CORRELATION ANALYSIS OF HOUSING PRICES AND ECONOMIC INDICATORS

by

Hamza Altınsoy

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ABSTRACT

CORRELATION ANALYSIS OF HOUSING PRICES AND ECONOMIC INDICATORS

In this thesis, we analyzed the effects of economic indicators on house prices in eighteen countries. The economic indicators, which we used, are Gross Domestic Product (GDP), population, Consumer Price Index (CPI) and Retail Price Index (RPI). By using the statistical programme SVM (Support Vector Machine), we found clusters which show similar distributions of house prices under the effect of GDP and population. Furthermore, we found equations that relate house prices of countries to their CPI and RPI values and we tested these equations statistically using the software Eviews.

ÖZET

EV FİYATLARI VE EKONOMİK GÖSTERGELERİN KORELASYON ANALİZİ

Bu tezde, bazı iktisadi göstergelerin ev fiyatları üzerindeki etkisi onsekiz ülke için incelenmiştir. İlgilenilen iktisadi göstegeler Gayri Safi Milli Hasıla (GSMH), nüfus, Tüketici Fiyat İndeksi (TFİ) ve Perakende Fiyat İndeksidir (PFİ). SVM adlı istatistik yazılımı kullanılarak, GSMH ve nüfusun etkisi altında ev fiyatlarının benzer dağılım gösterdiği ülke öbekleri oluşturulmuştur. Ayrca ülkelerin ev fiyatlarını Tüketici Fiyat İndeksi ve Perakende Fiyat İndeksiyle ilişkilendiren denklemler türetilmiş ve bu denklemler Eviews adlı istatistik yazılımı ile test edilmiştir.

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1. INTRODUCTION

Econophysics is an interdisciplinary research field,in order to solve problems in economics applying theories and methods originally developed by physicists , usually those including uncertainty or stochastic elements and nonlinear dynamics. Its application to the study of financial markets has also been termed statistical finance referring to its roots in statistical physics.

Basic tools of econophysics are probabilistic and statistical methods often taken from statistical physics.

Econophysics was started in the mid 1990's by several physicists working in the subfield of statistical mechanics. They decided to tackle the complex problems posed by economics, especially by financial markets. Unsatisfied with the traditional explanations of economists, they applied tools and methods from physics; first to try to match financial data sets, and then to explain more general economic phenomena.

One driving force behind econophysics arising at this time was the availability of huge amounts of financial data, starting in the 1980's. It became apparent that traditional methods of analysis were insufficient - standard economic methods dealt with homogeneous agents and equilibrium, while many of the more interesting phenomena in financial markets fundamentally depended on heterogeneous agents and far-from-equilibrium situations.

Housing is an important necessity for human beings to live, as a result of this, house price is a very interesting topic of research. There were several investigations about average house prices of a city, town or a country or about effects of house prices on other economic parameters. There are lots of topics for research such as house price bubbles, the effects of house price changes on the economy of a country, the effects of economic parameters on house price changes and the effect of conditions of houses such as having swimming pool, being near the center of the city, being new or old building, on the house prices.

Up to now physicists have investigated the mechanisms of the change of house prices [1], [2]. However there has been no research on effect of macroeconomic parameters on the house prices. We first tried to determine the macroeconomic parameters that may affect house prices using economic theory and we tried to analyze the significance of these parameters using the methods of statistical physics. We also tried to group the countries that we analyzed according to the pattern of the effects of these parameters.

In the first analysis, we used two parameters which trigger the house price changes and also the amount, comfort and solidity of houses.

One of them is Gross Domestic Product (GDP) which symbolizes the richness of a country and shows the life standard in this country. GDP parameter is the most significant variable which affects the people's willing to live more comfortably according to the economists.

The other one is population of a country which is the first and essential factor for the amount of houses in a country.

In some countries, the effect of these economic parameters on house price changes has the same pattern. We found some clusters that contains expected countries in it. The surprising result comes from the most best fit cluster which we didn't estimate but obtained during the analysis.

According to some physicists, the house price fluctuations and further peaks can be estimated by observing their previous peaks and prices. They used some statistical methods to find the relationship between the previous and future peaks and found a specific formula.

They claim that this formula can be used to estimate house price bubbles of developed countries. They found very surprising results for two cities and a specific part of a country. We used this method and formula for several countries and all cities of UK to find their bubble prices if we can.

We derived new formulas. By using them, we can estimate average house prices of a country or a city. Furthermore, we can find the relationship between the Consumer Price Indices (CPI's) and average house prices of a country and obtained a house price equation for some countries and cities. Also we can estimate the future peak price of a specific country. After the average house price reaches this peak value, it starts to fall.

In the background section, we gave definitions of some economic variables which we used in our research. Then, we gave some information about the statistical computer programmes which we used in our research. Finally, we stated the comments and claims of physicists and economists which triggered us to make such a research and use these methods, programmes and economic parameters.

We separated the third chapter into two sections. In the first section, we did our calculations and used Support Vector Machine (SVM) algorithm and our formulas to answer the question: "Are there any countries which established a cluster according to their three economic parameters; GDP, population and house price?"

In the second section, we tried several formulas to find most appropriate parameter to estimate the house price equation of a country. Then, we continued our research by trying other formulas which we can make some estimations about house prices of specific countries.

In the forth section, we showed several clusters which we expected. We used the SVM on our expected clusters, and found the real clusters. After this analysis we reached our first conclusions. Next, we used Eviews to estimate equations and after collecting the results of this program, we made different estimations.

In the conclusion, we summarized our research and briefly gave our comments about our results. Also, we gave information about the further topics which can be continued in later investigations.

2. BACKGROUND

2.1. Macroeconomic Definitions

In the following paragraphs, we state the definitions which are essential to understand the subject but we do not go into the details.

Gross Domestic Product (GDP): It is defined as the total market value of all final goods and services produced within a given country in a given period of time. It is also considered the sum of value added at every stage of production of all final goods and services produced within a country in a given period of time, and it is given a money value. GDP can be measured by adding consumption,gross investment,government spending,exports and subtracting imports.

Consumer Price Index (CPI): It is a price index for the goods purchased by consumers in an economy, usually based on only a small sample of what they consume. Commonly used to measure inflation.

Inflation: It is the increase in the overall price level of an economy, usually as measured by the CPI or by the implicit price deflator.

Income: It is the amount of money (nominal or real) received by a person, household, or other economic unit per unit time in return for services provided or goods sold.

Income Elasticity: It is normally the income elasticity of demand; that is, the elasticity of demand with respect to income.

Price Elasticity: It is the elasticity of supply or demand with respect to price.

The Real GDP: It is the real counterpart to nominal GDP, which is the GDP measured in terms of money, obtained by valuing output in a given year at prices from another year, called the base year.

Interest Rate: The rate of return on bonds, loans, or deposits. When one speaks of "the" interest rate, it is usually in a model where there is only one.

Real Estate It is a term that encompasses land along with anything permanently affixed to the land, such as buildings, specifically property that is stationary, or fixed in location.

Rental Price: The payment per unit time for the services of a unit of a factor of production, such as land or capital.

Recession: It is a significant decline in economic activity.

Bubble: A rise in the price of an asset based not on the current or prospective income that it provides but solely on expectations by market participants that the price will rise in the future. When those expectations cease, the bubble is said to be burst and the price falls rapidly.

Real Estate Bubble or Property Bubble (or Housing Bubble for Residential Markets): It is a type of economic bubble that occurs periodically in local or global real estate markets. It is characterized by rapid increases in valuations of real property such as housing until they reach unsustainable levels relative to income and other economic elements.

Retail Price Index(RPI): The traditional measure of inflation in the UK for many years was the Retail Price Index, which was first calculated in the early 20th Century Initially, the target was based on the RPIX, which is the RPI calculated excluding mortgage interest payments. This was felt to be a better measure of the effectiveness of macroeconomic policy. It was argued that if interest rates are used to curb inflation, then including mortgage payments in the inflation measure would be misleading.

2.2. Software and Algorithms Used

The main tool that we used in data analysis is the “Support Vector Machine” (SVM). SVM is a set of related supervised learning methods used for classification and regression. It belongs to a family of generalized linear classifiers. A special property of SVM is that it simultaneously minimizes the empirical classification error and maximizes the geometric margin; hence it is also known as a maximum margin classifier. Viewing the input data as two sets of vectors in an n-dimensional space, an SVM will construct a separating hypersurface in that space, one which maximizes the ”margin” between the two data sets. To calculate the margin, we construct two parallel hypersurface , one on each side of the separating one, which are ”pushed up against” the two data sets. Intuitively, a good separation is achieved by the hyperplane that has the largest distance to the neighboring data points of both classes. The hope is that, the larger the margin or distance between these parallel hypersurfaces, the better the generalization error of the classifier will be.

The second statistical tool that we used is Evievs. Eviews is a statistical package, used mainly for econometric analysis. Eviews can be used for general statistical analysis and econometric analysis, such as cross-section and panel data analysis and time series estimation and forecasting.

2.3. Previous Research on the Subject

Many articles have been written about the house price bubble phenomenon. One of them is the research of W. Zhou and D. Sornette [1]. They analyzed 27 house price indices of Las Vegas from June 1983 to March 2005, corresponding to 27 different zip codes. This analysis confirmed the existence of a real estate bubble, defined as a price acceleration faster than exponential, which was found, however, to be confined to a rather limited time interval in the recent past from approximately 2003 to mid-2004 and has progressively transformed into a more normal growth rate comparable to pre-bubble levels in 2005. There has been no bubble till 2002 except for a medium-sized surge in 1990. They predicted the evolution of the indices one year ahead, which was validated with new data up to September 2006. The analysis demonstrated the existence of very significant variations at the local scale, in the sense that the bubble in Las Vegas seems to have preceded the more global US bubble and has ended approximately two years earlier (mid-2004 for Las Vegas compared with mid-2006 for the whole of the US.

They also wrote another article [2] in which they discussed the issue further. They analyzed the quarterly average sale prices of new houses sold in the US as a whole, in the northeast, midwest, south, and west of the US, in each of the 50 states and the District of Columbia of the US to determine whether they have grown faster-than-exponential which they took as the diagnostic of a bubble. They found that 22 states (mostly Northeast and West) exhibit clear-cut signatures of a fast growing bubble. From the analysis of the S&P 500 Home Index, they concluded that the turning point of the bubble will probably occur around mid-2006.

B. M. Roehner is another physicist who is interested in the bubbles. In his article [3], he emphasized that the real estate price peaks which are currently under way in many industrialized countries. In his conclusion, he proposed a prediction for real estate prices in the Western US, which states over the period 2005-2011.

Peter Richmond made an investigation about Ireland with the motivation of Roehner's paper. In his paper [4], he analyzed, following the recent work of Roehner, changes in house prices for both the UK and Ireland. He concluded that prices in the UK/London have reached a tipping point and relative to inflation are set to fall over the next few years. House prices (again relative to inflation) in Ireland are shown to have broken away from the more moderate rises found in the provinces of mainland UK, and Dublin seems to have emerged as another global "hot" spot. He declared that on the evolution similar to that in London can be anticipated and they can anticipate that prices in Dublin will evolve in a similar fashion to those of London. He claimed that Dublin, as a result of the economic expansion during the last 20 years, has now emerged once again as a major city relative to London and by implication a global "hot spot". He also claimed that while house prices in all these cities across the world have been rising strongly in recent years, reports from the US suggest that they have cooled during the first half of 2006 and this analysis suggests that London and by implication Dublin prices have also now peaked and an equally strong downturn (relative to inflation) is likely. One can speculate that another peak will begin around 2011-2012 that will last through to 2016. By the time of the next house price boom it is possible that other European cities such as Warsaw, Prague and Budapest will have joined the list of "hot spots".

H. Selim made a research on the effects of types of houses on the house prices [5]. His study examines the determinants of house prices in Turkey for the whole country, the urban and the rural areas. He claimed that water system, pool, type of house, number of rooms, house size, locational characteristic and type of the building are the most significant variables that affect the house prices.

B. M. Roehner emphasized [3] that the real estate price peaks which are currently under way in many industrialized countries share many of the characteristics of previous historical price peaks. In particular, he showed that in the present episode real price increases are, at least for now, of the same order of magnitude as in previous episodes.

As stated above, the price peaks in previous periods also effect the further real estate prices. So one may expect a relation between not only previous peaks and current peaks but also a relation between previous and current prices.

Roehner also asked the question "Are the increases in property prices much faster than GDP growth?" and he answered this question by giving the case of Hong Kong between 1992 and 1998 as an example. The average price of apartments jumped from US 2,100$ to 8,600$ which represents an annual growth rate of 41%. Obviously this is completely disconnected from GDP growth.

From this result, we can conclude that GDP is also an important parameter which affects or have a relationship with house prices.

The changes of house prices affect the economy of countries. Roehner gives two examples for hypothesis. He claimed that the recession experienced by the Californian economy between 1991 and 1995 had its origin in the real estate market crash of 1990. The other one is the property crash in Japan during the 1990s affected the Japanese economy adversely. It leads to a disappearance of wealth that amounted to 1.6 quadrillion Yen that is to say twice the Japan's GDP. Instead of using about 10% of their salaries to service their loans, Japanese households had to devote more than 20% of their salaries to the repayment of their debt.

A. Black, P. Fraser and M. Hoesli [6] indicated that household consumption is an important expenditure component of real GDP and the relationship between real house price inflation and consumption growth has been frequently examined in the literature. They also investigate the correlation between real house price inflation and consumption growth.

Giussani and Hadjimatheou [7] estimated a relative house price equation for the South East and the North West US, and income is a parameter of the function of the house price. The basic model consists of three equations - a demand equation which, given the housing stock, real incomes, interest rates etc. largely determines house prices in the short run. Their model captured long run structural features such as the effect of income, population, age composition, the housing stock, and interest rates on the long-run level of real house prices. Furthermore, their conclusion is that the evolution of regional prices in this period can be explained by the combination of strong income growth, higher population growth (partly from in-migration), lower interest rates and low rates of house-building.

M. Kelly found in his work that in Ireland, if and when the fall occurs, it will be from around 18% of national income [12].

In UBS Wealth Management Research, it is indicated that Swiss real estate prices will probably continue to rise in 2007. Strong economic growth and population movements have a positive effect on demand for space [9].

K. Case and R. J. Shiller [10] also point the importance of GDP by saying that "Income growth alone explains the pattern of recent home price increases in most states".

S. Holly and N. Jones [**?**] infer the comparability and relationships of house prices and GDP with these words: " Real house prices are much more volatile than real incomes". In the continuing part of their research, they suggested that real incomes are the central driving force behind the real house prices. They reached this result after they found that the real incomes have increased by 312% since 1939 while real house prices have increased by 278% in UK.

The research of A. G. Ahearne, J. Ammer, B. M. Doyle, L. S. Kole, and R. F. Martin explains [11] the relationship between GDP and the house price by saying that real house prices are pro-cyclical-co-moving with real GDP, consumption, investment, CPI inflation, budget and current account balances, and output gaps in their research.

The results that we mentioned above also show that GDP is one of the basic factors which affects the house price changes.

M. Kelly wrote in [12] that rising population led to a building boom that should sound familiar: people queuing overnight to buy houses in new developments; builders increasing prices by a few thousand a week.

A. Black, P. Fraser and M. Hoesli claim [6] that another indicator which effects the house price changes is population. They used population as a variable in their model,

$$\frac{hs}{pop} = (\frac{y}{pop})^{\alpha}(rh)^{-\beta}d \tag{2.1}$$

where hs is the housing stock, pop is population, y is real income, rh is the real rental price and d represents other factors, such as demography, which shift the demand for housing curve. The α and β coefficients are the income and price elasticities of the demand for housing services. They divide the amount of houses in a region by the population of this region, and they divide the real income by population and multiply by real rental price and other factors. They claimed that the ratio of the amount of the houses in a region to the population of that region is directly proportional to the other variables.

Moreover, they say that their model captures long run structural features such as the effect of income, population, age composition of population, the housing stock, and interest rates on the long-run level of real house prices. Furthermore, their conclusion is that the evolution of regional prices in this period can be explained by the combination of strong income growth, higher population growth, power interest rates and low rates of house-building [6].

The importance of population is emphasized in UBS Wealth Management Research [9] by the following words: “Population trends and the labor market will likely provide a further boost to demand for floor space".

S. Holly and N. Jones says [11] that "the proportion of the population is believed to have a major (short run) effect on the real price of houses".

The results that we mentioned above establishes that population also has a significant effect on the house price changes.

The following result points that the inflation is an essential parameter for house price changes. P. Richmond says [4] that house prices (again relative to inflation) in Ireland are shown to have broken away from the more moderate rises found in the provinces of mainland UK, and Dublin seems to have emerged as another global "hot" spot.

Generally, house price indices are constructed only for the last decades, and few house price indices are available for the period before World War II [13]. According to [11], the real price of houses rose sharply during the Second World War. After a small decrease in 1940, house prices rose by 42% between 1940 and 1945, with a 15% rise in 1943. Prices continued to rise until 1948 from which point there began a period of decline in real house prices that did not cease until 1958. From 1948 to 1958 real prices declined by almost 21%. There are a number of possible explanations for these rises and falls in house prices. There was considerable damage to the housing stock as a result of aerial bombing. This supply shock may have put upward pressure on traded houses. There was a sharp decline from the end of the World War II until the end of the 1950s from which point it rose sharply, leveled out during the 1970s and then rose sharply again during the 1980s. While this demographic factor fits the 1950s, it did not help to explain the behavior of real house prices during the Second World War, when anyway the normal 'nesting' activities of people in their twenties would had been disrupted by the war.

As can be seen above, the house prices had fluctuated a lot before the 1980's. By the

1980's, the World economy became more stable following the political stability. Therefore we prefer to use the data beginning by 1980's assuming that this data is more unbiased.

On the other hand, using a data set from 1939 to 1994, S. Holly and N. Jones [11] are able to provide a much longer perspective on the behavior of house prices in the UK than is common in the literature. This allows them to look at the effects of a number of factors such as real income, demography, interest rates and the housing stock over a number of business cycles and periods of low and high inflation. They find that the single most important determinant of real house prices is real income. Over the last 60 years real house prices have risen broadly in line with income.

Similar to the research above, we used a wide period data (even wider than the period that is used above) for UK and USA, and decided on the parameters that we can relate to the house price changes. Because of the data problems that are mentioned above, we have to use a narrow time period in the rest of our analysis.

3. METHOD

We use US for United States of America and UK for United Kingdom during our research.

For US, we have the house price data, beginning from 1893; population and GDP data, beginning from 1790; and inflation rate data, beginning from 1786.

For UK, we have the house price data; beginning from 1975, population and GDP data; beginning from 1831 and inflation rate data; beginning from 1831.

We did several calculations for these two countries. We decided on the most appropriate formula which we used for 18 countries.

3.1. Eliminating Inflation from House Prices

Method 1. For USA; we put $2005 \geq m \geq 1892$ and

$$Y_{m+1} = (Y_m).\left(1 + \frac{iRA_m}{100}\right) \tag{3.1}$$

For UK; we put $2005 \geq n =\geq 1975$ and

$$Z_{n+1} = (Z_n).\left(1 + \frac{iRB_n}{100}\right) \tag{3.2}$$

In formulas (3.1) and (3.2), Y_{m+1}, Z_{n+1} are the average house prices in US and UK respectively in a specific year. Y_m, Z_n are the average house prices in US and UK respectively in the previous year. iRA_m, iRB_n are the inflation rate in US and UK respectively in the previous year. These formulas say that the house price in a year is equal to the sum of the previous year's house price and the previous year's house price scaled by the inflation rate.

By this method; in 2006, we found the house price of USA as 1.950.000\$, however in our data it is 202.818\$; and the house price of UK as 81.250£, however in our data it is 209.000£.

Method 2. For USA; we put $t_1 = 1892$ and $1 \leq m \leq 113$

$$K_{t_1+m} = Y_{t_1}.\left(1 + \frac{iRA_{t_1}}{100}\right).\left(1 + \frac{iRA_{t_1+1}}{100}\right).....\left(1 + \frac{iRA_{t_1+(m-1)}}{100}\right) \tag{3.3}$$

For UK; we take $t_2 = 1975$ and $1 \leq n \leq 30$

$$R_{t_2+n} = R_{t_2}.\left(1 + \frac{iRB_{t_2}}{100}\right).\left(1 + \frac{iRB_{t_2+1}}{100}\right).....\left(1 + \frac{iRB_{t_2+(n-1)}}{100}\right). \tag{3.4}$$

Here Y_{t_1}, R_{t_2} are the first average house prices in our data set for US and UK respectively. K_{t_1+m} and R_{t_2+n} are the average house prices in a specific year for US and UK respectively. iRA_{t_1+m} and iRB_{t_2+n} are the inflation rates in a given year for US and UK respectively. In this method we used only the first house price to calculate the other prices.

After calculations, for 2006, we found that the house prices in UK and US were calculated to be thousand times bigger then the house prices shown in our data.

Method 3. For USA; we put $1892 \leq m \leq 2005$ and

$$RM_m = (M_m).\left(1 + \frac{iRA_m}{100}\right) \tag{3.5}$$

For UK; we put $1975 \leq l \leq 2005$ and

$$RN_l = (N_l).\left(1 + \frac{iRB_l}{100}\right). \quad (3.6)$$

Here, RM_m and RN_l stand for the real average house for each country in a specific year. M_m and N_l are average house prices for each country in the same year. iRA_m and iRB_l are the corresponding interest rates for each country. Real average house price means the average house price from which the effect of inflation is eliminated.

In Method 1; the values were not similar with the house price data that we have. There are mainly two reasons for this situation.

The change of inflation rates could be very big year by year, especially before 1900's. Moreover; in a year it would be a negative two digit number, in the next year; it would be a positive two digit number. Consequently, the change of the house prices were very big when we used Method 1. We took only the first price from the data; because of that the prices are independent from other prices in data.

There were specific events which affected the economic conditions of a country sharply such as World War I, The Great Depression in 1929 and World War II. The effects of these events were dominant in economies of these countries for several years and also decades.

In Method 2; the values were far away from each other. The main reason was the change of the inflation rate year by year too. However, the effect of it seemed more strongly, since the value of a specific house were dependent a lot on interest rates. The value of house prices increased rapidly because of the fluctuating interest rates.

In Method 3; the values were very similar to data in our hand and the formulas (3.5) and (3.6) are more appropriate for house prices.

3.2. Eliminating Inflation from GDP

We tried three methods which were similar to the previous methods.

In the first method, we used the following formulas: for USA,

$$2005 \geq t_3 \geq 1892, \qquad D_{t_3} = (D_{t_3-1}).\left(1 + \frac{iRA_{t_3-1}}{100}\right), \tag{3.7}$$

for UK,

$$, \qquad F_{t_4} = (F_{t_4-1}).\left(1 + \frac{iRB_{t_4-1}}{100}\right). \tag{3.8}$$

In these formulas, D_{t_3} and F_{t_4} stand for nominal GDP's, iRA_{t_3} and iRB_{t_4} are the inflation rates for time t_3 and t_4 respectively.

In the second method, we used the following formulas: for US,

$t_3 = 1892$

$$J_{t_3+m} = J_{t_3}.\left(1 + \frac{iRA_{t_3}}{100}\right).\left(1 + \frac{iRA_{t_3+1}}{100}\right).....\left(1 + \frac{iRA_{t_3+(m-1)}}{100}\right), \tag{3.9}$$

and for UK, $t_4 = 1975$

$$H_{t_4+m} = R_{t_4}.\left(1 + \frac{iRB_{t_4}}{100}\right).\left(1 + \frac{iRB_{t_4+1}}{100}\right).....\left(1 + \frac{iRB_{t_4+(m-1)}}{100}\right), \tag{3.10}$$

where J_{t_3+m}, H_{t_4+m} stand for nominal GDP's.

In the third method, we tried the following formulas: for US,

$$2005 \geq t_3 \geq 1831, \qquad RD_{t_3} = (D_{t_3}).\left(1 + \frac{iRA_{t_3}}{100}\right). \tag{3.11}$$

and for UK,

$$2005 \geq t_4 \geq 1975, \qquad RS_{t_4} = (S_{t_4}).\left(1 + \frac{iRB_{t_4}}{100}\right). \tag{3.12}$$

where RD_{t_3} and RS_{t_3} stand for the real GDP's in time t_3, t_3 respectively.

The GDP values increased rapidly (almost doubled) year by year in some part of the data. The inflation rate's fluctuation is also essential. Because of these, more appropriate formulas are (3.11) and (3.12).

In the first and second methods, we separated the data from previous part of data, especially from the parts which had big increases, however this was not also a solution.

For our analysis, we found that two variables could be used as independent variables. These are GDP and population. There are mainly five data series; house prices of eighteen countries (Japan, Germany, Switzerland, Sweden, Canada, New Zealand, Australia, Denmark, Belgium, Ireland, Italy, Spain, France, UK, USA, Netherlands, Finland, and Norway), the populations, GDP's, inflation rates of these countries, and money exchange rates. We use [14] as a source for house prices. For inflation rate, GDP, population and exchange rates data, we used the database of IMF.

The inflation rate is one of the main factors which affect the house price. We used the following formula to eliminate the effect of the inflation rate from house prices:

$$P_m = \left(1 + \frac{IR_m}{100}\right).PRI_m \Leftrightarrow P_m = \frac{100.PRI_m + IR_m.PRI_m}{100}. \tag{3.13}$$

Here, IR_m is the inflation rate, $HPRI_m$ is the house price of that country with the effect of inflation, we observed at the year $1978 + m$. HP_m is the house price of that country without the effect of inflation at that year.

These HP_m's has different money types. Here HP_m is in Sterling for UK, Finland, Netherlands, Spain, and Ireland; in Canadian Dollar for Canada; in Swiss Franc for Switzerland; in Sek for Sweden; in DKK for Denmark; in Australian Dollar for Australia, in New Zealand Dollar for New Zealand; in Yen for Japan; in US Dollars for USA.

We converted all money units to Euro; because observations and calculations could be done more accurately and easily if all prices had the same money unit. We chose Euro because of two reasons. One of them is the fact that Euro is the common money unit for most of the countries that we observed. The second one is that most of the house prices have the money unit Euro.

After all these observations, measurements and calculations we could reach the real house prices of Japan, Germany, Switzerland, Sweden, Canada, New Zealand, Australia, Denmark, Belgium, Ireland, Italy, Spain, France, UK, USA, Netherlands, Finland, and Norway, which are independent from the inflation rates, and have the same money unit.

The inflation rate also effects GDP. We used the following formulas to neutralize the effect of the interest rate in GDP:

$$RGDP_n = \left(1 + \frac{IR_n}{100}\right).GDP_n \Leftrightarrow RGDP_n = \frac{100.GDP_n + IR_n.GDP_n}{100} \tag{3.14}$$

Here, IR_m is again the inflation rate, and $RGDP_n$ is the gross domestic product at the year $1978 + n$ which was distinguished from the inflation. These $RGDP_n$ values had different money units. We converted all $RGDP_n$ money units to Euro.

We observe that normalization of population, GDP, and house price is necessary for comparison and later for clusters analysis. Therefore we normalized these three variables using the following formulas:

$$NY_n = \frac{(Y_n - Y_{min})}{Y_{max} - Y_{min}}, \tag{3.15}$$

$$NG_n = \frac{(RGDP_n - RGDP_{min})}{RGDP_{max} - RGDP_{min}}, \tag{3.16}$$

$$NP_n = \frac{(HP_n - P_{min})}{HP_{max} - HP_{min}}. \tag{3.17}$$

where NY_n, NG_n, and NP_n stands for normalized values of population, GDP and house price respectively. Then we drew three types of graphes for each country. There we 54 graphs:

(1) GDP versus Population,
(2) House Price versus Population,
(3) House Price versus GDP.

The next step was fitting this data to a first and second order curves to observe trends in data. Then we got three lines and three parabolas for each country.

We put $y = ax + b$ and $y = cx^2 + dx + e$ for the equations of lines and parabolas

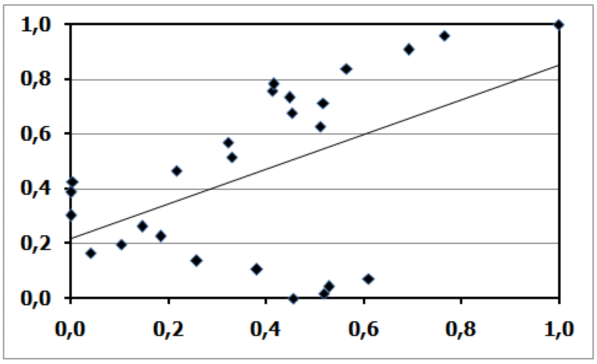

Figure 3.1. “Population of New Zealand” vs. “GDP of New Zealand”

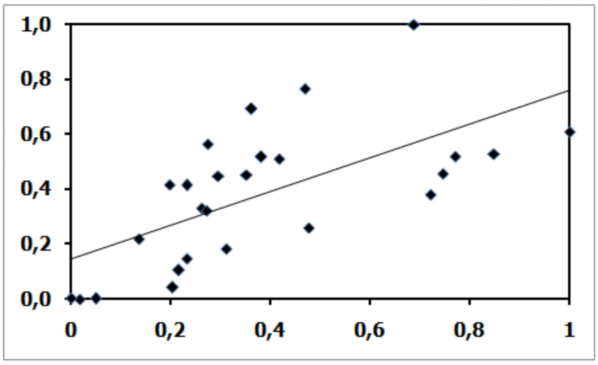

Figure 3.2. “GDP of New Zealand” vs. “Average House Price of New Zealand”

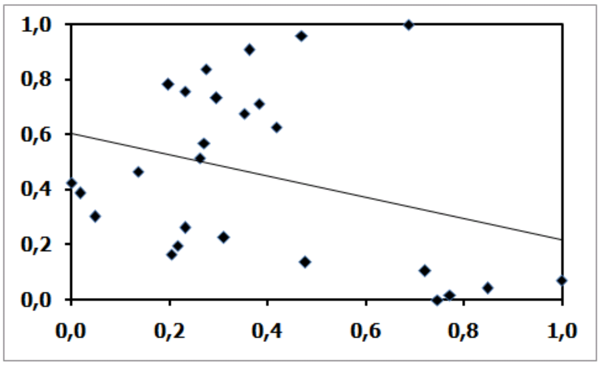

Figure 3.3. “Population of New Zealand” vs. “Average House Price of New Zealand”

respectively and determined best a, b, c, d, e values. We named the values coming from the Population/House Price graphs as A_1, B_1, C_1, D_1, and E_1; the values coming from the GDP/House Price graphs as A_2, B_2, C_2, D_2, and E_2; the values coming from the Population/GDP graphs as A_3, B_3, C_3, D_3, and E_3.

After collecting these values, we drew 15 scatter graphs ($A_1/A_2, A_1/A_3, \ldots, E_2/E_3$ graphs, where A_1/A_2 means that we A_1 values are in x-axis and A_2 values are in y-axis).

3.3. Derivation of the House Price equation

We were dealing with Consumer Price Index (CPI), Retailed Price Index (RPI) and house prices for second part, since Roehner and Richmond used these three variables to find the peak time, peak amplitude and peak prices. In previous researches, physicists used RPI as a parameter, however RPI is used only for UK. RPI, as mentioned before , has same pattern with CPI. Because of this reason, in our calculations, we used RPI for UK and Ireland, and CPI for other countries. One of our aims was finding the peak prices, if they existed, as Roehner and Richmond did. We also tried to find a formula for house prices of countries. Furthermore, we tried a formula for further house prices of countries and also cities. After we found the house price formulas and future house price formulas, we compared them with each other. Moreover, we looked at the house price changes and formulas of all cities of some countries, and tried to see that whether they are similar or not.

We decided on three variables which we used to find a formula during our research. These are:

P: the house price of a country in a given year,

CPI: we mentioned about this variable in background section,

RPI: we also mentioned about this variable in background section.

We used Eviews for our research in this part. We used the following five formulas to decide house prices, and five formulas to estimate the further house prices:

$$P_t = a\log(\frac{P_t}{CPI_t}) + b, \tag{3.18}$$

$$\log(P_t) = a\log(\frac{P_t}{CPI_t}) + b, \tag{3.19}$$

where P_t is the house price for the year t, CPI_t is the consumer price index for in t. Here, a and b are the coefficients which will be obtained by a linear regression performed by Eviews.

In addition, we took the house price of a country or a city in a specific year as 100 and we scaled the rest of the data accordingly. Then we rewrote the equations above as the following:

$$Ps_t = a\log(\frac{Ps_t}{CPIs_t}) + b, \tag{3.20}$$

$$\ln(Ps_t) = a\ln(\frac{Ps_t}{CPIs_t}) + b, \tag{3.21}$$

where Ps_t is the scaled house price for the time t, $CPIs_t$ is the consumer price index for time t which is also scaled accordingly.

We used the following five formulas to estimate the further house prices:

$$P_t = a\log(\frac{P_{t-1}}{CPI_{t-1}}) + b, \tag{3.22}$$

$$\log(P_t) = a\log(\frac{P_{t-1}}{CPI_{t-1}}) + b, \tag{3.23}$$

$$Ps_t = a\log(\frac{Ps_{t-1}}{CPIs_{t-1}}) + b, \tag{3.24}$$

$$\ln(Ps_t) = a\ln(\frac{Ps_{t-1}}{CPIs_{t-1}}) + b, \tag{3.25}$$

where P_t, $CPIs_t$, Ps_t, and $CPIs_t$ are as above.

Table 3.1. Average house prices of Germany(Euro)

Year	House Price Of Germany(ϵ)
1980	156.117,86
1981	158.997,68
1982	168.556,61
1983	159.595,11
1984	150.633,62
1985	142.357,12
1986	141.145,31
1987	140.492,79
1988	139.980,10
1989	142.310,52
1990	143.475,72
1991	150.633,62
1992	148.539,07
1993	153.383,51
1994	154.117,94
1995	153.620,78
1996	152.127,20
1997	147.646,45
1998	142.310,52
1999	141.611,39
2000	142.145,27
2001	141.439,79
2002	140.734,31
2003	139.556,39
2004	138.045,15
2005	136.731,65

Table 3.2. The nominal and real house prices for New Zealand

Year	House Price N.Z.($)	Real House Price N.Z.($)	Real House Price(ϵ)
1980	164.111,57	162.762,33	120.368,42
1981	161.675,78	160.141,18	122.348,75
1982	170.787,02	168.904,53	128.457,36
1983	179.444,43	177.319,27	140.389,43
1984	178.657,39	176.411,84	118.392,93
1985	166.851,84	164.432,16	99.118,82
1986	160.457,88	157.823,29	77.589,27
1987	156.804,19	153.823,79	78.601,60
1988	163.502,62	160.197,52	86.050,04
1989	160.153,41	156.730,24	79.855,87
1990	153.759,45	150.272,77	65.360,32
1991	151.628,13	148.100,04	62.924,87
1992	151.019,18	147.470,72	61.469,97
1993	150.105,76	146.532,56	72.221,20
1994	160.153,41	156.274,05	82.132,15
1995	166.851,84	162.658,86	82.891,62
1996	170.787,02	166.396,79	94.414,28
1997	172.361,10	167.877,35	89.291,00
1998	173.935,17	169.352,81	91.648,74
1999	173.148,14	168.593,38	84.830,32
2000	171.574,06	166.941,56	79.856,16
2001	169.999,99	165.289,27	77.099,14
2002	170.787,02	165.929,17	83.143,63
2003	176.296,28	171.194,09	90.079,44
2004	190.462,95	184.823,02	98.560,33
2005	203.842,58	197.623,12	115.748,07

4. RESULTS AND DISCUSSIONS

4.1. The Cluster Analysis

Our main aim is to find the countries which behaves similarly under the changes of house price, GDP and population. Hence, we looked the graphs such as A_1/A_2, B_1/B_2, C_1/C_2, D_1/D_2, E_1/E_2 and to find the countries which show similar behavior in these graphs.

At first glance, we saw several clusters which have the same countries in it in all graphs, however it must be justified by mathematically. SVM is a program which puts legitimacy to these clusters that are seen by eye. In order to check these clusters, we have used the Support Vector Machine (SVM) algorithm for data classification. A data classification task normally uses training and testing data. Each instance in the training data set consists of two target values(the x-axis value and the y-axes value). The aim of SVM is to produce a model which then predicts the target value of data instances in the testing set. In training set, we have used some positive target values (belonging to the countries we are analyzing) and some negative target points (belonging to different countries). In the testing set, we supplied the algorithm with all of the countries in our data set and asked the program to identify the different regions. Hence, we defined a cluster in our training data set by giving specific points around it. Then we put our data set which contains all of the countries in to the test data to test it. After all, the output data showed us the result of our test. The positive values in output data showed that the countries which had the positive values are in the cluster and the negative values in the same output data showed that the countries which had these negative values are not in the cluster.

The performance of such an algorithm is usually quantified by its accuracy during the test phase which mainly depends on the correct treatment of true positives (TP) and true negatives (TN). It is usually also important to distinguish between two types of errors: a false positive (FP) and a false negative (FN).

TPs are the values which are inside the selected cluster and members of this cluster.

FPs are the values which are inside the selected cluster and not members of this cluster.

TN's are the values which are outside the selected cluster and members of this cluster.

FNs are the values which are outside the selected cluster and not members of this cluster.

Consequently, the performance of the prediction is better judged if we add two more quantifiers, sensitivity and specificity. The accuracy of the data classification is defined as the ratio between the number of correctly identified samples and the total number of samples:

$$\text{accuracy} = (\text{TP} + \text{TN})/(\text{TP} + \text{FP} + \text{TN} + \text{FN}).$$

The sensitivity is the ratio between the number of TP predictions and the number of positive instances in the test set:

$$\text{sensitivity} = \text{TP}/(\text{TP} + \text{FN}).$$

Finally, the specificity is defined as the ratio between the number of TN predictions and the number of negative instances in the test set:

$$\text{specificity} = \text{TN}/(\text{TN} + \text{FP}).$$

For our initial analysis, we used only eighteen different countries mentioned above. To obtain train data set; we plotted some points in the graphs. Each point had two coordinates (x-axis and y-axes). Then we gave "+1" value, if the points which we plotted were near or inside the cluster which we estimated. If the points were far from cluster we gave "-1" values to these points. Then we obtain train data set by putting all values in it.

We put the original points (eighteen data set), which we had from the graphs in to the test data. At last, we applied SVM and it gives us results as "test.out" data. In "test.out" data, there were eighteen values which corresponded to the values in the test data. If the values in "test.out" data are positive , this means that the country, which had this point, was in the cluster. If it was negative, this country was not in the cluster.

We observed A_1/A_2, B_1/B_2, C_1/C_2, D_1/D_2, E_1/E_2 to learn the answer of this question: Are there any countries which can establish a cluster according to their distribution of "the change of population with house prices" versus "the change of Gross Domestic Product with house prices"

We observed A_1/A_3 , B_1/B_3 , C_1/C_3 , D_1/D_3 , E_1/E_3 similarly to see the countries' distributions of "the change of population with house prices" versus "the change of population with GDP".

In the graphs, we symbolized Canada as CAN, Australia as AU, Belgium as BEL, Denmark as DEN, Finland as FIN, France as FR, Germany as D, Ireland as IRL, Italy as I, Japan as JP, Netherlands as NL, New Zealand as NZ, Norway as NOR, Spain as SP, Sweden as SWE, Switzerland as SWI, United Kingdom as UK, United States of America as USA.

For A_1/A_2, we found six clusters.

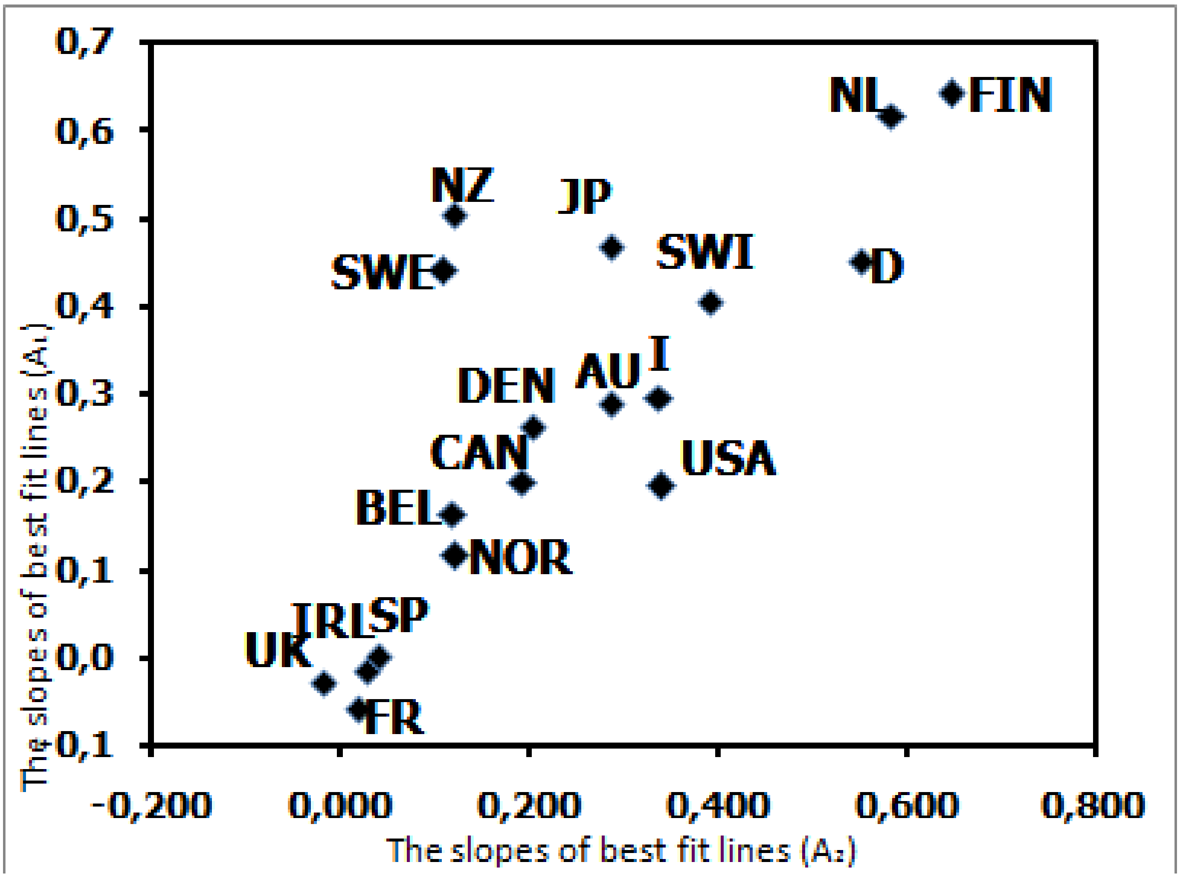

Figure 4.1. “The slopes of the best fit lines (A_1)” vs. “The slopes of the best fit lines (A_2)”

4.2. First cluster from the graph A_1/A_2

i) The countries in the first cluster are Ireland, Spain, Belgium and UK, France, Denmark.

In testing set, we have used six positive target values (belonging to the country classes we are analyzing) and twelve negative target points (belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Ireland, Spain, Belgium and UK, France, Denmark are in same cluster. Accuracy, sensitivity and also specificity values can be seen in the Table A5.

4.3. Second cluster from the graph A_1/A_2

ii) The countries in the second cluster are Sweden and New Zealand.

In testing set, we have used two positive target values (belonging to the country classes we are analyzing) and sixteen target points (belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Sweden and New Zealand are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

4.4. Third cluster from the graph A_1/A_2

iii) The countries in the third cluster are Netherlands and Finland.

In testing set, we have used two positive target values (belonging to the country classes we are analyzing) and sixteen target points (belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Netherlands and Finland are in same cluster. Accuracy, sensitivity and also specificity values can be seen in the Table A5.

4.5. Forth cluster from the graph A_1/A_2

iv) The countries in the forth cluster are Ireland, Spain, Belgium, UK, France, Denmark, Canada, Australia, Norway.

In testing set, we have used nine positive target values (belonging to the country classes we are analyzing) and nine negative target points(belonging to the different country classes) The test gives appropriate result. Consequently, we can say that Ireland, Spain, Belgium, UK, France, Denmark, Canada, Australia, Norway are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

4.6. Fifth cluster from the graph A_1/A_2

v) The countries in the fifth cluster are Netherlands, Finland and Germany.

In testing set, we have used three positive target values (belonging to the country classes we are analyzing) and fifteen target points(belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Netherlands, Finland and Germany are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

4.7. Sixth cluster from the graph A_1/A_2

vi) The countries in the sixth cluster are Switzerland, Japan, New Zealand, Sweden, Netherlands, Finland and Germany.

In testing set, we have used seven positive target values (belonging to the country classes we are analyzing) and eleven target points(belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Switzerland, Japan, New Zealand, Sweden, Netherlands, Finland and Germany are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

For B_1/B_2, we found three clusters.

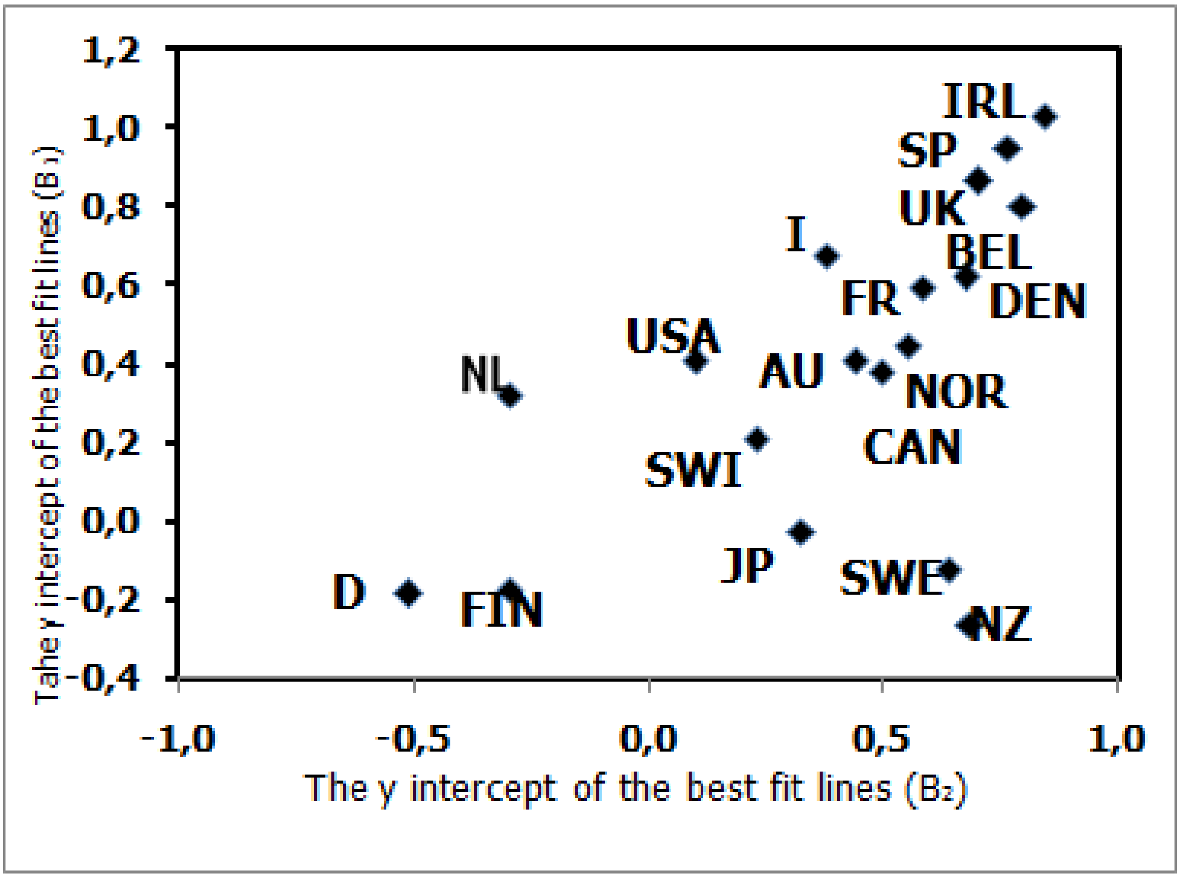

Figure 4.2. “The y intercepts of the best fit lines (B_1)” vs. “The y intercepts of the best fit lines (B_2)“

4.8. First cluster from the graph B_1/B_2

i) The countries in the first cluster are Ireland, Spain, France and UK.

In testing set, we have used four positive target values (belonging to the country classes we are analyzing) and fourteen negative target points(belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Ireland, Spain, France and UK are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

4.9. Second cluster from the graph B_1/B_2

ii) The countries in the second cluster are Ireland, Spain, France, UK, Norway, Belgium and Canada.

In testing set, we have used six positive target values (belonging to the country classes we are analyzing) and twelve negative target points(belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Ireland, Spain, France, UK, Norway, Belgium and Canada are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

4.10. Third cluster from the graph B_1/B_2

iii) The countries in the third cluster are Sweden, New Zealand and Japan.

In testing set, we have used three positive target values (belonging to the country classes we are analyzing) and fifteen negative target points(belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Sweden, New Zealand and Japan are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

For C_1/C_2, we found six clusters.

4.11. First cluster from the graph C_1/C_2

i) The countries in the first cluster are Ireland, Belgium, Spain, Italy, Canada, Norway, UK, Denmark, Australia, Netherlands, France and USA.

In testing set, we have used twelve positive target values (belonging to the country

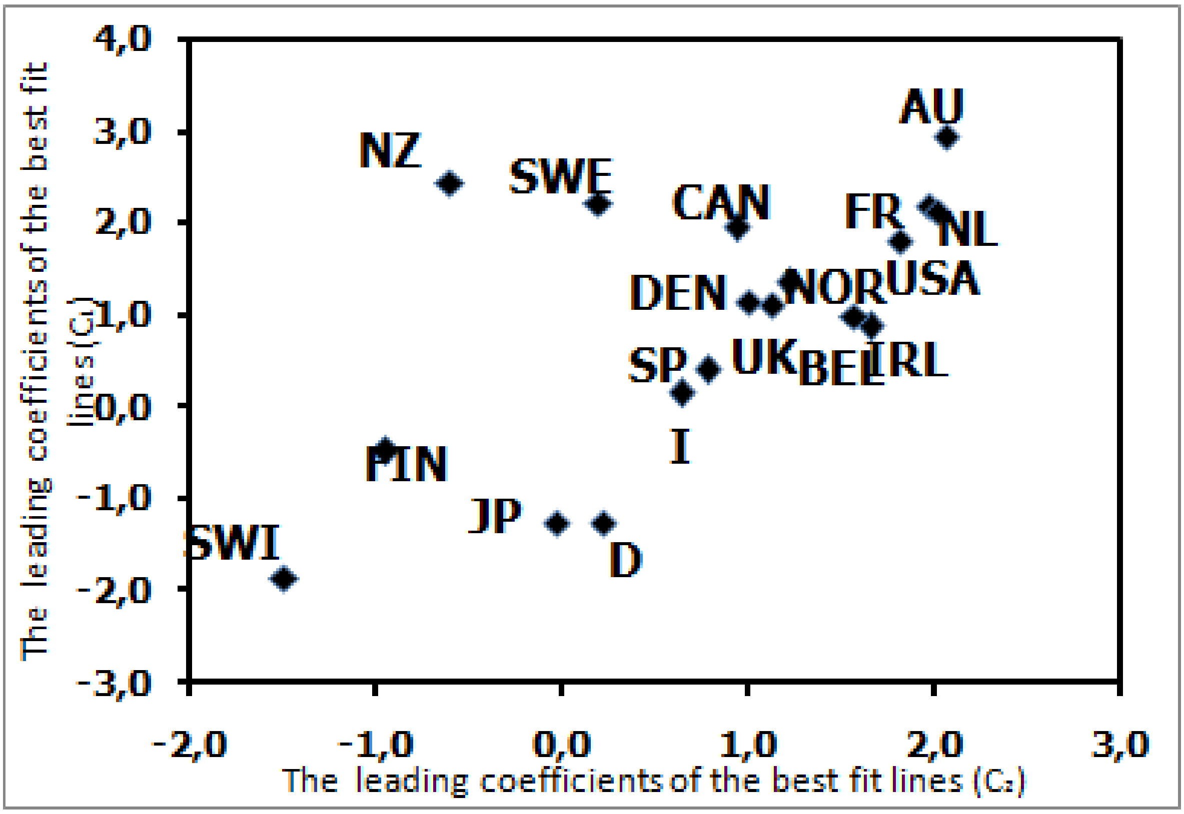

Figure 4.3. "The leading coefficients of the best fit parabolas (C_1)" vs. "The leading coefficients of the best fit parabolas (C_2)"

classes we are analyzing) and six negative target points (belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Ireland, Belgium, Spain, Italy, Canada, Norway, UK, Denmark, Australia, Netherlands, France and US are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

4.12. Second cluster from the graph C_1/C_2

ii) The countries in the second cluster are Ireland, Belgium, US, France, Netherlands and Australia.

In testing set, we have used six positive target values (belonging to the country classes we are analyzing) and twelve negative target points (belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Ireland, Belgium, USA, France, Netherlands and Australia are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

4.13. Third cluster from the graph C_1/C_2

iii) The countries in the third cluster are Ireland, Belgium, USA, France, Netherlands, Australia, UK and Norway.

In testing set, we have used eight positive target values (belonging to the country classes we are analyzing) and ten negative target points (belonging to the different country classes). The test gives appropriate result. Consequently, we can say that are Ireland, Belgium, USA, France, Netherlands, Australia, UK and Norway are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

4.14. Forth cluster from the graph C_1/C_2

iv) The countries in the forth cluster are Sweden and New Zealand.

In testing set, we have used two positive target values (belonging to the country classes we are analyzing) and sixteen negative target points (belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Sweden and New Zealand are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

4.15. Fifth cluster from the graph C_1/C_2

v) The countries in the fifth cluster are Switzerland, Japan and Finland.

In testing set, we have used three positive target values (belonging to the country classes we are analyzing) and fifteen negative target points (belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Switzerland, Japan and Finland are in same cluster. Accuracy, sensitivity and also specificity values can be seen in table Table A5.

4.16. Sixth cluster from the graph C_1/C_2

vi) The countries in the sixth cluster are Switzerland Japan, Finland and Germany.

In testing set, we have used four positive target values (belonging to the country classes we are analyzing) and fourteen negative target points (belonging to the different country classes). The test gives appropriate results. Consequently, we can say that Switzerland, Japan, Finland and Germany are in same cluster. Accuracy, sensitivity and also specificity values can be seen in the Table A5.

For D_1/D_2, we found one cluster.

4.17. First cluster from the graph D_1/D_2

i) The countries in the first cluster are Sweden and New Zealand.

In testing set, we have used two positive target values (belonging to the country classes we are analyzing) and sixteen negative target points(belonging to the different country classes). The test gives appropriate results. Consequently, we can say that Sweden

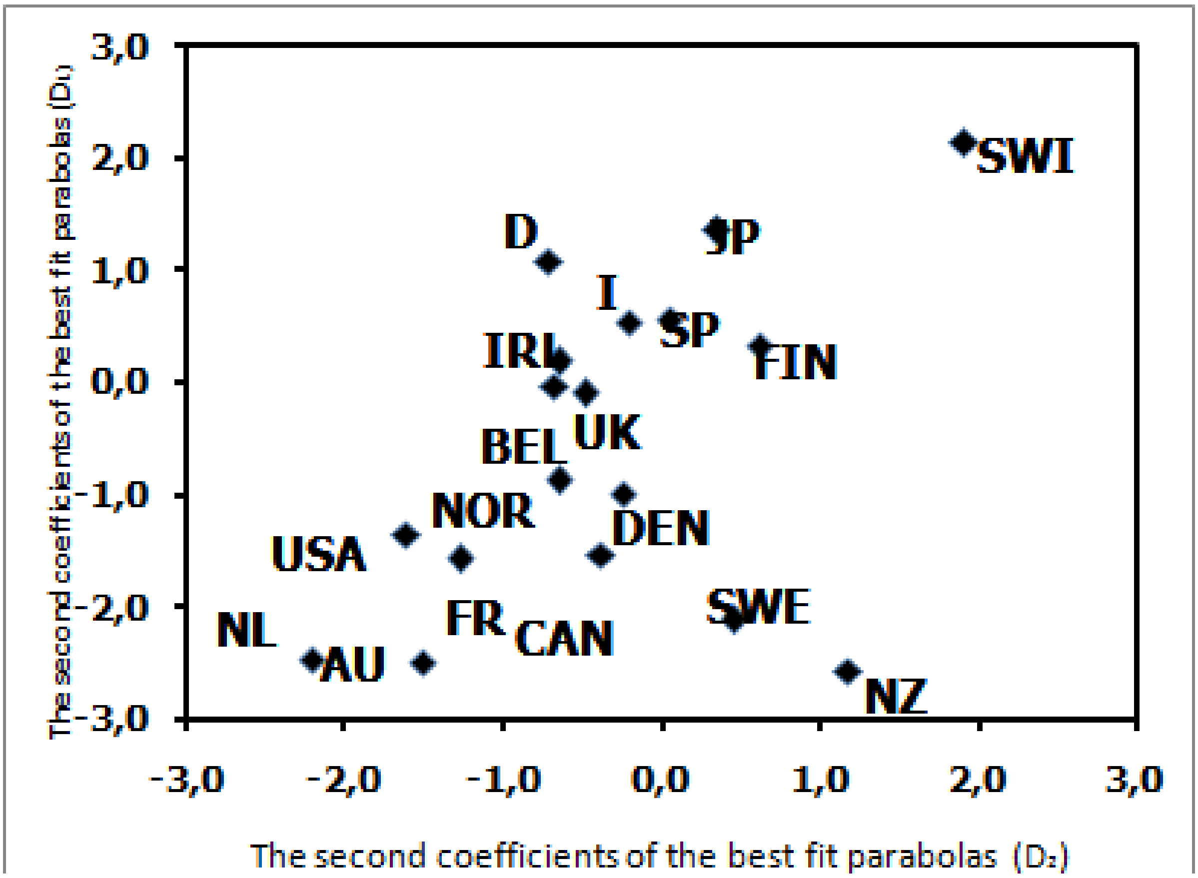

Figure 4.4. "The second coefficients of the best fit parabolas (D_1)" vs. "The second coefficients of the best fit parabolas (D_2)"

and New Zealand are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

For E_1/E_2, we found four clusters.

4.18. First cluster from the graph E_1/E_2

i) The countries in the first cluster are Denmark, Italy, France, Norway, Belgium, Japan, UK, Ireland and Spain.

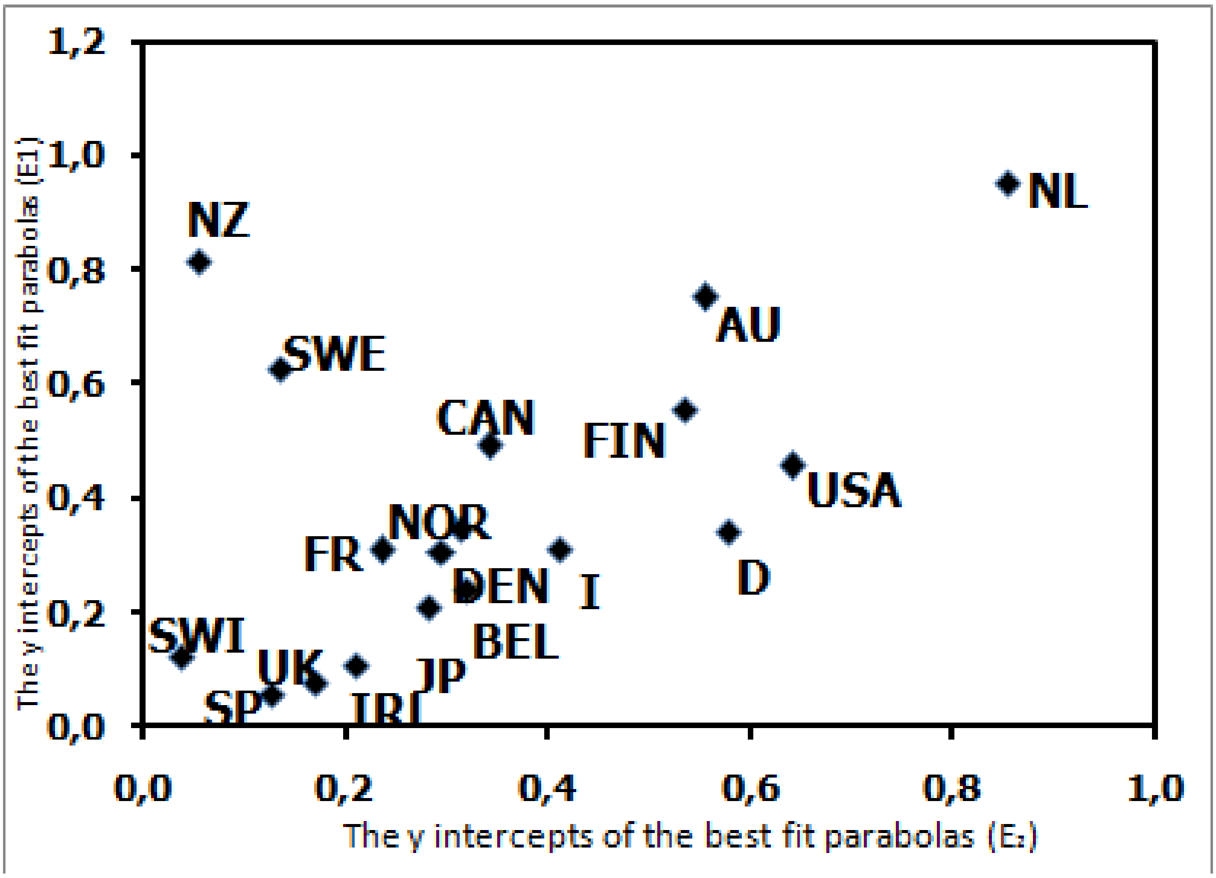

Figure 4.5. “The y intercepts of the best fit parabolas (E_1)” vs. “The y intercepts of the best fit parabolas (E_2)”

In testing set, we have used nine positive target values (belonging to the country classes we are analyzing) and nine negative target points(belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Denmark, Italy, France, Norway, Belgium, Japan, UK, Ireland and Spain are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

4.19. Second cluster from the graph E_1/E_2

ii) The countries in the second cluster are Finland and Netherlands.

In testing set, we have used two positive target values (belonging to the country classes we are analyzing) and sixteen negative target points(belonging to the different country classes). The test gives appropriate results. Consequently, we can say that Finland and Netherlands are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

4.20. Third cluster from the graph E_1/E_2

iii) The countries in the third cluster are Finland, Netherlands, Germany, USA and Australia.

In testing set, we have used five positive target values (belonging to the country classes we are analyzing) and thirteen negative target points(belonging to the different country classes). The test gives appropriate result. Consequently, we can say that Finland, Netherlands, Germany, USA and Australia are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

4.21. Forth cluster from the graph E_1/E_2

iv) The countries in the forth cluster are Sweden,New Zealand, Canada, Denmark, Italy, France, Norway, Belgium, Japan, UK, Ireland and Spain.

In testing set, we have used twelve positive target values (belonging to the country classes we are analyzing) and six negative target points(belonging to the different country classes). The test gives result. Consequently, we can say that Sweden, New Zealand, Canada, Denmark, Italy, France, Norway, Belgium, Japan, UK, Ireland and Spain are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

For A_1/A_3, we found one cluster.

Table 4.1. The clusters which we estimated

COUNTRIES	A1-A2	B1-B2	C1-C2	D1-D2	E1-E2
IRELAND	+	+	+	+	+
SPAIN	+	+	+	+	+
BELGIUM	+	+	+	+	+
UK	+	+	+	+	+
FRANCE	+	+	+	+	+
DENMARK	+	+	+	+	+
NORWAY	+	+	+	+	+
CANADA	+	+	+	+	+
ITALY	+	+	+	+	+
SWEDEN	+	+	+	+	+
NEW ZEALAND	+	+	+	+	+
SWITZERLAND	+	+	+	+	+
JAPAN	+	+	+	+	+
FINLAND	+	+	-	-	-
NETHERLANDS	+	+	-	-	-

4.22. First cluster from the graph A_1/A_3

i) The countries in the first cluster are Italy, Australia, France, Spain, Ireland, Denmark, Belgium, Norway and UK.

In testing set, we have used nine positive target values (belonging to the country

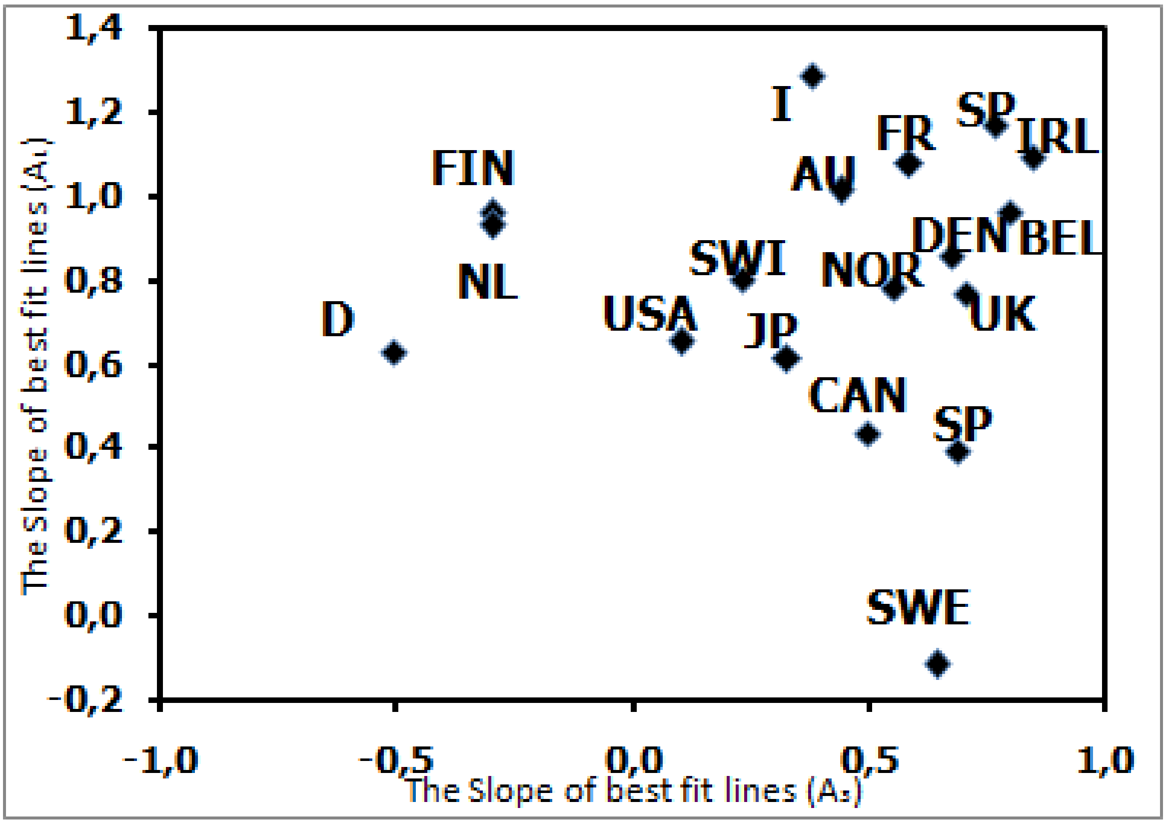

Figure 4.6. “The slopes of the best fit lines (A_1)” vs. “the slopes of the best fit lines (A_3)”

classes we are analyzing) and nine negative target points (belonging to the different country classes). The test gives appropriate results. Consequently, we can say that Italy, Australia, France, Spain, Ireland, Denmark, Belgium, Norway and UK are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

For B_1/B_3, we found one cluster.

4.23. First cluster from the graph B_1/B_3

i) The countries in the first cluster are New Zealand, Canada, UK, Ireland, Denmark, France, Norway, Belgium and Spain.

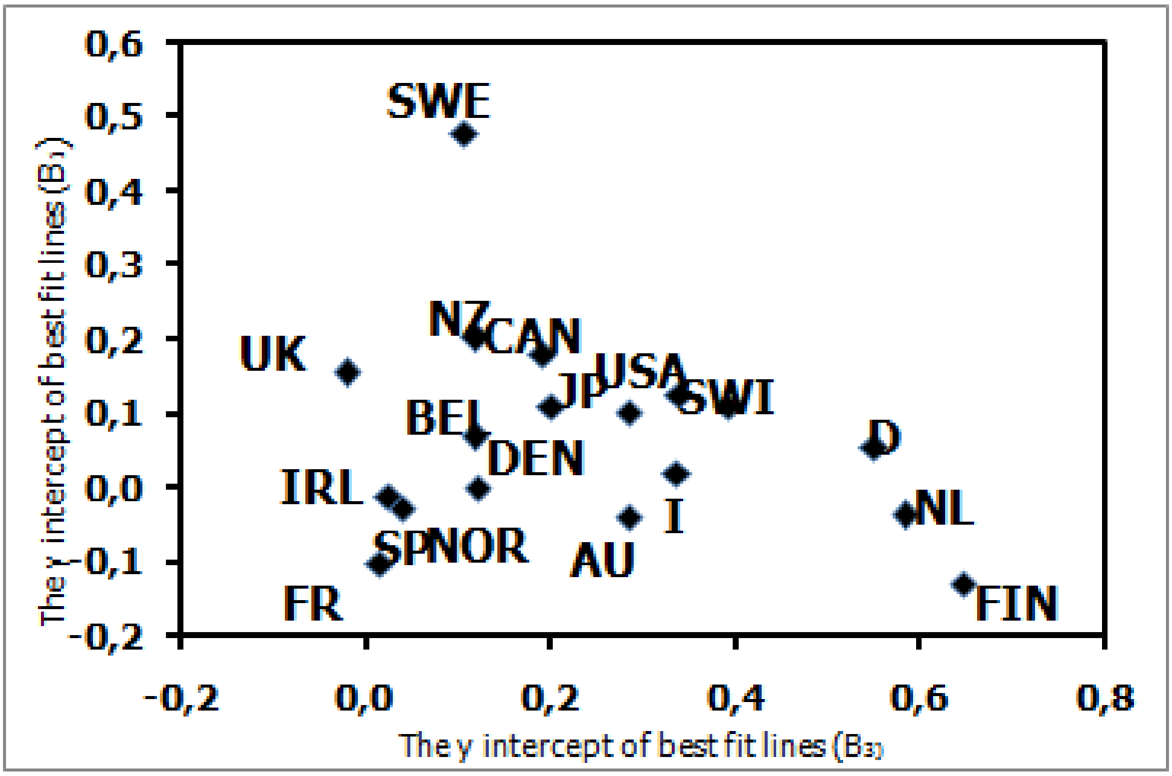

Figure 4.7. "The y intercepts of the best fit lines (B_1)" vs. "The y intercepts of the best fit lines (B_3)"

In testing set, we have used nine positive target values (belonging to the country classes we are analyzing) and nine negative target points(belonging to the different country classes). The test gives appropriate result, however they are not as well as other results. Consequently, we can say that New Zealand, Canada, UK, Ireland, Denmark, France, Norway, Belgium and Spain are in same cluster. Accuracy, sensitivity and also specificity values can be seen in Table A5.

For C_1/C_3, we couldn't found any clusters. As an example; the countries in the second cluster , which we tried to obtain, are Spain, Denmark, Belgium, Ireland.

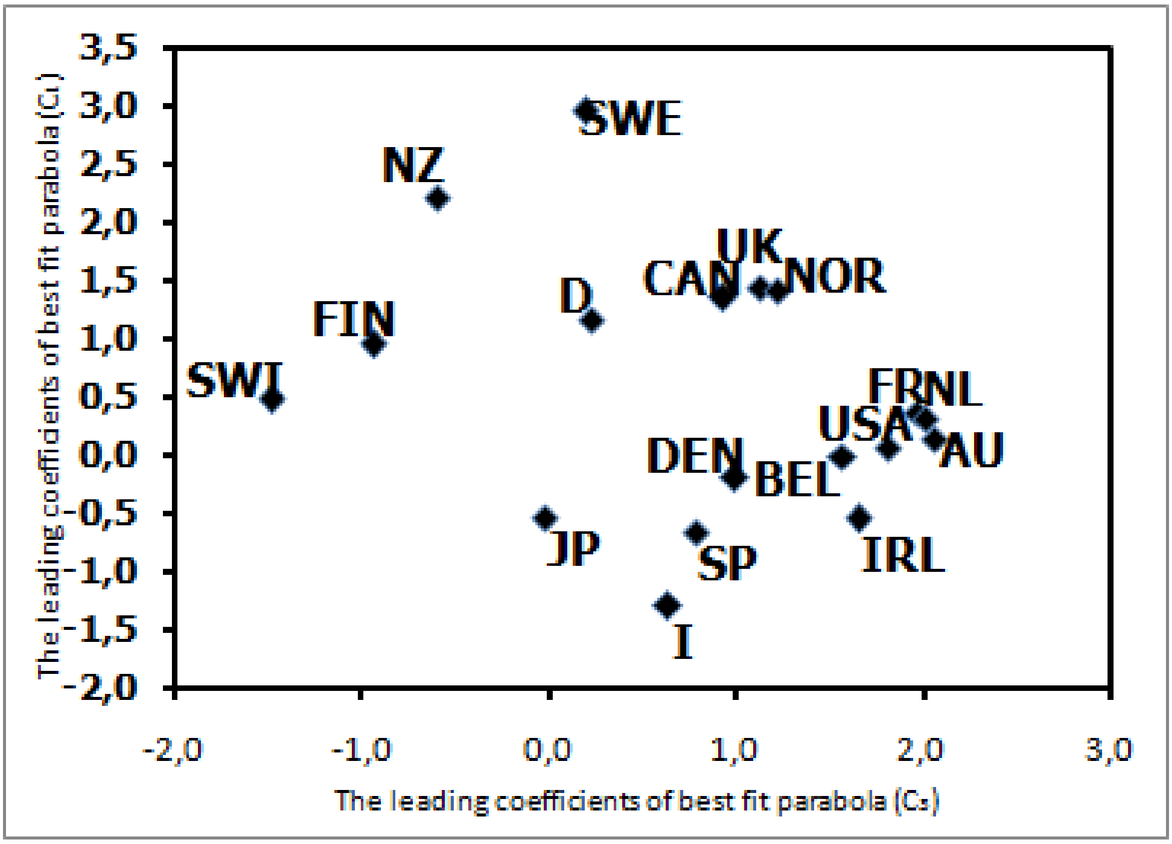

Figure 4.8. "The leading coefficients of the best fit parabolas (C_1)" vs. "The leading coefficients of the best fit parabolas (C_3)"

In testing set, we have used four positive target values (belonging to the country classes we are analyzing) and fourteen negative target points (belonging to the different country classes). The results of our test shows that we can not say that Spain, Denmark, Belgium and Ireland are in the same cluster. Moreover, we used another train data (another cluster) to obtain more reliable results, however the results of our second test also shows that we can not say that Spain, Denmark, Belgium, Ireland are in the same cluster.

As a result, we obtained 22 clusters by SVM test.

Firstly, we determined the clusters in A_1/A_2, B_1/B_2, C_1/C_2, D_1/D_2, E_1/E_2, A_1/A_3

$\ldots, E_2/E_3$. The most appropriate clusters are in A_1/A_2, B_1/B_2, C_1/C_2, D_1/D_2, E_1/E_2.

In the analysis of A_1/A_2, we obtained 6 clusters. These clusters are the following:

(1) Ireland, Spain, Belgium, UK, France, Denmark,
(2) Sweden, New Zealand,
(3) Netherlands, Finland,
(4) Netherlands, Finland, Germany
(5) Switzerland, Japan, New Zealand, Sweden, Netherlands, Finland, Germany, and
(6) Ireland, Spain, Belgium, UK, France, Denmark, Canada, Australia, Norway.

We obtained 3 clusters while we are observing B_1/B_2 ;

(1) Ireland, Spain, France, UK,
(2) Ireland, Spain, France, UK, Belgium, Canada, and
(3) Sweden, New Zealand, Japan.

We obtained 6 clusters while we are observing C_1/C_2 ;

(1) Ireland, Belgium, Spain, Italy, Canada, Norway, UK, Denmark, Australia, Netherlands, France, USA,
(2) Ireland, Belgium, USA, France, Netherlands, Australia,
(3) Ireland, Belgium, USA, France, Netherlands, Australia, UK, Norway ,
(4) Switzerland, Japan, Finland, Germany,
(5) Switzerland, Japan, Finland, and
(6) Sweden, New Zealand.

We obtained only one cluster but we expected to establish more clusters while we are observing D_1/D_2. We tried several methods to get more than one cluster, however we could get only one cluster.

Firstly, we normalize the data, then apply SVM test, the result doesn't change.Secondly we take a lot of countries in the cluster but the result also doesn't change. Thirdly, we don't take all countries in to test set.For example, we take only 15 data set, we throw the three country which are far away from other countries, there is no change. Then, we throw the countries which are very near to each other in test set, but we can not get the results which we want. At last we change the train set for all clusters, but there is no change after applying this method. As a result, we can obtain only one cluster: "Sweden, New Zealand".

We obtained 4 clusters while we were observing E_1/E_2:

(1) Finland, Netherlands,
(2) Finland, Netherlands, Germany, USA, Australia,
(3) Sweden, New Zealand, Canada, Denmark, Italy, France, Norway, Belgium, Japan, UK, Ireland, Spain and,
(4) Denmark, Italy, France, Norway, Belgium, Japan, UK, Ireland, Spain.

As we mentioned before, A and B values comes from the same equation. For this reason, we take the clusters which are found not only in A but also in B. We found four results by observing A_1/A_2 and B_1/B_2, we see that the countries in the following groups have similar causal relation between house prices, GDP and population:

(1) Ireland, UK, Spain and France,
(2) Ireland, UK, Spain, France, Belgium and Canada,
(3) Sweden and New Zealand and,
(4) Sweden, New Zealand and Japan.

C, D and E values comes from same equation which is more complicated than the other equations. Because of this, we take the clusters which are found in A, B, C, D and E. We found one result by observing A_1/A_2, B_1/B_2, C_1/C_2, D_1/D_2, E_1/E_2 that Sweden and New Zealand have similar causal relation between house prices, GDP and population.

We obtained one cluster while we are observing A_1/A_3: "Italy, Australia, France, Spain, Ireland, Denmark, Belgium, Norway, UK".

We obtained one cluster while we are observing B_1/B_3: "New Zealand, Canada, UK, Ireland, Denmark, France, Norway, Belgium, Spain".

We did not obtain any clusters while we are observing C_1/C_3.

We found one result by observing A_1/A_3 and B_1/B_3 that France, Spain, Ireland, UK, Denmark, Belgium and Norway have structural similarities in the dynamics determining the house prices.

We could not observe A_1/A_3, B_1/B_3, C_1/C_3, D_1/D_3, E_1/E_3, since we can not get any clusters from C_1/C_3. C values are leading coefficients. If we did not obtain any clusters from C_1/C_3, to obtain clusters from D_1/D_3, E_1/E_3 did not mean similarity.

Finally, we can say that the effect of GDP and population on House Price have similar patterns in Sweden and New Zealand, hence they are in same cluster in A_1/A_3, B_1/B_3, C_1/C_3, D_1/D_3, E_1/E_3.

Moreover, it can be said that the effect of GDP and population on house price have similar patterns in UK, Ireland, France, Belgium and Spain, however this similarity is not as strong as the similarity of Sweden and New Zealand, because they did not obey similar pattern in a more complicated function.

4.24. The House Price Equation

We used the formulas that are given in Section 3.3 related to the estimation of the house price equation for two country clusters which we obtained from the first part of the research. The first clusters countries are Ireland, UK, France, Belgium and Spain. The second clusters countries are Sweden and New Zealand. We also used our formulas for Japan for testing. If we chose appropriate formula, the coefficients of Japan should not be close to the coefficients of the first cluster's countries, however it could be close to the coefficients of second cluster's countries, since Japan was in the same cluster with Sweden and New Zealand in some clusters in our research.

Furthermore, we found the appropriate formulas for the cities of UK and Ireland. Then we observed if the coefficients of formulas of these cities are close to each other or not.

At last, we deal with the house price peaks. There were two investigations about this subject until now.

Roehner made an observation of the house price peaks of the cities which are in the Western US. The other research was made by Richmond. He investigated the house price peaks of London and Dublin.

Roehner had enough previous peaks which could give healthy results, however Richmond made his research only two data sets and we think this amount of data is not enough for a healthy results.

We found a lot of countries and cities which had at least two data sets, but we could find only one country which had enough data to make sense. We applied the model of Roehner to this country to estimate the further house price peak value.

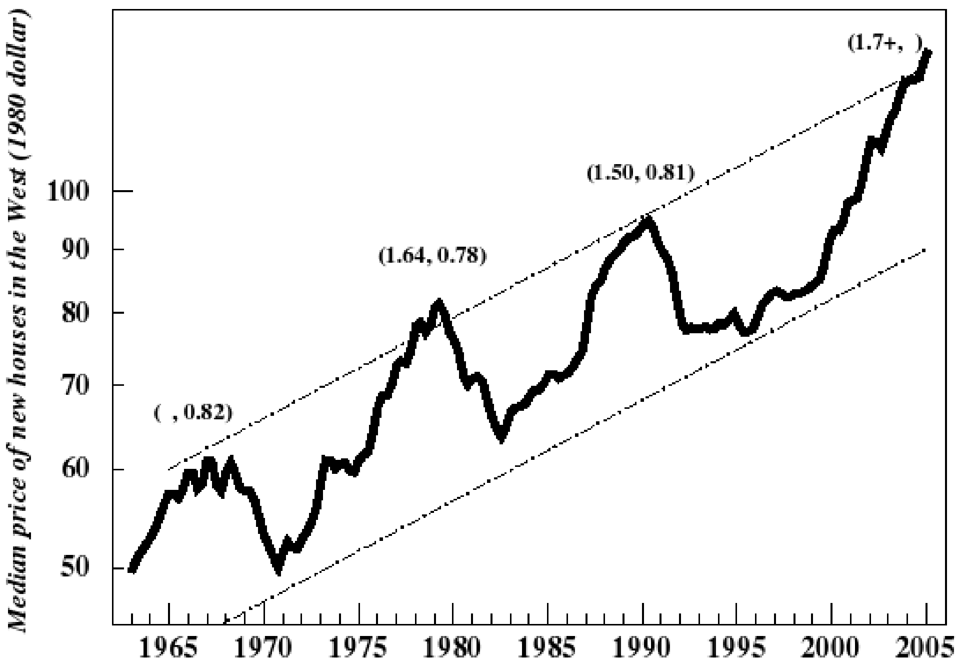

Figure 4.9. The graph in which Roehner observed the future peak price for the Western US

We chose the peak prices and the bottom prices of the peaks which peak started to rise.

Peak Price (P_2) is the top price in a period, which must be greater than the previous peak price and the price must go downward after attaining this value.

Bottom Price (P_1) is the bottom price between two peaks. The initial P_1 is the bottom price of the graph. We define "A " as P_2/P_1

CPI and RPI are Consumer Price Index and Retail Price Index of bottom price in

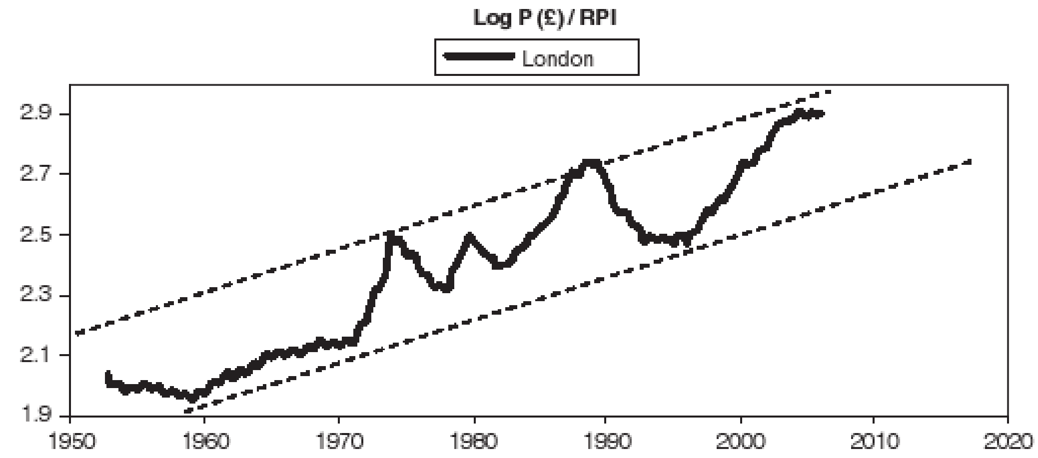

Fig. 2. Log_{10} house price/RPI (1980 prices) for London over the period 1952–2006.

Figure 4.10. The graph in which Peter Richmond observed the future peak price for London

the same year.

$$A = a \log(\frac{P_1}{CPI_1}) + b, \tag{4.1}$$

Then, we tried the formula (4.1) for Belgium, since its graph has enough data sets to observe, like Roehner and Richmond used ,to find future peak Price for Belgium, and we tested it with Eviews.

We found the value of “a” as $\approx$ 0,57. The “ a ” value of Roehner is $\approx$ 0,5. Also we had a good R value ($\approx$ 0,9)

From this analysis we might conclude that the house prices in Belgium will peak at around ϵ 220.000. Further analysis and data are required to reach more accurate results.

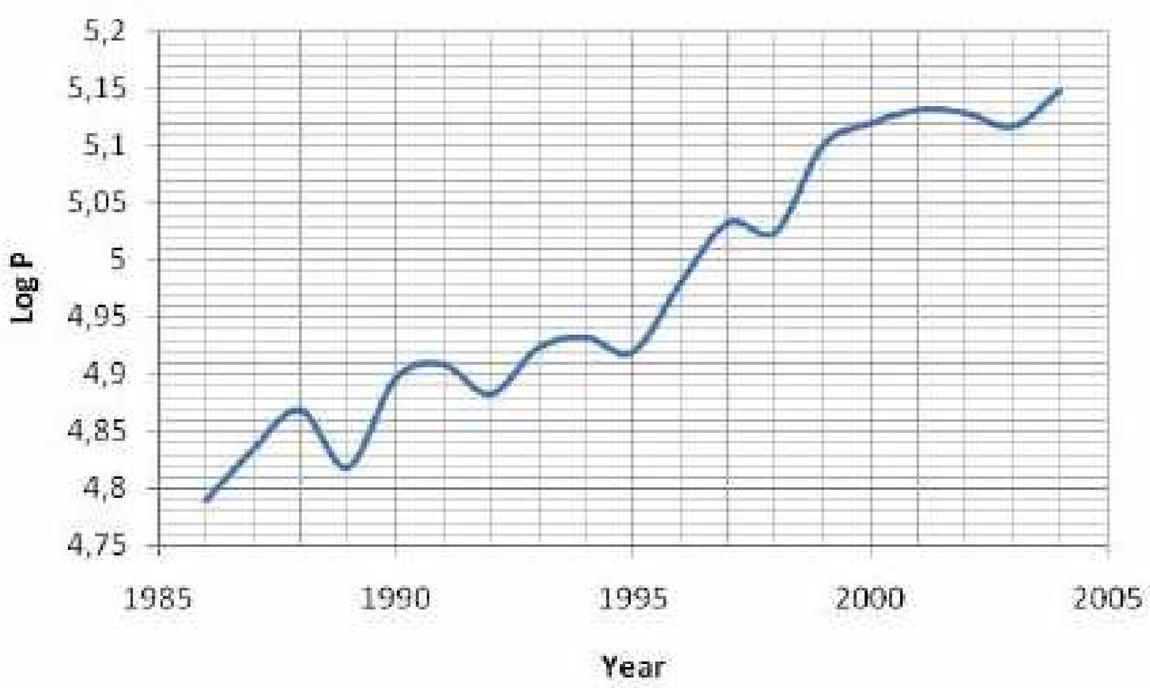

Figure 4.11. The graph in which we observed the future peak price for Belgium

We used equations (3.18), (3.19) and (3.20) to find house price relation with CPI for UK and tested these formula with Eviews. We found that equations (3.19) gave quality result with the same R = 0.978 for UK.

"R" is interpreted as the proportion of response variation "explained" by the regressors in the model. Thus, "R" = 1 indicates that the fitted model explains all variability in y, while "R" = 0 indicates no 'linear relationship between the response variable and regressors. An interior value such as "R" = 0.7 may be interpreted as follows: "Approximately seventy percent of the variation in the response variable can be explained by the explanatory variable. The remaining thirty percent can be explained by unknown, lurking variables or inherent variability."

A caution that applies to R, as to other statistical descriptions of correlation and association is that "correlation does not imply causation." In other words, while correlations may provide valuable clues regarding causal relationships among variables, a high correlation between two variables does not represent adequate evidence that changing one variable has resulted, or may result, from changes of other variables.

In case of a single regressor, fitted by least squares, "R" is the square of the Pearson product-moment correlation coefficient relating the regressor and the response variable. More generally, "R" is the square of the correlation between the constructed predictor and the response variable.

We used equations (3.18), (3.19) and (3.20) to find house price relation with CPI for Spain and tested these formula with Eviews. We found that there is no appropriate equation for Spain. We used equations (3.18), (3.19) and (3.20) to find house price relation with CPI for France and tested these formula with Eviews. We found that there is no appropriate equation for France. We used equations (3.18), (3.19) and (3.20) to find house price relation with CPI for Ireland and tested these formula with Eviews. We found that equation (3.19) gave quality result with the same $R = 0.46$ for Ireland. We used equations (3.18), (3.19), (3.20) and (3.21) to find house price relation with CPI for Belgium and tested these formula with Eviews. We found that equations (3.20) gave quality result with the same $R = 0.77$ for Belgium. We used equations (3.18), (3.19) and (3.20) to find house price relation with CPI for Sweden and tested these formula with Eviews. We found that equations (3.18) and (3.19) gave similar quality results with the same $R = 0.59$ for Sweden. We used equations (3.18), (3.19) and (3.20) to find house price relation with CPI for New Zealand and tested these formula with Eviews. We found that equation (3.19) gave quality result with the same $R = 0.99$ for New Zealand. We used equations (3.18), (3.19) and (3.20) to find house price relation with CPI for Japan and tested these formula with Eviews. We found that equations (3.18), (3.19) and (3.20) gave similar quality results with the same $R = 0.57$ for Japan. The coefficients and the R value of other equations can be seen in Appendix in Table A.6.

We used equations (3.22), (3.23), (3.24) and (3.25) to find the future year Price,by using CPI and previous house price for UK and tested these formula with Eviews. We found that equations (3.22) gave similar quality results with the same R = 0.92 for UK. We used equations (3.22), (3.23) and (3.24) to find the future year house price, by using CPI and previous house price for Spain and tested these formula with Eviews. We found that there is no appropriate equation for Spain. We used equations (3.22) to find the future year Price,by using CPI and previous house price for France and tested these formula with Eviews. We found that there is no appropriate equation for France. We used equations (3.22) to find the future year house price, by using CPI and previous house price for Ireland and tested these formula with Eviews.We found that there is no appropriate equation for Ireland. We used equations (3.22), (3.23) ,(3.24) and (3.25) to find the future year house price, by using CPI and previous house price for Belgium and tested these formula with Eviews. We found that equation (3.25) gave quality results with the same R = 0.59 for Belgium. We used (3.22) to find the future year house price, by using CPI and previous house price for Sweden and tested these formula with Eviews. We found that there is no appropriate equation for Sweden. We used equation (3.23) to find the future year house price, by using CPI and previous house price for New Zealand and tested these formula with Eviews. We found that there is no appropriate equation for New Zealand. We used equations (3.22), (3.23) and (3.24) to find the future year Price,by using CPI and previous house price for Japan and tested these formula with Eviews. We found that equations (3.22) and (3.24) gave similar quality results with the same R = 0.72 for Japan. The coefficients and the R value of other equations can be seen in Appendix in Table A.7.

To summarize, equations (3.19) can be used for UK; equation (3.19) can be used for Ireland; equations (3.20) and (3.21) can be used for Belgium; equations (3.18) and (3.19) can be used for Sweden; equation (3.19) can be used for New Zealand; equations (3.18), (3.19) and (3.20) can be used for Japan. Consequently, equation (3.19) might be used for many countries in general to find price relation with CPI or RPI.

Furthermore, equation (3.22) can be used for UK; equations (3.24) and (3.25) can be used for Belgium and equations (3.22) and (3.24) can be used for Japan to estimate future year's house price.

We also observed the house price change of UK and Ireland cities. We used the equation (3.18) to analyze the house price equations of each cities in Ireland. The values of a's are nearly same (between the range 3,4 and 3,9) except for Dublin. It is nearly 4,4 for Dublin. One can say that the change of House price of Ireland is closely similar to each other except Dublin. Dublin has a more sharper increase than the other cities. Moreover, (3.18) can be used as house price equation for all cities of Ireland with very good R values as shown in the Table A1.

We used equation (3.21) to analyze the house price equations for UK cities.The values of a's are nearly same (between the range 1 and 1,28) except for Scotland . It is nearly 1,93 for Scotland .As shown in the figures (in Appendix B) change of house price of UK is similar to each other except for Scotland. This difference can be seen by analyzing the last year house price/CPI change of cities. The value of this change started to decrease for all cities except Scotland. Moreover, equation (3.21) can be used as house price equation for all cities of Ireland with very good R values except Northern Ireland as shown in the Table A2.

To sum up, the equation (3.19) can be used for UK house price calculations with the very well R value. Moreover the next year average house price of UK can be calculated by using the formula equation (3.22) with very good R value (0.918207). The equation (3.19) can be used for Ireland's house price calculations with the R value (0.458634). The equation (3.19) can be used for also Sweden house price calculations with the R value (0.591258). The equation (3.19) can be used for New Zealand house price calculations with the very well R value(0.986068). The equation (3.18) can be used for Japan house price calculations with R value 0.571454. Moreover the next year average house price of

Japan can be calculated by using the equations (3.22) and (3.24) with very good R value (0.918207).

Finally, we can estimate Belgium house price by using the equations (3.20) and (3.21) which have very well R value(0.763679) for Belgium data set. Also, the next year average house price of Belgium can be calculated by using the equations (3.20) and (3.21) with very good R value(0.585025).

Table 4.2. The clusters which we estimated

COUNTRIES	A1-A3	B1-B3	C1-C3	D1-D3	E1-E3
DENMARK	+	-	+	+	+
IRELAND	+	-	+	+	+
SPAIN	+	-	+	+	+
BELGIUM	+	-	+	+	+
DENMARK	+	+	-	-	-
NORWAY	+	+	-	-	-
CANADA	+	+	-	-	-
ITALY	+	+	-	-	-
AUSTRALIA	-	+	+	+	+
USA	-	+	+	+	+
SWITZERLAND	+	+	-	-	-
USA	+	+	-	-	-
JAPAN	+	+	-	-	-
CANADA	+	+	-	-	-
NEW ZEALAND	+	+	-	-	-
SWEDEN	+	+	-	-	-
FRANCE	+	+	-	-	-
NORWAY	+	+	-	-	-
UK	+	+	-	-	-
BELGIUM	+	+	-	-	-
IRELAND	+	+	-	-	-
SPAIN	+	+	-	-	-

5. CONCLUSIONS

In this research, we found a lot of results from our observation. Firstly, different from the previous researches, we analyze the distribution of countries according to their GDP, house price and population. We estimated several clusters during our research, but we took the clusters which SVM gave good results. We found that the effects of GDP and population on house prices are similar Sweden and New Zealand. A similar relation has been found by S. C. Bourassa, P. H. Hendershott and J. Murphy [15]. They analyzed different economic indicators and found that these two countries are statistically similar. We claimed and have found same idea by using SVM.

We also found that UK, Ireland, France, Spain and Belgium are in the same basic clusters concerning the effects of population and GDP on house prices. We combined this result with the researches which were made recently by Richmond to understand the type of house price bubbles. He found the type of house price peaks and bubbles of London and Dublin are close to each other. Inspired by this investigation, we analyzed whether there will be a house price bubble in France, Spain and Belgium. We used the same method with Richmond and Roehner in our research. Moreover, our data set is more adequate to analyze than the Richmond's data set. We estimated that Belgium will reach its local maximum when the average house price becomes nearly 220,000 Euros. The value of coefficient "a" that we found is nearly same with the value which Roehner found.

Furthermore, we tried to find specific house price equations of specific cities and countries. We found appropriate equations for UK , Ireland, New Zealand, Sweden, Japan and Belgium. Also we found equations which have "a" coefficients that are close to each other for the cities of Ireland and UK as shown in the Table A1 and Table A2.

Finally, we observed the house price changes with CPI in Ireland's cities and with RPI in UK's cities. We found that Dublin and Scotland have different House Price changes and equations from the other cities of their country. However, there are not very big differences between the coefficients of Scotland and other UK cities, Dublin and other Ireland cities. By looking the graphs in the Appendix B and observing the "a" and "b" values of these cities' house price equation, we understood that the price changes of these cities are very similar with each other. Since these countries are developed countries, prices change similarly in almost every region of country.

We found equations for Japan, Belgium and UK to estimate their next year house prices as shown in the Table A7.

From these equations, one may infer that CPI or RPI is directly related to house prices. These variables are also indicators which affect the house prices.

APPENDIX A: TABLES

Table A.1. The estimated coefficients of house price equation for cities of Ireland and the corresponding R values

CITIES(IRELAND)	a	b	R
CORK	3,743,857	-1,021,985	0.956461
GALWAY	3,899,581	-1,079,518	0.926326
LIMERIK	3,558,175	-9,720,438	0.898256
WATERFORD	3,410,497	-9,245,123	0.911623
DUBLIN	4,370,996	-1,226,856	0.933196
OTHER	3,506,985	-9,549,788	0.913627

Table A.2. The estimated coefficients of house price equation for cities of UK and the corresponding R values

CITIES	a	b	R
NORTH	1,093,573	4,685,675	0.924416
YORKS. & HUMB.	1,160,227	9,435,411	0.887923
NORTH WEST	1,127,186	2,517,979	0.894642
E. MIDLANDS	1,127,445	1,413,611	0.870176
W. MIDLANDS	1,190,608	-1,017,687	0.882005
EAST ANGLIA	1,002,332	4,520,461	0.795657
SOUTH WEST	1,046,227	3,851,656	0.846635
SOUTH EAST	1,043,149	3,231,904	0.817946
GR. LONDON	1,172,068	-1,280,298	0.853824
WALES	1,123,804	2,924,371	0.903906
SCOTLAND	1,926,319	4,313,606	0.665822
N. IRELAND	1,287,240	2,306,789	0.038636
UK	1,157,053	8,525,675	0.883659

Table A.3. The sensitivity, accuracy and specificity values of clusters

A1/A2	Sensitivity	Accuracy	Specificity
Cluster1	1	1	1
Cluster2	1	1	1
Cluster3	1	1	1
Cluster4	1	1	1
Cluster5	1	1	1
Cluster6	1	1	1
B1/B2	Sensitivity	Accuracy	Specificity
Cluster1	1	1	1
Cluster2	1	1	1
Cluster3	1	1	1
C1/C2	Sensitivity	Accuracy	Specificity
Cluster1	1	1	1
Cluster2	1	1	1
Cluster3	1	1	1
Cluster4	1	1	1
Cluster5	1	1	1
Cluster6	1	1	1
D1/D2	Sensitivity	Accuracy	Specificity
Cluster1	1	1	1
E1/E2	Sensitivity	Accuracy	Specificity
Cluster1	1	1	1
Cluster2	1	1	1
Cluster3	1	1	1
Cluster4	1	1	1
A1/A3	Sensitivity	Accuracy	Specificity
Cluster1	1	1	1
B1/B3	Sensitivity	Accuracy	Specificity
Cluster1	1	1	1

Table A.4. The estimated coefficients for the house price equation and corresponding R values(The blanks mean that we did not use the corresponding equation for corresponding country)

COUNTRIES	R value of 3.18	R value of 3.19	R value of 3.20	R value of 3.21
UK	0.853597	0.977792	0.853597	
Spain	0.014846	0.034583	0.091331	
France	0.157896	0.171783	0.157896	
Ireland	0.375161	0.458634	0.254552	
Belgium	0.019898	0.473960	0.763679	0.763679
Sweden	0.581314	0.591258	0.168601	
New Zealand	0.091784	0.986068	0.401887	
Japan	0.571454	0.532399	0.567404	
COUNTRIES	a value of 3.18	a value of 3.19	a value of 3.20	a value of 3.21
UK	5.097173	2.299046	3.951352	
Spain	-8.343205	5.507121	1.623661	
France	4.519350	0.342587	9.885563	
Ireland	3.466198	0.686057	6.006738	
Belgium	5.725779	0.776861	5.868653	2.548724
Sweden	6.314082	0.400544	2.555031	
New Zealand	4.193630	2.209039	2.527739	
Japan	8.639922	1.001039	2.742801	
COUNTRIES	b value of 3.18	b value of 3.19	b value of 3.20	b value of 3.21
UK	-1.352236	-1.613775	1.098662	
Spain	3.491935	-9.435572	1.045045	
France	-6.494525	3.821224	1.152024	
Ireland	-9.627118	2.972317	6.394331	
Belgium	-9.186211	2.745836	8.959949	8.959949
Sweden	-9.286662	3.802976	9.453001	
New Zealand	-3.416072	-1.002384	9.774281	
Japan	-2.733897	1.967925	1.073162	

Table A.5. The estimated coefficients for the future house price equation and corresponding R values(The blanks mean that we did not use the corresponding equation for corresponding country)

COUNTRIES	R value of 3.22	R value of 3.23	R value of 3.24	R value of 3.25
UK	0.918207	0.822710	0.822710	0.822710
Spain	0.307828	0.225416	0.054837	
France	0.055520			
Ireland	0.248401			
Belgium	0.165239	0.166721	0.585025	0.585025
Sweden	0.314457			
New Zealand		0.286232		
Japan	0.717015	0.694180	0.717015	
COUNTRIES	a value of 3.22	a value of 3.23	a value of 3.24	a value of 3.25
UK	2.253584	5.208638	4.037760	1.753577
Spain	4.159374	5.208638	7.017256	
France	6.024844			
Ireland	7.2854573			
Belgium	1.038756	0.454105	5.644425	2.451343
Sweden	4.549667			
New Zealand		0.334407		
Japan	9.853820	1.136804	2.901519	
COUNTRIES	b value of 3.22	b value of 3.23	b value of 3.24	b value of 3.25
UK	-1.455872	-1.378076	1.151612	1.151612
Spain	-6.549407	3.228061	1.447522	
France	1.150257			
Ireland	-7.52599			
Belgium	-2.008137	3.669755	9.968462	9.968462
Sweden	-4.805905			
New Zealand		3.934869		
Japan	-3.168926	1.078055	3.934869	

APPENDIX B: GRAPHS

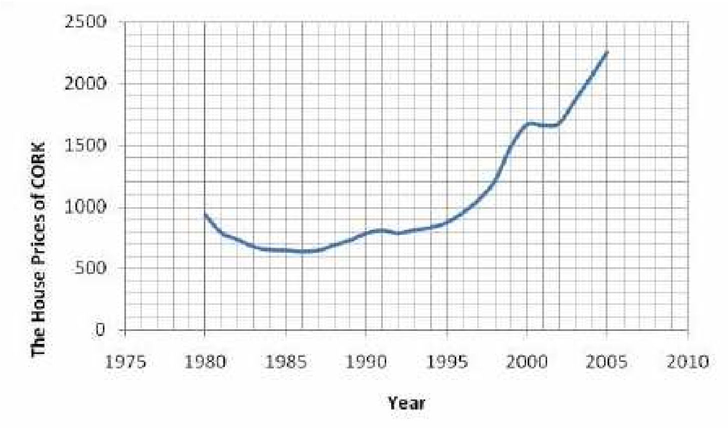

Figure B.1. “Change of house prices of Cork in time”

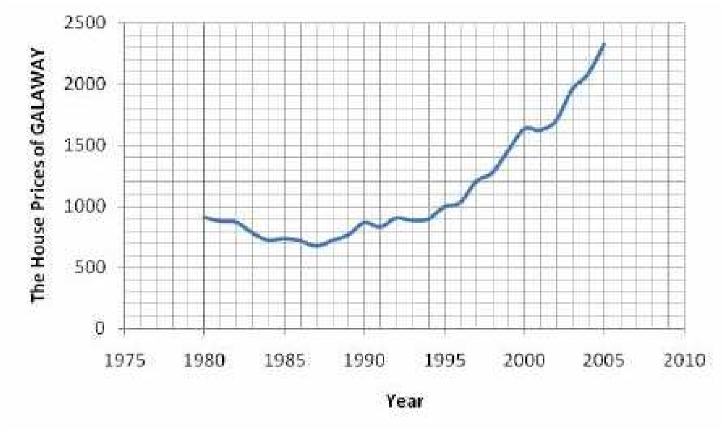

Figure B.2. “Change of house prices of Galaway in time”

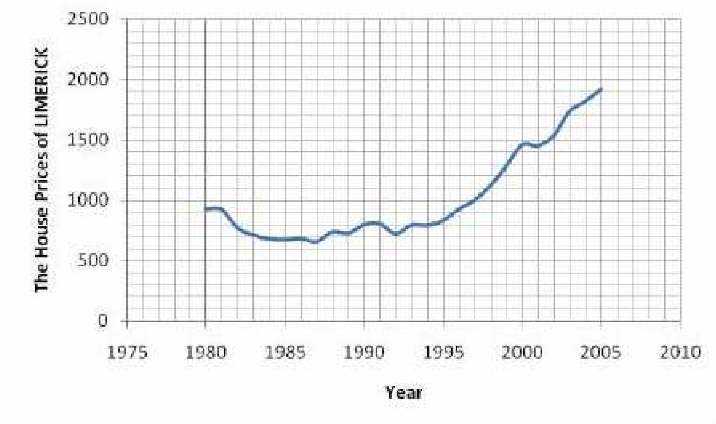

Figure B.3. “Change of house prices of Limerick in time”

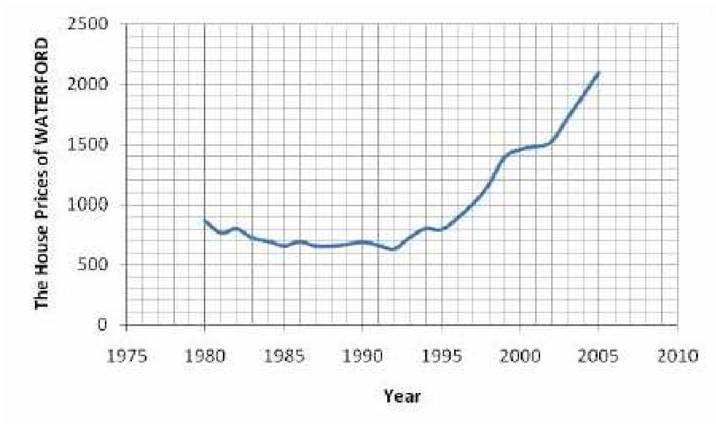

Figure B.4. “Change of house prices of Waterford in time”

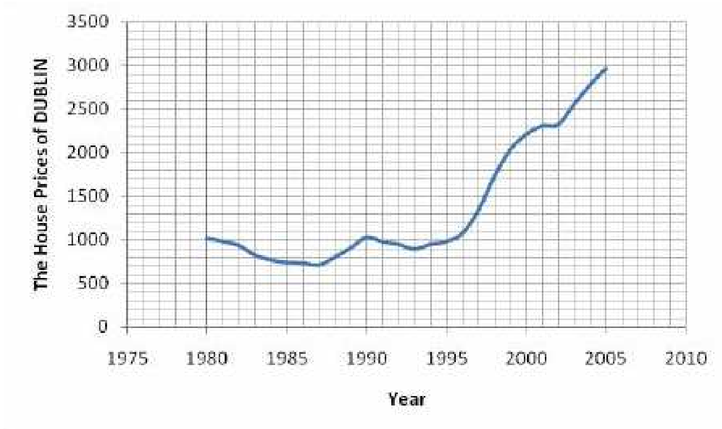

Figure B.5. “Change of house prices of Dublin in time”

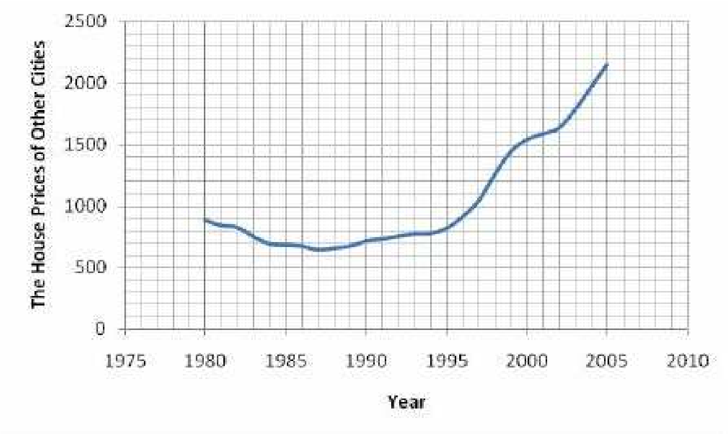

Figure B.6. “Change of house prices of other cities of Ireland in time”

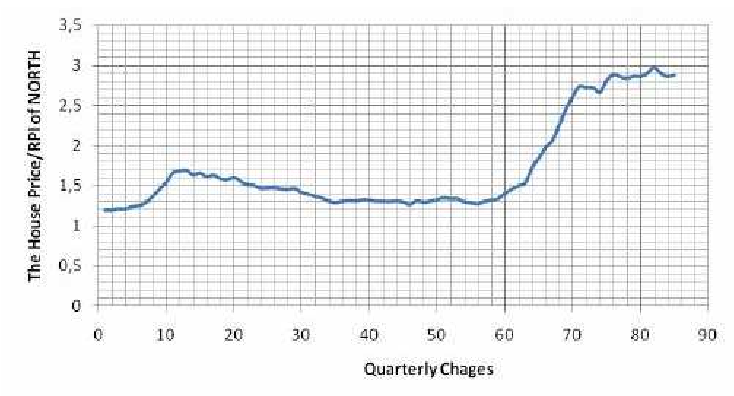

Figure B.7. “The house price/RPI changes of North in time”

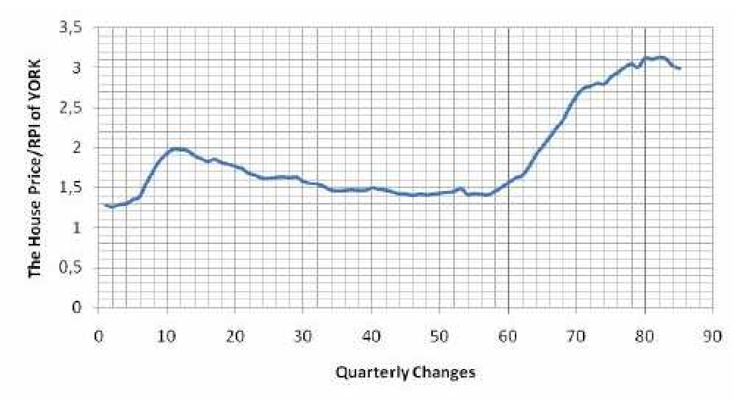

Figure B.8. “The house price/RPI changes of York in time”

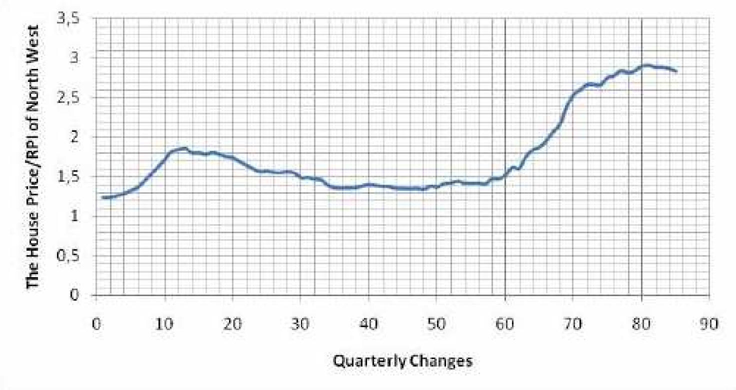

Figure B.9. “The house price/RPI changes of North West in time”

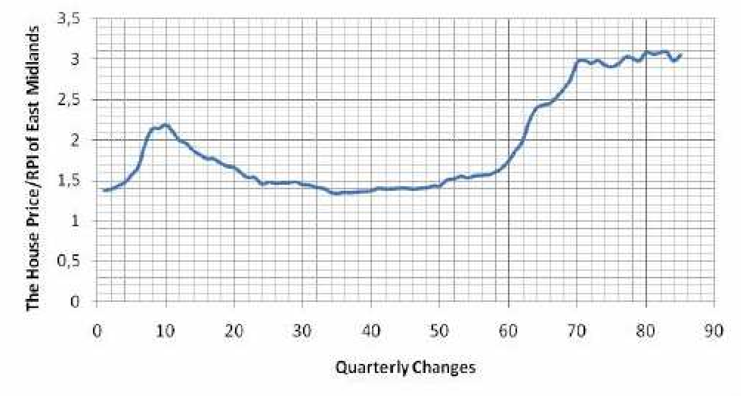

Figure B.10. “The house price/RPI changes of East Midlands in time”

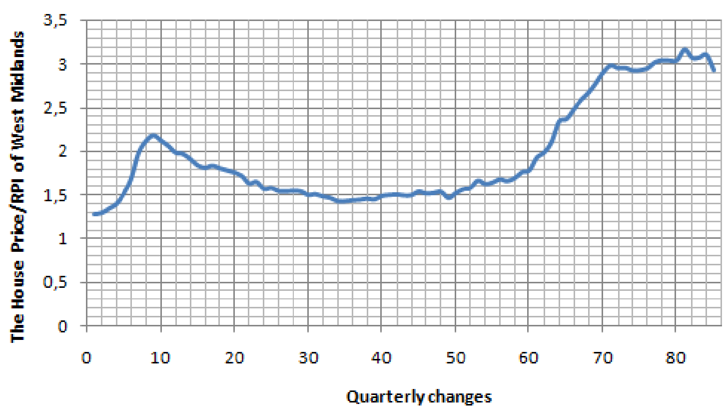

Figure B.11. “The house price/RPI changes of West Midlands in time”

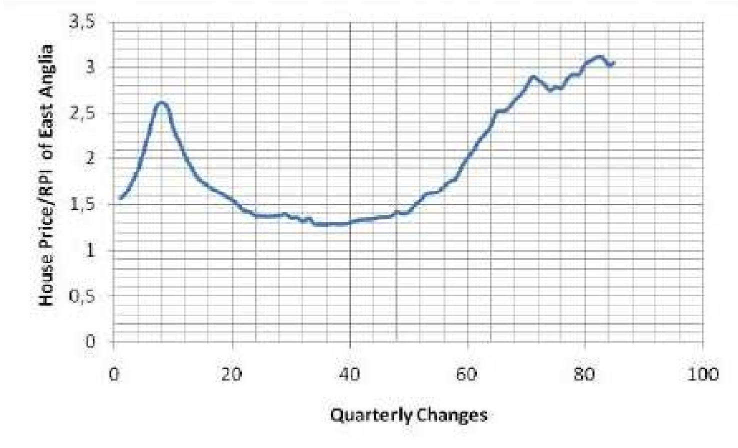

Figure B.12. “The house price/RPI changes of East Anglia in time”

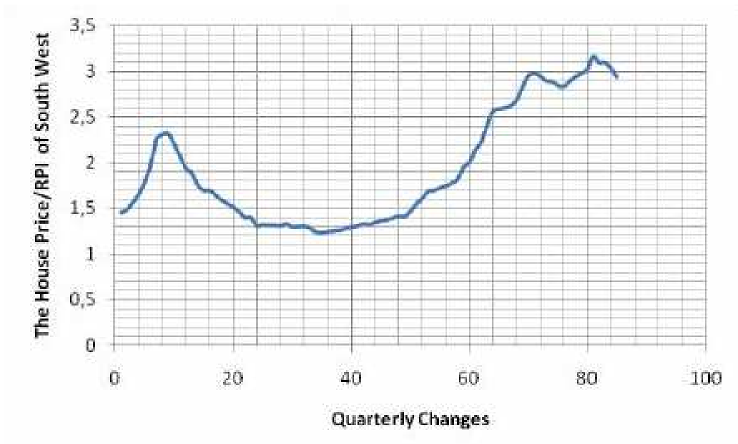

Figure B.13. “The house price/RPI changes of South West in time”

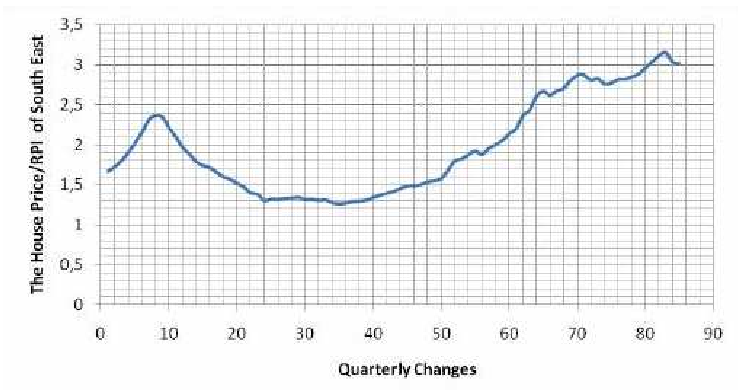

Figure B.14. “The house price/RPI changes of South East in time”

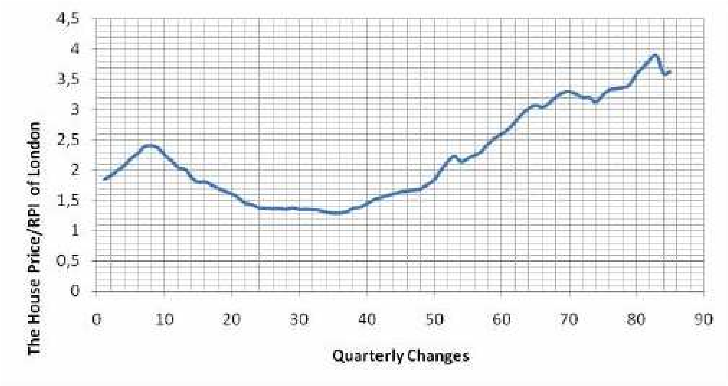

Figure B.15. “The house price/RPI changes of London in time”

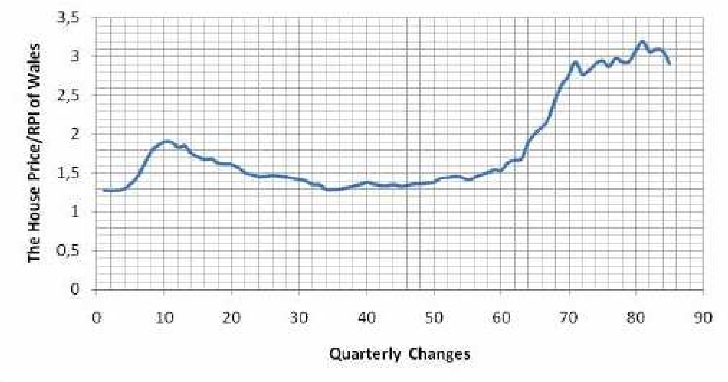

Figure B.16. “The house price/RPI changes of Wales in time”

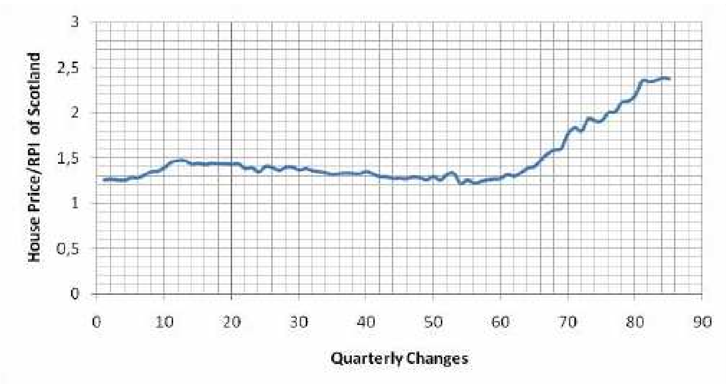

Figure B.17. “The house price/RPI changes of Scotland in time”

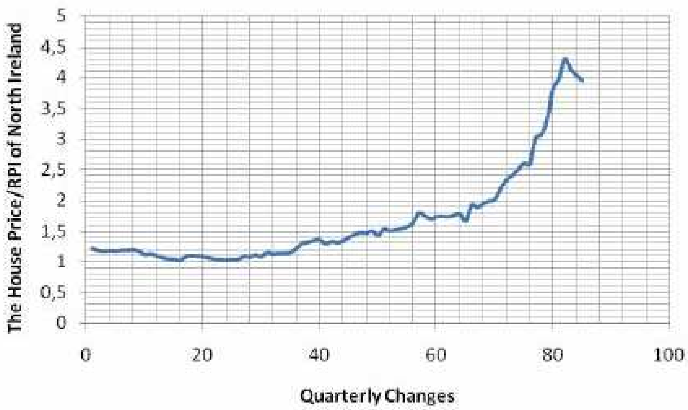

Figure B.18. “The house price/RPI changes of UK in time”

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