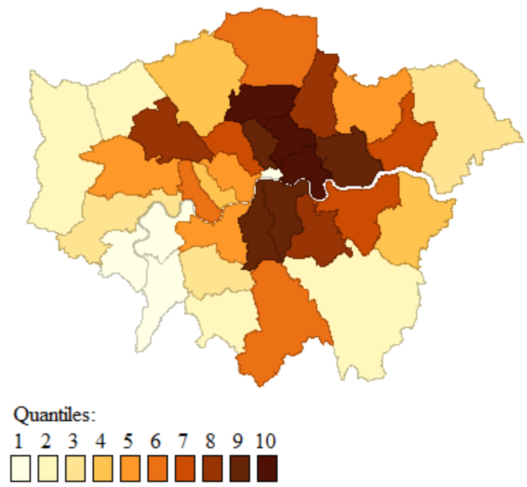


Figure 56. Unemployment rate in London

Source: author’s calculations

Interestingly the largest house sales drop during the same period of time was observed in the centre of the city in a borough of Westminster (-1.45 percentages). In addition, during the economic slowdown Westminster has observed the largest decrease in sales (-3.74 percentages), while the lowest decrease in sales was observed in Tower Hamlets (-0.34 percentages). From the mapped data, it is seen that house sales growth was relatively higher in the eastern part of the city and especially before the financial crisis; while after the financial crisis the sales growth were less geographically clustered. There could be several reasons for stagnating house sales growth: a limited increase in new house supply, a stable appreciation in house prices that and high rent prices that made houses an attractive investment, thus increasing a desire to hold houses as investments.

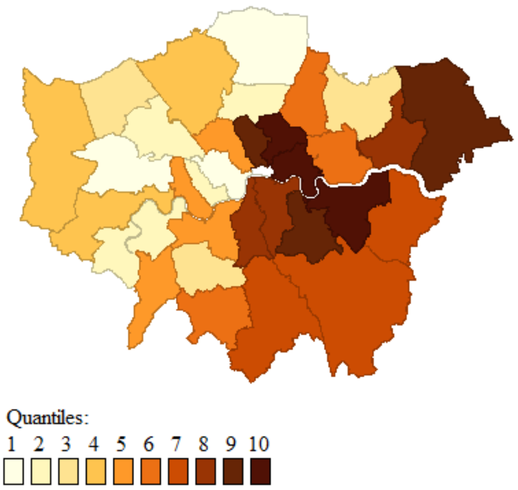


Figure 57. House sales change in London

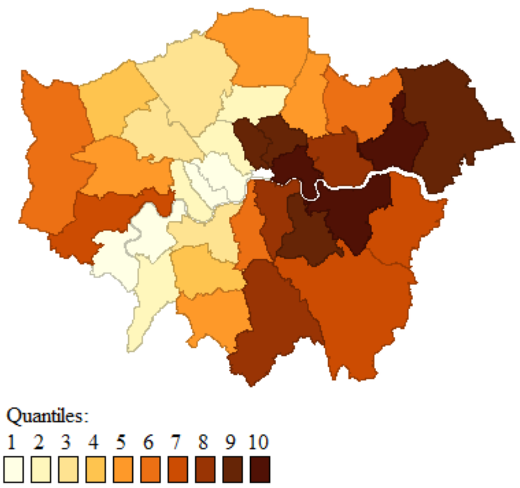


Figure 58. House sales change in London from 1997 to 2007

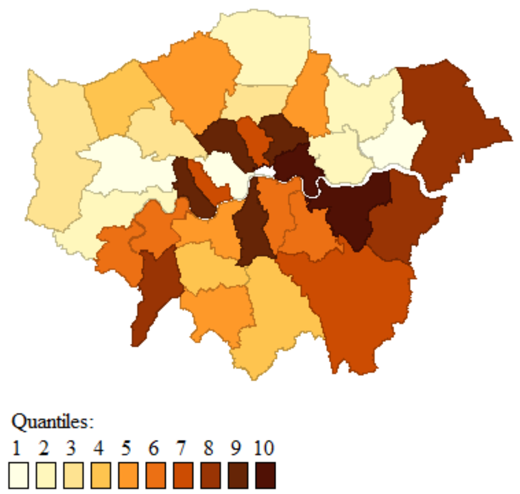


Figure 59. House sales change in London from 2008 to 2014

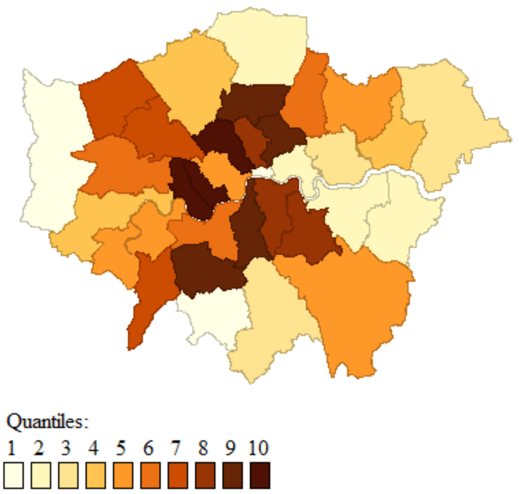


Figure 60. Market risk in London

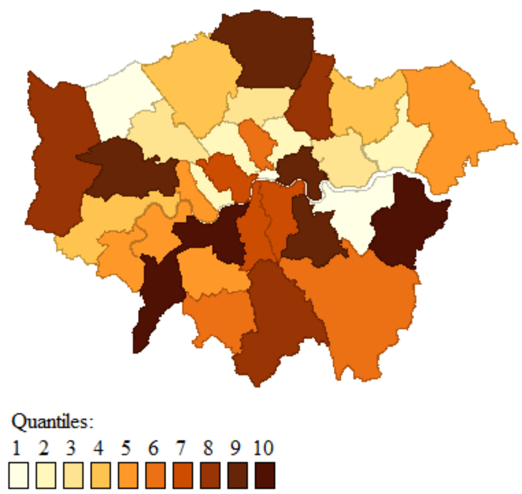


Figure 61. Sharpe ratio in London

Source: author’s calculations

2. Correlation analysis

In order to understand the relationships among the variables, Pearson correlation coefficients were calculated for the variables (table 21). Pearson correlation coefficients show that returns were highly related with systematic risk (0.71), idiosyncratic risk (0.50), volatility (0.50), price level (0.37), and population growth (0.30), but were oppositely related to unemployment (-0.76) and wages (-0.29). House sales transaction growth and returns were almost unrelated (0.02).

Interestingly, that various risk variables were highly correlated with the returns. However, when split data was considered (rapid economic growth period and slow economic growth period), very different correlation coefficients between the returns and risk variables appears. During the first period price level (0.58), volatility (0.49), idiosyncratic risk (0.47), and population (0.51) had the highest correlation coefficients; while unemployment (-0.69), sales (-0.41), and idiosyncratic risk 2 (-0.33) had the most negative coefficients. During the second period, the price level retained the highest correlation coefficient (0.68). Also relatively high correlation coefficients had systematic risk (0.66) and volatility (0.33); while high opposite correlation was among returns and unemployment (-0.40), wage (-0.27), and population (-0.27). It seen that only price level, volatility, idiosyncratic risk, and unemployment growth had approximately stable correlation with the returns.

In the previous sections, it was seen that housing market returns and volatilities in England and Wales possess inverse correlation. However, this is not the case in London housing markets that have highly positive correlation. Figures 62, 63, and 64 show house price returns and volatility relationships in all observed period and in the two periods of different economic growth from 1997 to 2007 and from 2008 to 2014.

Table 21. Correlations of the variables

1997-2014	*Returns*	*Volatility*	*Idiosyncratic*	*Beta*	*Idiosyncratic 2*	*Sharpe*	*Price level*	*Wage*	*Unemployment*	*Sales*	*Population*
Returns	1.00										
Volatility	0.62	1.00									
Idiosyncratic	0.59	0.99	1.00								
Beta	0.37	0.55	0.48	1.00							
Idiosyncratic 2	-0.30	-0.75	-0.76	0.10	1.00						
Sharpe	-0.26	-0.63	-0.63	-0.24	0.54	1.00					
Price level	-0.09	0.40	0.39	0.59	-0.05	-0.20	1.00				
Wage	-0.30	-0.30	-0.30	-0.39	0.03	0.10	-0.15	1.00			
Unemployment	-0.27	-0.54	-0.51	-0.56	0.19	0.11	-0.39	0.16	1.00		
Sales	0.16	0.01	0.03	-0.28	-0.20	0.00	-0.31	0.50	-0.17	1.00	
Population	0.45	0.41	0.40	-0.13	-0.59	-0.14	-0.19	0.25	-0.41	0.43	1.00

1997-2007	*Returns*	*Volatility*	*Idiosyncratic*	*Beta*	*Idiosyncratic 2*	*Sharpe*	*Price level*	*Wage*	*Unemployment*	*Sales*	*Population*
Returns	1.00										
Volatility	0.49	1.00									
Idiosyncratic	0.47	0.97	1.00								
Beta	0.10	0.19	0.03	1.00							
Idiosyncratic 2	-0.33	-0.75	-0.78	0.41	1.00						
Sharpe	-0.41	-0.77	-0.71	-0.11	0.63	1.00					
Price level	0.58	0.24	0.20	0.03	-0.22	-0.43	1.00				
Wage	-0.13	-0.34	-0.42	0.04	0.26	0.07	-0.02	1.00			
Unemployment	-0.69	-0.33	-0.33	-0.09	0.13	0.30	-0.47	0.17	1.00		
Sales	-0.41	0.09	0.11	-0.02	-0.09	0.15	-0.57	0.33	0.42	1.00	
Population	0.51	0.61	0.58	0.03	-0.56	-0.36	0.42	-0.11	-0.34	-0.07	1.00

Correlations of the variables (continued)

2008-2014	*Returns*	*Volatility*	*Idiosyncratic*	*Beta*	*Idiosyncratic 2*	*Sharpe*	*Price level*	*Wage*	*Unemployment*	*Sales*	*Population*
Returns	1.00										
Volatility	0.33	1.00									
Idiosyncratic	0.27	0.98	1.00								
Beta	0.66	0.56	0.48	1.00							
Idiosyncratic 2	0.20	-0.62	-0.65	0.25	1.00						
Sharpe	0.74	0.04	-0.02	0.36	0.26	1.00					
Price level	0.68	0.55	0.58	0.55	-0.07	0.51	1.00				
Wage	-0.27	0.02	0.07	-0.43	-0.45	-0.34	-0.20	1.00			
Unemployment	-0.40	-0.49	-0.46	-0.20	0.39	-0.17	-0.19	-0.30	1.00		
Sales	0.09	-0.04	-0.02	0.13	0.18	-0.07	-0.02	0.23	-0.18	1.00	
Population	-0.27	0.01	-0.03	-0.37	-0.41	-0.28	-0.57	0.45	-0.52	0.08	1.00

Source: author’s calculations

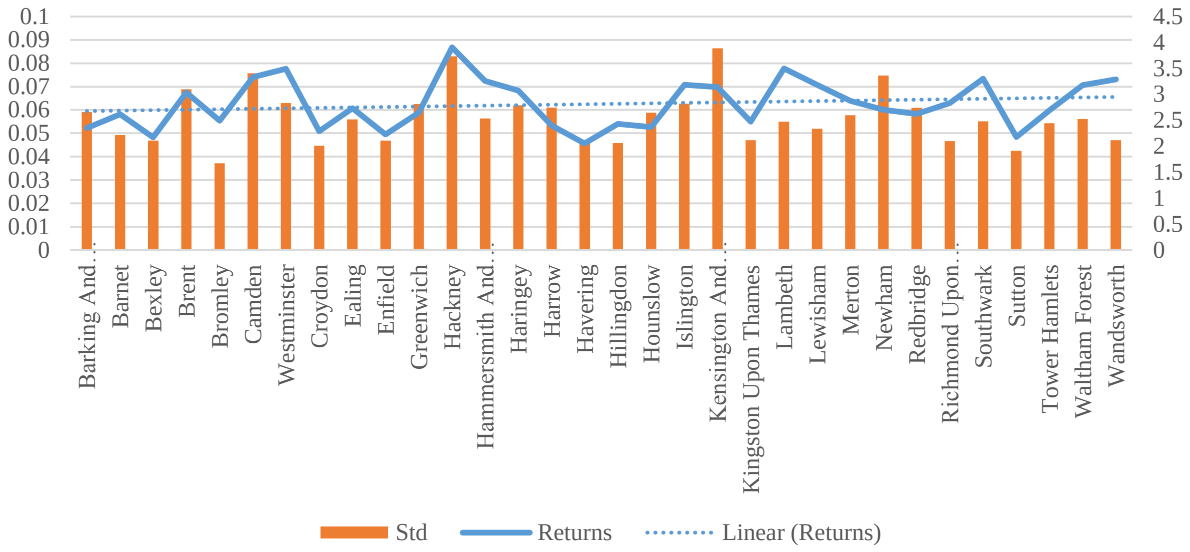


Figure 62. Housing market returns and volatility in London

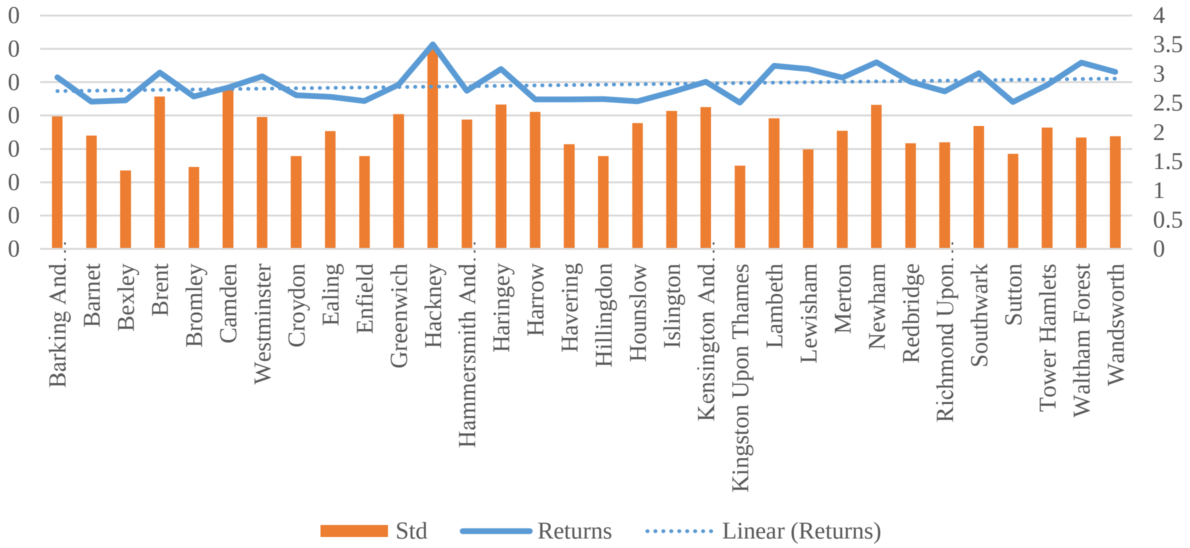


Figure 63. Housing market returns and volatility in London from 1997 to 2007

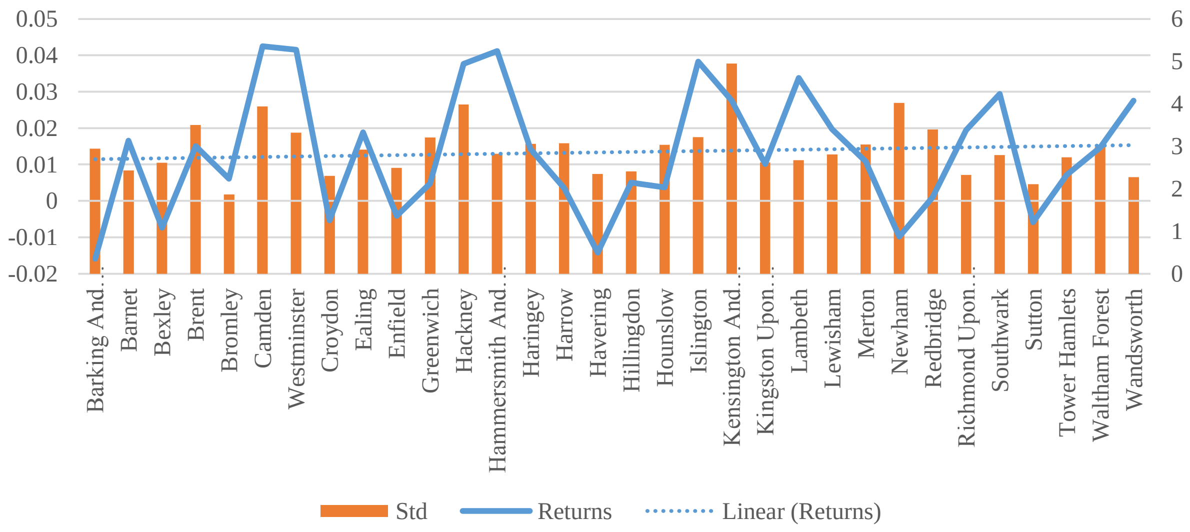


Figure 64. Housing market returns and volatility in London from 2008 to 2014

Source: author’s calculations

3. Summary of the chapter

The descriptive and correlation analysis of London housing markets indicate a difference between Inner London and Outer London. Boroughs closer to the centre of London observed the highest increase in house prices, while the returns gradually decreased when going further from the centre. The separation increased further after the financial crisis. Highest wages, employment growth and population growth was also concentrated in the Inner London. In addition, London housing markets that have high positive robust return and risk correlation. This is in line with the traditional return and risk framework and opposite to English and Welsh housing markets.

IX. Analysis of housing returns in London

The following chapter presents result of the regression analysis of the returns in London housing market. In the first section, findings of the linear regression analysis are presented. In the second section, the results of spatial diagnostics and spatial regression analysis are provided. In the third section, the analysis was repeated for two separate periods to assess robustness of the results. In the final section, summary of the chapter was provided.

1. Linear regression analysis

The returns were analysed at first, performing multiple linear regressions with fundamental factors that should describe differences of the returns in housing markets in London. We suspected that differences in housing markets' returns among the areas should be influenced by economic and labour conditions (e.g. unemployment, wages), demographic characteristics of the area (e.g. population), housing market conditions (e.g. house sales volume), and attractive locations (e.g. prime locations versus subprime). These influences on housing markets were intend to capture with house sales volumes, population, unemployment, employee compensation, and house prices level. Then risk variables were added to check whether they would provide any additional information.

Regression variables were checked for multicollinearity using variance inflation factor (VIF) coefficients (table 22). None of VIF coefficients was higher than five, which indicates that variables are not correlated with the other independent variables.

The first multiple regression model (Model I) explains average return variation among the areas relatively well. The adjusted coefficient of determination of the model 0.53 (table 23). However, only one variable, unemployment growth, was statistically significant. It is interesting that a single variable could explain more than a half of returns variation among the housing markets in London. The coefficient of the unemployment growth variable was negative, as expected, indicating that a decrease in unemployment was positively related with the returns.

The most statistically insignificant variables were removed from the equation and calculations were performed again. House sales, population growth, price level were, and wage growth were not statistically significant at ten percent level. Thou wage level improved coefficient of determination, thus it was left in the basic model (Model IV). The residuals of the regression are homoscedastic. Breusch-Pagan test for heteroscedasticity returned insignificant value (coefficient = 1.42, p-value = 0.49), as well as non-constant variance score test did (chi-square = 0.01, p-value = 0.92).

Additionally, risk variables were included into the basic model to investigate whether they could provide more information in housing returns analysis. Systematic risk was the single statistically significant risk variable (significant at 5 percentages level). A significant coefficient suggests that returns across the housing markets in London move approximately together, yet with a different magnitude, which as expected was positively correlated with a rate of systemic risk.

Table 22. Multicollinearity test

VIF Coefficients								
	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII	Model VIII
Price level	1.66	1.44	1.19	1.03				
Unemployment	2.01	1.79	1.19	1.03	1.42	1.47	1.35	1.06
Wage	1.59	1.18	1.03		1.1	1.18	1.1	1.02
Population	1.67	1.65						
Sales	1.81							
Volatility					1.52			
Systematic						1.68		
Idiosyncratic							1.45	
Idiosyncratic 2								1.04

Source: author's calculations

Overall, it was rather unexpected that more than a half variation in returns were explained by changes in unemployment rates; while other commonly used variables in a housing market analysis were insignificant, e.g. population growth, wage growth.

Table 23. Linear regression results.

	Returns							
	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII	Model VIII
Price level, mil. £	2.18	2.26	2.63					
	p = 0.49	p = 0.43	p = 0.60					
Unemployment	-1.02***	-1.01***	-1.12***	-1.17***	-1.03***	-0.85***	-1.08***	-1.17***
	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00
Wage	-0.27	-0.28	-0.23	-0.24	-0.19	-0.07	-0.20	-0.24
	p = 0.23	p = 0.15	p = 0.20	p = 0.17	p = 0.30	p = 0.67	p = 0.26	p = 0.18
Population	0.24	0.23						
	p = 0.46	p = 0.46						
Sales	-0.01							
	p = 0.95							
Volatility					0.33			
					p = 0.27			
Systematic risk						3.65***		
						p = 0.01		
Idiosyncratic risk							0.04	
							p = 0.45	
Idiosyncratic risk 2								0.22
								p = 0.90
Constant	2.56***	2.59***	2.63***	2.72***	2.26***	0.11	2.72***	2.64***
	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.01	p = 0.92	p = 0.00	p = 0.01
N	32	32	32	32	32	32	32	32
R^2	0.61	0.61	0.60	0.60	0.62	0.69	0.61	0.60
Adjusted R^2	0.54	0.55	0.56	0.57	0.58	0.66	0.57	0.56

Note: ***p < .01; **p < .05; *p < .1

Source: author's calculations

2. Spatial analysis

It is proceeded with the examination of the returns using spatial diagnostic analysis to find whether returns of house price returns in London have spatial patterns. For this purpose, Global Moran's I coefficient was calculated and plotted (figure 65).

Visual data points representing house price returns are distributed along the line going from a bottom left to a top right; this indicates that the returns data is positively spatially correlated. The estimated Global Moran's I coefficient of 0.38 shows strong spatial correlation and is statistically significant at five percent level (p-value = 0.00). It is also necessary to check whether spatial correlation among the housing market returns could not be captured by independent variables. Thus, additionally, Global Moran's coefficient was estimated for residuals of the linear regression with the unemployment growth and wage growth variables. The plot (figure 66) shows that independent variables have captured the spatial correlation. The estimated coefficient is negative -0.05 and statistically insignificant at ten percent level (p-value = 0.49). It is rather unexpected that independent variables have captured spatial correlation.

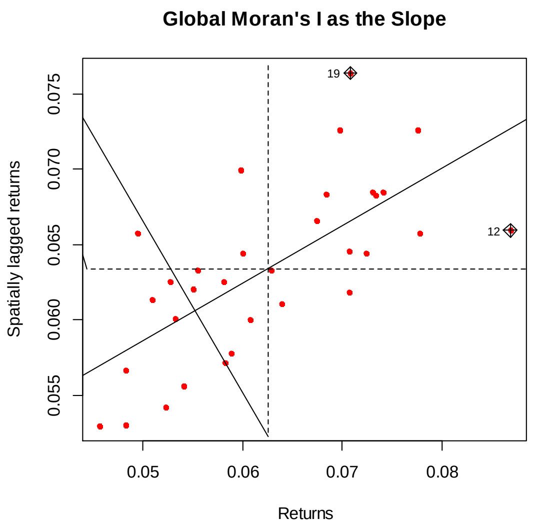


Figure 65. Global Moran's for the housing returns in London

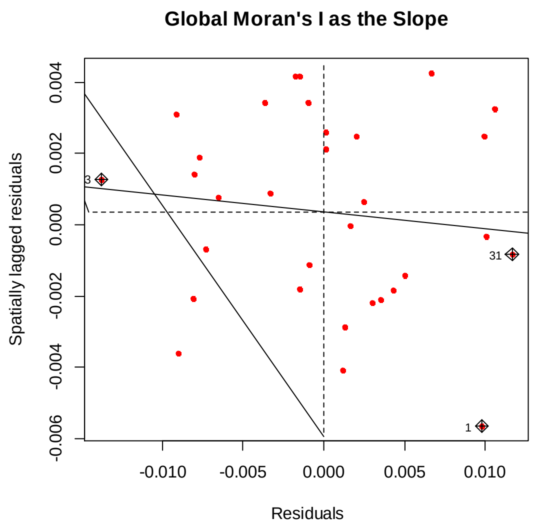


Figure 66. Global Moran's for the residuals of the benchmark regression in London

Source: author's calculations

Overall, house price returns were shown to be spatially correlated, however the inclusion of independent variables in the explanatory models have eradicated the spatial structure. The unemployment growth seems to explain majority of the spatial variability in housing returns in London including spatial variability.

3. Robustness check

In this section of the study, regression analyses were performed on two sets of data that represent a high economic growth period from 1997 to 2007 (table 24) and a low economic growth period from 2008 to 2014 (table 25). The analysis is going to serve in observing whether the independent variables are able to retain significant and similar coefficients. The two periods, as was mentioned in the diagnostic analysis section, have very different qualities thus, it is important to observe how the housing markets react in different economic environment.

The results in both periods were relatively poor in terms of models' consistency. Model IV, which had the highest coefficient of determination when the full period was analysed, yet in a split data analysis its adjusted coefficient of determination were only 0.08 and 0.28 respectively for the first and the second periods. The significance of the unemployment growth variable also was lower. It was significant in the second period that represents low economic growth, yet mostly insignificant during the high economic growth period. However, models that contained other explanatory variables were performing relatively better (e.g. Model I, Model II, and Model III).

Table 24. Testing robustness of the linear regression results (1997-2007)

	Returns							
	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII	Model VIII
Price level, mil. £	-4.75	-7.28**	-4.27					
	p = 0.21	p = 0.03	p = 0.21					
Unemployment	-0.54	-0.46	-0.62*	-0.40	-0.11	-0.34	-0.14	-0.36
	p = 0.11	p = 0.16	p = 0.10	p = 0.22	p = 0.70	p = 0.27	p = 0.63	p = 0.26
Wage	-0.42*	-0.30	-0.36	-0.38	-0.14	-0.42*	-0.09	-0.31
	p = 0.10	p = 0.19	p = 0.17	p = 0.15	p = 0.53	p = 0.10	p = 0.71	p = 0.26
Population	1.43**	1.66***						
	p = 0.02	p = 0.01						
Sales	0.21							
	p = 0.25							
Volatility					1.14***			
					p = 0.002			
Systematic risk						2.15**		
						p = 0.04		
Idiosyncratic risk							0.24***	
							p = 0.01	
Idiosyncratic risk 2								-2.61
								p = 0.23
Constant	8.70***	9.12***	9.21***	9.25***	7.38***	7.45***	8.67***	9.74***
	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00
N	32	32	32	32	32	32	32	32
R^2	0.44	0.40	0.19	0.14	0.40	0.27	0.35	0.18
Adjusted R^2	0.33	0.32	0.10	0.08	0.33	0.20	0.28	0.10

Note: ***p < .01; **p < .05; *p < .1

Source: author's calculations

Table 25. Testing robustness of the linear regression results (2008-2014)

	Returns							
	Model I	Model II	Model III	Model IV	Model V	Model VI	Model VII	Model VIII

Price level, mil. £	6.22^{**}	5.98^{**}	6.93^{***}					
	p = 0.03	p = 0.03	p = 0.0002					
Unemployment	-0.91^{**}	-0.97^{**}	-0.82^{***}	-1.14^{***}	-1.01^{**}	-0.72^{**}	-1.07^{**}	-1.33^{***}
	p = 0.05	p = 0.04	p = 0.01	p = 0.003	p = 0.02	p = 0.04	p = 0.02	p = 0.001
Wage	-1.34^{*}	-1.23^{*}	-1.31^{**}	-2.05^{**}	-1.97^{**}	-0.68	-2.02^{**}	-1.53^{*}
	p = 0.06	p = 0.08	p = 0.05	p = 0.02	p = 0.02	p = 0.39	p = 0.02	p = 0.07
Population	-0.47	-0.62						
	p = 0.73	p = 0.64						
Sales	0.27							
	p = 0.45							
Volatility					0.30			
					p = 0.54			
Systematic risk						6.73^{***}		
						p = 0.003		
Idiosyncratic risk							0.03	
							p = 0.69	
Idiosyncratic risk 2								6.09^{*}
								p = 0.10
Constant	-1.68	-1.86	-2.67^{***}	-0.38	-1.17	-5.68^{***}	-0.58	-1.76^{*}
	p = 0.38	p = 0.33	p = 0.001	p = 0.56	p = 0.42	p = 0.002	p = 0.48	p = 0.10
N	32	32	32	32	32	32	32	32
R^2	0.61	0.60	0.60	0.32	0.33	0.52	0.33	0.39
Adjusted R^2	0.53	0.54	0.55	0.28	0.26	0.47	0.26	0.32

Note: $^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$

Source: author's calculations

Consequently, complementary regression analyses were performed to identify the best fitting models in the two separate periods (table 26 and table 27). The best fitting model for the first period included price level, unemployment growth, and population; while the best fitting model for the second period included price level, unemployment growth, and wage growth.

The analysis revealed that price level was statistically significant variable at five percent level in both periods, yet it had different signs. During the high growth period, the price level variable was negatively related with the house price returns; while during the low growth period the price level was positively related with the house price returns. The results suggests that during economic growth period less expensive housing markets in London were a better investment in terms of capital gain; while it changed during economic stagnation, when more expensive areas were performing better.

Unemployment growth was statistically significant during the first period at 5 percent level with a negative sign, which indicated that a decrease in unemployment was associated with a faster house price appreciation. The unemployment growth variable retained the negative sign, yet it was not statistically significant at ten percent level during the second period (however, it increased overall goodness of fit of the model, thus it was included in the equation).

Wage growth was a statistically significant variable at five percent level in explaining differences in returns during the economic growth period. Yet, counter intuitively the sign of the variable was negative. A possible explanation could be that employees were commuting to work in other boroughs and thus there was a mismatch in data. Also, it could be that with wages were increasing at almost all wage levels and areas, yet at a lower levels wages were increasing at a slower rate, still a wider population of those who benefitted from a wage increase could have driven house price appreciation in certain areas. Furthermore, it could be that the effect intended to be captured by the unemployment growth variable was already caught by the wage growth variable. Wage growth variable was not significant in the second period.

Population growth variable was statistically significant at 5 percent level and positive during the second period but not the first period.

Table 26. Linear regression results (1997-2007)

	Returns				
	Model I	Model II	Model III	Model IV	Model V
Price level	-7.68**	-6.93**	-7.61**	-6.74**	-7.68**
	p = 0.02	p = 0.02	p = 0.02	p = 0.03	p = 0.02
Unemployment	-0.53	-0.37	-0.47	-0.38	-0.54
	p = 0.11	p = 0.20	p = 0.12	p = 0.22	p = 0.11
Population	1.72***	0.79	1.72***	0.96	1.56**
	p = 0.00	p = 0.18	p = 0.00	p = 0.12	p = 0.03
Volatility		1.00***			
		p = 0.01			
Systematic risk			2.03**		
			p = 0.02		
Idiosyncratic risk				0.19**	
				p = 0.03	
Idiosyncratic risk 2					-1.02
					p = 0.65
Constant	8.42***	7.25***	6.64***	8.47***	8.68***
	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00
N	32	32	32	32	32
R^2	0.36	0.51	0.48	0.47	0.37
Adjusted R^2	0.29	0.44	0.41	0.40	0.27

Note: $^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$

Source: author’s calculations

Table 27. Linear regression results (2008-2014)

	Returns				
	Model I	Model II	Model III	Model IV	Model V
Price level	6.93***	8.61***	5.36***	9.46***	7.38***
	p = 0.00	p = 0.00	p = 0.00	p = 0.00	p = 0.00
Unemployment	-0.82***	-1.07***	-0.66**	-1.10***	-1.03***
	p = 0.01	p = 0.00	p = 0.03	p = 0.00	p = 0.00
Wage	-1.31**	-1.32**	-0.72	-1.17*	-0.62
	p = 0.05	p = 0.04	p = 0.30	p = 0.06	p = 0.31
Volatility		-0.75*			
		p = 0.09			
Systematic risk			3.76*		
			p = 0.08		
Idiosyncratic risk				-0.16**	
				p = 0.02	

Idiosyncratic risk 2					7.50^{***}
					p = 0.01
Constant	-2.67^{***}	-1.22	-5.11^{***}	-2.46^{***}	-4.52^{***}
	p = 0.00	p = 0.27	p = 0.00	p = 0.00	p = 0.00
N	32	32	32	32	32
R^2	0.60	0.64	0.64	0.67	0.70
Adjusted R^2	0.55	0.59	0.59	0.63	0.65

Note: $^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$
Source: author's calculations

Subsequently, spatial diagnostics were performed to investigate whether spatial structure has changed when the split data was analysed. Global Moran's I for the house price returns in the first period from 1997 to 2007 were significant at five percent level and positive (0.26), thus indicating that housing price returns were spatially correlated. For the second period from 2008 to 2014, the coefficient was also statistically significant and positive (0.34). However, Global Moran's I coefficients were also calculated for the residuals of the linear models. This was done in order to check whether spatial correlation among the housing market returns could be captured by independent variables. If it was spatial correlation that could be captured, then spatial structure of the models could be avoided. The residuals of Model I from table 26 and Model I from table 27 were used. For the first period Global Moran's I was 0.05 and it was insignificant, for the 0.1 and it was significant only at ten percent level. Hence, explanatory variables could explain the majority of spatial variability among housing markets returns in London.

Overall, it appears that the price level played an important role in explaining differences in housing market returns. However, different signs in the two analysed periods possibly indicate about changing attitude at a higher priced and lower priced housing markets under different economic conditions. A possible explanation could be that during economic growth period lower priced housing markets were appreciating at a faster rate because the city was expanding and housing markets were gentrified; while during economic slowdown when uncertainty was widespread, there was a capital flight to best areas in order to preserve capital while other asset prices were falling.

4. Summary of the chapter

London housing market returns appear to have spatial dependency which is driven by employment. Thus inclusion of the variable mentioned eliminated the need to apply spatial model structure. It was rather unexpected that more than a half variation in returns among boroughs was explained by changes in unemployment rates.

Overall, it appears that the price level played an important role in explaining differences in housing market returns. However, different signs in the two analysed periods possibly indicate about changing attitude at a higher priced and lower priced housing markets under different economic conditions. A possible explanation could be that during economic growth period lower priced housing markets were appreciating at a faster rate because the city was expanding and housing markets were gentrified; while during economic slowdown when uncertainty was widespread, there was a capital flight to best areas in order to preserve capital while other asset prices were falling.

X. Analysis of volatility in London

The following chapter presents result of the regression analysis of the volatility in London housing market. In the first section, findings of the linear regression analysis are presented. In the second section, the results of spatial diagnostics and spatial regression analysis are provided. In the third section, the analysis was repeated for two separate periods to assess robustness of the results. In the final section, summary of the chapter was provided.

1. Linear regression analysis

We further analyse the volatilities of house price returns in London. Regressions with fundamental factors that should describe differences of the returns volatilities were performed.

The first multiple regression model (Model I) explains close to 0.48 percent average return volatility variation across boroughs in London (table 28). The model includes five explanatory variables representing house price level in the area, unemployment, population, house sales volume, and employment compensation. Employment compensation and house sales volume fail in significantly describing housing markets, this was also the case when volatilities across country were analysed. Model III describes the return volatility with the best fit; the adjusted R squared was equal to 0.50. Breusch-Pagan test was statistically significant at 5 percent level indicating heteroscedasticity problems, however non-constant variance score test was statistically not significant (chi-square 1.40, p-value = 0.24). All explanatory variables and constant were significant at five percent level.

The house price level was statistically significant and positively correlated with the dependent variable. Housing market where price level was higher by one million pounds was related to the returns volatility that was 4.48 standard deviation higher. This means that returns volatility was higher in areas that were more expensive. The finding is opposite to what was found for in a countrywide analysis of volatility.

The coefficient of the wage was statistically significant and negative. One pound higher compensation per employee was related to -0.27 standard deviation lower volatility.

The coefficient of population variable was statistically significant and positive. One percent higher population in an area was related to 0.60 standard deviations higher volatility of the housing returns in the area. This suggests that more populated boroughs had more volatile housing markets. This could be because population increase is related to the slope of the demand curve, and steeper slopes should indicate larger sensitivity price to the changes in housing supply.

Table 28. Multiple linear regression results

	Volatilities		
	Model I	Model II	Model III
Price level, mil. £	4.38**	4.72***	4.48***
	p = 0.02	p = 0.00	p = 0.00
Unemployment	-0.05		
	p = 0.73		
Wage	-0.29**	-0.31***	-0.27***
	p = 0.02	p = 0.01	p = 0.01
Population	0.53***	0.56***	0.60***
	p = 0.00	p = 0.00	p = 0.00
Sales	0.05	0.06	
	p = 0.54	p = 0.43	
Constant	1.31***	1.41***	1.30***
	p = 0.01	p = 0.00	p = 0.00
N	32	32	32
R^2	0.56	0.56	0.55
Adjusted R^2	0.48	0.50	0.50

Note: $^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$
Source: author’s calculations

2. Spatial analysis

As in the analysis of the returns, spatial diagnostics for the volatility data was performed for the purpose to identify spatial patterns. According to visual analysis of Moran’s I plot (figure 67), data were positively spatially correlated. The data points distributed along the line from the bottom left corner to the top right one indicate a positive spatial autocorrelation. This is confirmed by Global Moran's I coefficient for volatility. The coefficient was positive and significant 0.24, and statistically significant at five percent level, which suggests a strong spatial autocorrelation. The models residuals (Model III) were also examined for spatial autocorrelation characteristics. The spatial diagnostics of the residuals indicate that the spatial structure were not present in among volatilities in London. Moran's I plot (figure 68), and positive (0.09), yet it was statistically significant only at ten percent level, which suggests that after controlling for explanatory variables the spatial autocorrelation is rather weak.

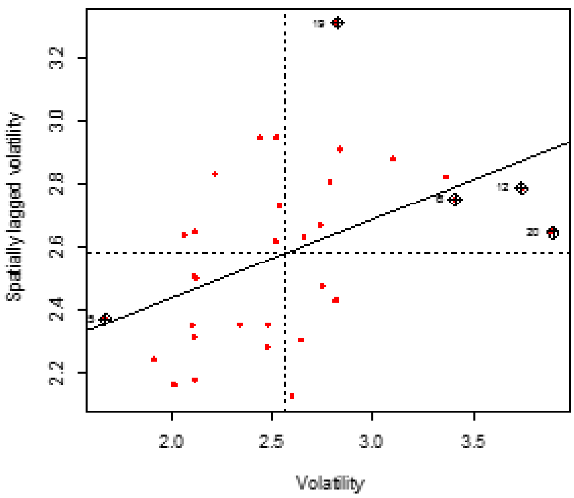


Figure 67. Global Moran's for the house price returns volatility in London

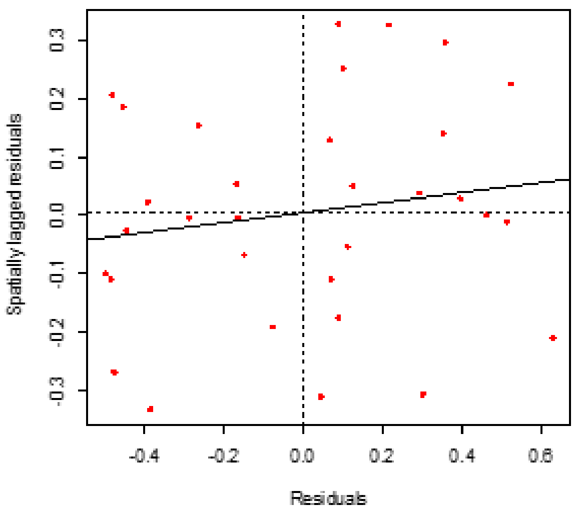


Figure 68. Global Moran's for the residuals of the benchmark regression in London

Source: author's calculations

3. Robustness check

In this section of the study, analysis of the return volatilities was performed on two sets of data. This was done to check the robustness of the model and it provides an insight how housing returns volatility have changed under different economic circumstances. The two data sets that are obtained by splitting the complete data: from 1997 to 2007 and from 2008 to 2014.

The analysis was executed based on all five explanatory variables (Model I), the best fitting model for the whole data set (Model II and Model II for the first and for the second periods), and the best fitting models for the data (Model I and Model III for the first and for the second periods).

The results showed that explanatory power of the models are very similar and relatively high during both periods. The model that fitted the best for the whole period is robust as adjusted coefficients of determination in the first period were 0.38 and 0.40 for the second. Thus, the model explains the variation of volatility in the first period almost as good as for the second period. However, not all the variables were significant at five percent level. In the first period, the price level variable was highly insignificant, while the wage variable was highly insignificant in the second period.

The variable representing population growth was statistically significant at five percent level in both periods and retained a positive coefficient. Overall, the linear model appears to be robust in explaining the housing market volatility, but it explains only around 40 percent of the volatility variation across counties and unitary authorities.

The analysis was proceeded by investigating the spatial structure of the two periods. Likewise, in the returns analysis, spatial diagnostics was performed to check whether spatial structure was comparable in the first and in the second periods.

The results of Global Moran's I indicated that housing price volatility was highly spatially correlated in both time streaks. In the first period, the Moran's I coefficient was 0.27 and was statistically significant at five percent level (p-value=0.00). In the second period, the coefficient was 0.19 and was statistically significant at five percent level (p-value=0.02). However, when the residuals of the linear models of the Model II had only weak spatial structure. In the first period, the Moran's I coefficient was 0.09 and was statistically significant only at ten percent level (p-value=0.07). In the second period, the coefficient was 0.09 and also was statistically significant at ten percent level (p-value=0.06). Thus indicating that spatial structure of the volatilities was diminishing when controlling for other impacts.

Table 29. Multiple linear regression results (1997-2007; 2008-2014)

	Volatilities 1997-2007 Model I	 Model II	 2008-2014 Model I	 Model II	 Model III
Price level, mil. £	1.84	-0.1	3.03**	3.90***	2.25***
	p = 0.26	p = 0.94	p = 0.02	p = 0.00	p = 0.00
Unemployment	-0.19		-0.21		-0.33***
	p = 0.20		p = 0.27		p = 0.00
Wage	-0.30***	-0.20*	-0.06	-0.08	
	p = 0.01	p = 0.07	p = 0.86	p = 0.78	
Population	0.68**	0.92***	0.53	1.01**	
	p = 0.02	p = 0.00	p = 0.37	p = 0.02	
Sales	0.20**		-0.09		
	p = 0.02		p = 0.57		
Constant	1.21**	1.88***	1.12	0.63	1.94***
	p = 0.02	p = 0.00	p = 0.18	p = 0.30	p = 0.00
N	32	32	32	32	32
R^2	0.56	0.44	0.49	0.46	0.46
Adj. R^2	0.48	0.38	0.39	0.40	0.42

Note: $^{***}p < .01$; $^{**}p < .05$; $^{*}p < .1$

Source: author's calculations

4. Summary of the chapter

Spatial dependency of the volatilities in London housing market could be explained by other factors. It seems that three explanatory factors, price level, population, and wages could explain enough spatial dependency to eliminate the need of its application. However, also the variables mentioned must be reconsidered as they appeared not to be robust.

XI. Discussion

In this chapter we overview and discuss the objectives and findings of the study, as well as mention limitations and recommendations for the future research.

1. Discussion of the results

The this chapter the above findings on house price returns and volatilities among English and Welsh housing markets, as well as, findings among housing markets in London are discussed and recommendation for further research are provided.

The analysis of the house price returns is a relatively common subject, while there are few studies, which investigate volatilities. Residential real estate market is important factor of the economy, which results that many parties are concerned about house price returns and volatilities, as abrupt changes in house prices could affect their stability, e.g. households' consumption, home ownership rate, individual savings and investments. This study examines house price returns and volatilities of the returns in residential markets in England and Wales at a county/unitary authority level for the period from 1997 to 2014. A variety of data is used in order to explain house price performance. The data is analysed by employing descriptive statistics, linear regression models, spatial diagnostics, and spatial econometrics. Models assess for the significance and magnitude of the coefficients in order to describe return and return risk distribution across the markets. Additionally, direct and indirect spatial impacts are calculated to enrich the interpretation.

In the study, relatively much attention is given for the spatial analysis methods and geographical representation of the housing market performance indicators. Previous studies showed that when analysing real estate spatial econometrics could provide efficiency, simplicity, and accuracy, yet there are relatively few studies in real estate economics, which analyses housing market returns and employs spatial econometrics. The study tries to exploit spatial diagnostics and spatial econometrics in housing market examination. We investigate whether spatial econometrics could improve the analysis of residential real estate and consequently real estate investments decision making. It is examined whether spatial models provide any value in the housing market volatility analysis and consequently in risk diversification of the real estate portfolio. We also investigate how house price returns risk is distributed within the English and Welsh real estate market. Furthermore, we analyse how house price determinants, such as economic environment or demographics, affect risk distribution across the country.

The results showed that spatial analysis could be beneficial in residential real estate investment decision-making. Spatial modelling structure was useful in analysing English and Welsh housing markets but not London housing market. This could be due to London boroughs better capturing socioeconomic processes than unitary authorities or counties. While there certainly exists social and economic diffusion in London boroughs, it could be that very close links cause housing returns driving factors to change almost simultaneously across the city, thus preventing to capture spatial structure.

English and Welsh housing markets have shown to possess spatial lag structure, which indicates dependency on characteristics of a neighbouring area and diffusion process. Thus by applying the spatial models for the data analysis provided more efficient and less biased estimations. The analysis above showed that ignoring spatial structure mostly provided inflated results.

Spatial econometrics could improve real estate investments decision-making because housing markets in England and Wales were proven to contain spatial patterns when assessing both house price returns and house price returns volatilities. While spatial equations compared to linear ones have not showed many changes in statistical significance or signs of the explanatory coefficients, without including spatial structure in the regressions, the coefficient estimates often were less accurate, and the magnitudes of the coefficients were overestimated and, in most cases, inflated. Spatial models provided extra information about the returns and risk not only in terms that the coefficients are more accurate; spatial structure revealed that house sales volume growth was not statistically significant in explaining house price returns. The finding of existence of spatial patterns in real estate, and more specifically in housing markets in the UK, were expected. Spatial connections in real estate markets were already analysed in previous studies; using various methodologies, many of them confirm the results (Meen, 1999; Hayunga & Pace, 2010; Ferrari & Rae, 2013; Gray, 2012).

Furthermore, volatility and returns were shown to be related, yet unconventional and contrary to Modern portfolio theory (Markowitz, 1952), the relationship among the variables were negative. Usually higher volatility, which should indicate higher risk, is related to higher returns because investors should request more profit from riskier investment. Apparently, this is not the case in English and Welsh housing markets. This could be due to several reasons. The analysed period was relatively short and covered a very long house price growth period. Also, it could be that not all relevant housing market factors were included in explaining returns, which could have changed the relationship. Moreover, the theory may not be applicable for the English and Welsh housing market or there could be issues with the data. Finally, housing market investors could account risk in different terms or consider other risk factors as more important, e.g. housing market liquidity.

The volatility in England and Wales had the same statistically significant determinants, yet with opposite signs of the coefficients. In addition, returns and volatilities had unconventional oppositely correlated relationship. A decrease in volatility by 1 percent is related with a return higher 0.11 percent. This is an interesting development indicating that risk and return trade off concept is not applicable in English and Welsh housing market. Theoretically, investors should act oppositely to the concept and simultaneously increase their potential returns and reduce the investment risk. Cannon *et al.* (2006) in with somewhat similar equations researched risk and return relationship in the U.S. in a cross sectional setting and found a robust positive correlations among the two variables even after incorporating multiple socioeconomic variables. However, in our study London housing market does have a positive risk and return relationship. Thus while London contradicts risk and return trade off by having high returns and low risk, within the London the contradiction does not work. This is an interesting finding opening questions for further research to investigate the causes of differences.

In theory, higher risk should represent higher returns (the relationship appears to be conventional in Wales, yet actions in England outweighs the results, because England and Wales are treated as an integral entity). This means that homebuyers in England and Wales were not rewarded for taking risk. While the unconventional relationship remains a puzzle, a negative risk and returns relationship in housing market has been documented in research before (e.g. Han, 2013; Miles, 2008) and was often grounded on low supply in growing markets. While the results of this study confirmed that lower volatility was related with the conditions, which suggests tighter housing market supply (e.g. higher population and price level), there is not enough evidence to make a strong conclusion.

Returns and risk relationship in the housing market could also be a result of homebuyers tolerating lower house price returns in exchange for other gains - for example, a benefit of hedging against housing price increase. The role is, in particular, sensitive in an environment that combines "climbing the ladder" and owning-a-home culture with long, consecutive house price growth, high house prices, increasing population, and increasing house sales volume. The hedging price in such an environment should be higher. The analysis above confirms that population growth and high house prices do have a positive correlation with returns. "…declining and slow-growing markets always exhibit a significant and positive risk-return relationship, suggesting a strong financial risk effect. In contrast, in fast-growing markets, the financial risk and consumption hedge effects are found to be simultaneously present, with the relative strength of the latter being determined by local hedging incentives and housing supply constraints” (Han, 2013, p.g.881). Moreover, it could be that a constantly growing housing market creates a false impression for the investors, who then ignore conventional wisdom. Consequently, a negative risk-return relationship could indicate an unsustainable market. This partly is confirmed by the way many variables fail to hold significance for the period during financial crisis.

Furthermore, house market returns and risk were shown having to be spatially clustered into southern eastern counties and unitary authorities, Wales, and the rest of the country. Areas having higher housing market returns were frequently clustered in the southern eastern of the country, while markets in the northern England more often possessed lower housing market returns. In a similar way, markets that are more volatile were clustered in the north of England and Wales, while the markets in the south of England were less volatile. The findings are also in line with the previous studies that documented South-North division of England in economics and real estate markets (Hincks et al., 2013; Rowthorn, 2010; Tsai, 2014).

Additionally, volatility of the house price returns could be caused by a poor data. In a shallow market house price indices could be more volatile just because there is a lack of comparable house sales transactions.

The above analysis indicates that house price level, and population were statistically significant in explaining returns across housing markets and had positive coefficients. The unemployment rate was also statistically significant and had negative coefficients. This is in line with the findings in the literature review part. Multiple real estate economics studies, have found that economic variables, which often also indicates the general health of the economy, also drives residential real estate prices and has an impact on price volatility. In the same way, demographic factors are also are generally accepted as being major drivers in the residential real estate markets. Demographic factors have a positive impact for the house price development because they are related to higher amount of households or larger space required. However, the models investigated were lacking robust explanatory variable under different economic environment conditions. The only robust variable was the unemployment rate, which retained negative coefficients under different economic circumstance. In the analysis of volatilities across the markets, population growth was the sole robust variable. On the other hand, the proven socioeconomic explanatory variables have proved to be sound factors, even in when conditions have changed due to the largest financial crisis.

In general, cross sectional variation of housing market returns were explained relatively well by fundamental variables. Higher population growth, higher house price level, and lower unemployment were factors that were related with the higher housing market returns. Increasing population indicates increasing demand for housing and, thus, if all other factors are held constant, housing prices are raising. Higher house price level suggests that there is a steeper supply curve in the housing market and, thus, house prices react more sensitive if demand factors change (due to supply limitations in real estate market, it is assumed that supply curve should be convex). Moreover, house price level indicates the wealth of people living in the area, and richer people may be less sensitive for economic fluctuations. Unemployment factor also influences demand side, as it represents economic conditions in an area. A drop in unemployment rate suggests improving economic conditions, raising household income and consequently more investment in housing.

A positive relationship among house price level and returns suggests about the on-going polarization in English and Welsh housing markets. The relationship shows that house prices in the areas that were more expensive were increasing at a faster rate compared to the house prices in the less expensive areas. Moreover, the polarization is not only in the housing market. If assumed that households in the more expensive areas already are richer, then different house price growth rates increases the gap between wealthier and poorer households. This may have implications on personal portfolio formation and balanced economic growth policies. It could be that market polarization was stimulated by intentions to preserve money during a period of decreasing economy when there was a lack of alternative investment opportunities and houses in solid areas seemed enough good investment to preserve value.

Additionally, housing market dynamics and unemployment in the neighbouring areas also had significant impacts. Higher house price returns in the neighbouring areas were associated with higher house price returns in the observed area. Yet, higher unemployment in the neighbouring areas was positively associated with the housing market returns in the observed area, which is against immediate economic logic.

While volatility was found having a negative correlation with the returns of housing markets in England and Wales, it is questionable whether it may remain as a risk measure when assessing housing markets. It seems that volatility could capture some unwanted specifics of housing markets. When assessed, volatility with the similar variables as in house price returns analysis (except for spatially lagged returns and spatially lagged unemployment) were also statistically significant in explaining house price returns volatility, yet the totally explanatory power was lower. Counties and unitary authorities that observed more rapid population growth, better economic conditions, and higher house price level were less volatile. Furthermore, lower volatility in neighbouring housing market also contributed to the lower volatility in the observed area. These findings suggest that volatility not only depends on the geographical situation of a county or unitary authority, but also from economic and demographic conditions.

The signs of the variables indicated that areas that had worse fundamentals had more volatile house price returns. A possible explanation of higher unemployment could be that higher volatility was caused by less stable rent cash flows (or households' expenses allocated to housing). Moreover, areas with higher house price levels could indicate that an area is populated by wealthier people whose housing market expenses are less exposed to fluctuations. It could be easier for the wealthier to cover housing expenses from other resources if, for example, their employment income decreases. Finally, a negative population coefficient could indicate lower exposure for thin market effect. Higher population indicates that there more buyers and sellers at any moment; thus, chances for huge price fluctuations are lower.

The analyses also have showed that the two different growth periods had an effect on the coefficient explaining housing returns and volatilities. Not all the coefficients were statistically significant during both growth periods. Price level was significant in explaining housing returns only during the low growth period. A possible explanation for this could be that wealthier people were seeing real estate as a safe asset in times when other assets were performing poorly and when interest rates were low. Moreover, in a declining economic environment, when house prices were declining, poorer households had less flexibility to wait out the absence of homebuyers and were forced to reduce prices. Interestingly, population was statistically significant in a linear regression in both periods, yet spatial structure had reduced the significance in both periods, thus indicating that the two variables partly captured similar effects. It could be that neighbouring regions near areas that had faster growing populations were observing higher returns. On the other hand, population growth (or causes that influenced population growth) could have been regional, but not counties of unitary authorities characteristic. For example, southern areas were observing better economic conditions, thus some of their areas had higher levels of population growth. Unemployment rate proved to be a consistent explanatory factor in explaining the variation of housing returns, even after a robustness check. Finally, spatial structure of the returns also remained significant in both growth periods. The stability of spatial structure over both periods is additional argument to use spatial statistics in real estate analysis.

The robustness test for house returns volatility had also revealed some instability. House price level was shown to be consistent variable in explaining housing returns volatility. Population growth was also significant in both periods in linear regressions, yet introducing spatial structure reduced the statistical significance of the variable in the low growth period. In a similar style as the returns explanation, it could be that some regions observed better economic or other conditions that caused lower house price volatility and, simultaneously, certain areas in these areas observed attractive higher population growth. Unemployment also had mixed results depending on spatial and linear structure of the analysis. Finally, spatially lagged volatility variables were consistent, and significantly explained volatility during high growth and low growth periods.

The robustness check of the results call into questioning some of the findings. The second period, which also includes the most recent housing market crash, does not seem to be explained by many of the variables. Even more, the specific spatial structure of the model does not seem to hold (yet it could be more of the variable fault). Still, the robustness check confirms that strong spatial patterns for returns and volatilities are consistent, and that spatial econometrics has to be applied for the investigation of housing markets results.

Moreover, compensation for employee work unexpectedly does not significantly affect returns. This may have to do much with the English and Welsh housing market specifics as many coastal areas, which attract holiday homebuyers and have relatively low average salaries. Thus, house price growth and level in some places do not match with the economic development of an area, and thus disturb the results - for example, some counties and unitary authorities in Wales and Cornwall. Paris (2009) noted that second-homebuyers have significantly contributed to the transformation of the countryside and coastal villages into gentrified leisure sites in the UK. Welsh housing market in the presence of second-homebuyers is extensively discussed by Gallent *et al.* (2003). They noted that second homebuyers from outside of Wales buy homes in the area for what is - for them – a relatively low price, and distort local housing market. While, at the same time, second-homebuyers make it more difficult for local resident to acquire homes, as their possessed wealth is relatively low due to rural Welsh economy.

2. Implications of the results

Spatial lag in English and Welsh housing markets suggests that there is housing market returns diffusion. According to calculation in the above if house price return on average in neighbouring areas increase by 1 percent, this is associated with an increase in house price returns from 0.55 to 0.69 to percent. The existing spatial structure has a wide ranging implications.

Firstly, for the macroeconomic policy makers. As it was shown in the literature review chapter that there are links between housing market and wellbeing of the general economy. The possible diffusion indicates that housing market is connected and economic shocks eventually could affect all the market. Thus making economy vulnerable even for local housing market shocks. This should be kept in mind when making macroprudential decisions to prevent asset price bubble growth in a specific area. If the diffusion exists, it is more difficult to target, for example London housing market and not to make an effect on the neighbouring housing market areas. On the other hand, the same links could be exploited monetary policy decision makers who want to as inverse effect.

Secondly, for targeting homeownership rate. While high house ownership rate is desirable status for the economy overall remains an open question. In the Literature review it was shown that homeownership could be affected by changes in house price volatility. As it was showed in the above calculations, an increase in volatility of neighbouring areas on average by 1 percent leads to an increase in the volatility of the observed area by 0.57

percent. Thus it could be that via returns and volatilities, a desire to own a home also could be spatially dependent.

Thirdly, a possible housing return diffusion could be a path for the increased consumption via higher wealth effect. Furthermore, a diffusion caused wealth effect may have an impact on wealth's distribution.

Fourthly, as housing market and migration are mutually dependent. Consequently, the spread of volatility in house prices may affect people's decisions to move to a particular area. A strong housing market may be attractive and repulsive for migration, depending individual household preferences.

Finally, our finding may have various implication in personal portfolio formation. A popular concept of climbing the ladder, if it is targeted for a specific market is not supported. A better way would be purchasing a house in a low risk and high return area, as it inverse risk and return trade off suggest. Even more, it would still provide 'insurance' against house price increase in the area because of housing returns diffusion. On the other hand, a person should consider a strong positive housing market return correlation with economic factors, such as wages and employment. If person risks unemployment of a decrease in salary during economic downturn, additional pro cyclical investment in housing should be reconsidered.

3. Limitations and recommendations for the future research

The estimates, results, and interpretations of the study should be accepted with caution, because the research was limited in several ways. The research includes relatively short time period from 1997 to 2014. The findings could be very time specific and not be applicable for the future. Partly, it is confirmed by the robustness check that disproved the significance of many explanatory variables of returns and volatilities in different observed periods.

Furthermore, some information was lost while performing analysis only in cross sections and taking averages of some information. Cross sectional analysis requires aggregation of the data, which causes loss of some information. Hence, some variables that were constructed for the analysis from more frequent data may not reflect a complete view, and occasionally may suggest inaccurate or incorrect results.

Additionally, data that are more comprehensive could be used in explaining return and volatility variation. As was indicated by economic literature or relatively low explanatory power of some equations, it is very likely that some important factors are missing in the explanations. The author would recommend including leverage and rent data as explanatory variables in the future research for a better representation of the volatility and return variation across the counties and unitary authorities.

Some of the significant variables may indicate that part of the returns volatility could be caused by poor data. Houses are not frequently traded assets, so one may assume that standard deviation of the monthly returns does not represent actual market volatility, but may be due to the inaccuracy of an index that tries to follow prices of thousands of assets with very different qualities. Larger populations are all related with the amount of transactions performed in the market. If there are more transactions, it is easier to accurately estimate house price indices and probably with fewer deviations. Repeat sales house index models like the one that is used for Land registry indices require many transactions. The absence of transactions may disturb the index calculation, making it more volatile. Still, more transactions may indicate that buyers and sellers are able to find each other faster, thus avoiding reducing selling or increasing buying price.

Moreover, the chosen way of weight matrix construction does not necessary represent the existing social and economic processes. The weights could reflect a wide variety of relations, e.g. trade amount between the subjects, border lengths, travelling time. Additionally, the weights may be arranged in different ways, e.g. “n” nearest observations,

observations within particular distance, and all observations. Alternative methods could be used capture spatial dependency of the housing market data.

Additionally, instead of computing direct and indirect effects. The model could include matrices of a several multiple order contiguities that could potential capture and separate direct and indirect effects.

Furthermore, different risk measures and asset pricing methods could be applied. Asset pricing methods for equity market already has developed from single factor CAPM model to three factor (see Fama & French 2004) or four factor models (see Carhart 1997). While there were aims to find multifactor models for the real estate, a widely accepted one is yet to be discovered.

Additionally, alternative regression analysis methods could have. For example a spatial and time varying data could be analysed using panel data setting (for example see Guirguis, Giannikos, & Garcia, 2007; Hossain & Latif, 2009; Miles, 2011; I.-C. Tsai & Chen, 2009; I. C. Tsai, Chen, & Ma, 2008) or spatial panel data setting (for example Zhu, Füss, & Rottke, 2013).

XII. Conclusion

Tobler (1970, p.236) noted that everything is related to everything else, but near things are more related than distant things. This quote could be applied to many things, including economy, thus, when analysing economic relationships geography, should be taken into account. Furthermore, particular locations have effects on economic relationships. The role of agglomerations, concentrations of industries, distance and size of the economies are widely discussed subjects by world famous economists (e.g. see P. Krugman, 1990; P. R. Krugman, 1991; Fujita, Krugman, & Venables, 2001). Consequently, it is difficult to overestimate the importance of geography in economics. Geography plays an important role in the economy and especially if real estate is included.

House price changes has an impact on a wide range of issues, starting from the macroeconomic stability of a country, household consumption, mortgage pricing, and ending with the amount of divorces (e.g. Farnham *et al.* 2011). The risk of residential real estate markets is a very under-researched subject. While most of the investment products are analysed through the perspective of returns and risks, residential properties are often left behind. This is because residential properties are primarily seen as a consumption product but not an investment (for comparison, commercial real estate, which is often being seen as investment product, is more researched, especially larger stocks that have a demand among institutional investors).

With the subsequent analysis, we set several goals: investigate whether spatial econometrics could improve the analysis of residential real estate and consequently real estate investments decision making and examine whether spatial models provide any value in the housing market volatility analysis. The objectives were accomplished. The findings are presented in this chapter in a following way.

This research investigated house price returns and house price risk in England and Wales from spatial perspective in a period from 1997 to 2014. The study employs economic and demographic variables as well as spatial econometrics, trying to explain differences in housing market returns and risks among English and Welsh counties and unitary authorities. The research reveals that differences among counties and unitary authorities in risk and returns could be partly explained by real estate market fundamentals. Price level, unemployment, and population were found significant in explaining housing market returns and risks. Additionally, spatial structure was also significant in defining returns and risks. However, much more variation in returns was explained compared to risk. Moreover, the analysis on two different periods revealed that the effects of the variables are different in different economic environments. Furthermore, risk variables were found to be a statistically significant variable in explaining house price returns, yet the signs of risk variables appear to be unconventional and contradicting thinking, which is based on Modern portfolio theory (Markowitz, 1952). On the one hand, the inverse relationship could be a proof that Modern portfolio theory does not apply to housing markets in England and Wales. On the other hand, it could be that the markets are distorted and funds invested in it are misallocated. Partly, the misallocation could be indicated by significant price level and returns relationship, which shows that more expensive housing areas are getting even more relatively expensive. The misallocation of funds could be caused by homebuyers' irrationality or momentum. Yet, partly, the increasing price level gap could be rational. As it was shown in the graphs, southern counties and unitary authorities have higher house price levels, yet economy is developing relatively better there compared to the rest of the country.

English and Welsh housing markets have shown to possess spatial lag structure, which indicates dependency on characteristics of a neighbouring area and diffusion process. Thus by applying the spatial models for the data analysis provided more efficient and less biased estimations. The analysis above showed that ignoring spatial structure mostly provided inflated results. Spatial structure appeared to be very consistent in explaining house price returns and risks. While the statistical significance of other explanatory factors varied when the regression equation was applied for different time periods, the lagged returns and volatility variables were statistically significant and consistent even when split periods were analysed. Thus, spatial econometrics proved to be useful in exploiting data and gaining richer explanation of the housing markets. The results indicated that without using spatial econometrics, the coefficients of the explanatory models could be inflated in many cases. This could help in an investment decision making in adequately estimating driving factors.

Housing market returns analysis is relatively frequent topic among real estate economists, yet there is a scarcity of research on the analysis of risk, and house price risk and returns relationships. It is important to analyse the risk and returns together, because houses are not only a consumption product but also an investment, and in most cases constitute the largest portions of assets for a household. Additionally, the results of the study could be used for further understanding of residential property markets. It may help in a direct investment decision-making process as well as in indirect investment, such as mortgage pricing. Furthermore, the research brings awareness of real estate analysis estimation biases caused by spatial autocorrelation. The analysis showed that, often, coefficients were inflated if spatial patterns of the data were not accounted.

However, the results of the study should be considered cautiously. The analyses was missing some important housing market factors, such as mortgage or rent data. Also, some information was lost due to data aggregation in time. Finally, the analysed period was relatively short for real estate markets.

XIII. References

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XIV. Appendix: Market returns and risk free rates

Date	10 year Real Zero Coupon	England & Wales	London
1997Q1	3.39	1.31	3.26
1997Q2	3.60	2.69	6.77
1997Q3	3.58	1.92	2.57
1997Q4	3.20	1.18	2.91
1998Q1	3.05	0.84	1.80
1998Q2	2.89	2.16	4.49
1998Q3	2.68	0.21	0.96
1998Q4	2.40	0.07	0.37
1999Q1	1.91	1.01	2.22
1999Q2	1.82	3.77	7.10
1999Q3	2.14	3.13	6.17
1999Q4	2.11	3.91	5.62
2000Q1	2.11	3.27	6.58
2000Q2	2.11	3.37	4.00
2000Q3	2.21	-0.16	-0.80
2000Q4	2.29	2.17	1.90
2001Q1	2.23	1.80	2.22
2001Q2	2.56	3.70	4.47
2001Q3	2.49	2.54	3.22
2001Q4	2.49	2.35	1.89
2002Q1	2.49	3.82	2.98
2002Q2	2.39	7.92	6.62
2002Q3	2.30	4.69	4.24
2002Q4	2.36	4.95	3.60
2003Q1	1.91	2.18	0.74
2003Q2	1.79	3.80	0.09
2003Q3	1.94	2.18	0.31
2003Q4	2.13	3.11	1.30
2004Q1	1.90	3.78	1.33
2004Q2	2.03	5.14	3.61
2004Q3	2.03	1.74	0.64
2004Q4	1.84	-1.00	-1.59
2005Q1	1.80	0.56	-1.45
2005Q2	1.70	0.56	1.01
2005Q3	1.59	-0.45	0.44
2005Q4	1.53	0.28	-0.08
2006Q1	1.35	1.12	0.77
2006Q2	1.62	0.90	2.70
2006Q3	1.56	1.25	2.77
2006Q4	1.53	1.56	2.91
2007Q1	1.76	1.51	2.93
2007Q2	2.06	2.34	4.79
2007Q3	1.99	0.18	1.28
2007Q4	1.58	-1.16	-0.13
2008Q1	1.23	-2.71	-2.78

Continued			
2008Q2	1.31	-4.04	-3.37
2008Q3	1.24	-7.06	-7.96
2008Q4	2.26	-4.72	-4.39
2009Q1	1.32	-3.25	-2.99
2009Q2	1.09	2.20	3.18
2009Q3	1.15	1.68	3.06
2009Q4	0.76	0.83	3.22
2010Q1	0.87	-0.50	-0.98
2010Q2	0.73	1.30	2.62
2010Q3	0.65	-1.66	-1.65
2010Q4	0.51	-3.55	-1.87
2011Q1	0.63	-1.94	-1.04
2011Q2	0.40	0.62	1.41
2011Q3	-0.06	-2.59	-2.59
2011Q4	-0.30	-0.44	1.31
2012Q1	-0.57	-1.14	0.66
2012Q2	-0.62	2.46	3.91
2012Q3	-0.67	-2.60	-2.27
2012Q4	-0.64	-0.36	1.79
2013Q1	-1.02	-0.72	0.01
2013Q2	-1.02	2.44	3.97
2013Q3	-0.40	-0.26	0.39
2013Q4	-0.30	1.43	4.84
2014Q1	-0.22	1.06	3.84
2014Q2	-0.35	3.67	6.53
2014Q3	-0.44	-0.16	0.12
2014Q4	-0.76	1.42	1.18

Sources: Land registry, Bloomberg, and author’s calculations