A Spatial Analysis of House Prices in the Kingdom of Fife, Scotland

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This contribution was double-blind reviewed as full paper.

Abstract

The research presented in this paper focuses on the analysis of spatial variations in house price adjustments due to economic conditions, and to quantify and describe patterns in the variations of house prices in the study area of Fife, Scotland. To show the impacts of national and local economic conditions on house price levels, specific methods of spatial analysis, such as Interpolation and Geographically Weighted Regression, are needed. The data for this analysis comes from the Registers of Scotland. The Registers of Scotland is responsible for compiling and maintaining registers relating to property and other legal documents. Their main aim is to record and safeguard rights (e.g. respond to policies adopted by the Scottish Government), whilst providing open and efficient access to important information. Results show that there are spatial variations in house prices, whereby the house prices in the north are on the rise, whereas in the south the hotspots seem to disappear.

1 Introduction

During the last 10 years, Scottish house prices experienced several fluctuations. These were also experienced in the Kingdom of Fife, which acts as a microcosm of the country as a whole. This paper is based on an analysis of these house price trends in Fife, our study area. Fife has two separate housing regimes, which makes it particularly interesting to determine if there are any differences according to each regime. While the south east of Fife consists largely of old mining towns, with a quiet depressed housing market, the north east of Fife contains the University city of St. Andrews, which has a very vibrant housing market. The large spatial-temporal database shows the house prices during a 10 year period of fluctuating economic conditions of both housing regimes. The results of this paper will be important for both the Scottish property market and for private persons who need a decision aid. Through the temporal analysis, trends in house prices are depicted as an aid to predicting house prices. This is important to analyse and forecast the drivers of spatio-temporal differences in property prices. For finding out which variables are relevant for house price changes in the Kingdom of Fife, Scotland, it is important to explore the Registers of Scotland (ROS) house price database. The database contains house price indicators such as:

Vogler, R., Car, A., Strobl, J. & Griesebner, G. (Eds.) (2014): GI_Forum 2014. Geospatial Innovation for Society.
 ISBN 978-3-87907-545-4.
 eISBN 978-3-7001-7652-7, doi:10.1553/giscience2014s125.

- Date of sale;
- Sale Price;
- X / Y – coordinates;
- Postcode – enabling linkage to census data.

The database contains all sold house prices from 2003 to 2013 of Fife, and was supplied for free from the ROS. The ROS is responsible for compiling and maintaining registers relating to property and other legal documents. In summary, the goal of this research is to perform temporal spatial analyses of the changing house prices in the Kingdom of Fife. From these results new house pricing trends may be shown.

2 Theoretical Background

The degree to which external effects affect real estate values is not unique at each location, but highly variable over space. There are an indeterminable number of externalities (local and nonlocal) which inflate the given location (FIK et al. 2003). The issue of changing house prices is important. For example, if there is an increase in asset values (creates positive equity), it can lead to housing equity withdrawal and rising confidence. Instead falling house prices reduce the equity and may create negative equity, especially for new homeowners, which creates negative consumer sentiment and is likely to lead to lower household spending. Changes in house prices also affect the distribution of wealth in the economy. During times of rapidly rising prices, those who own property will experience an increase in their wealth relative to those who rent accommodation.

2.1 Changes in the Scottish House Price Market between 2006 and 2011

The real estate market is a very important part of an economy. It is a rather interesting field of research both at macro- and micro-economic levels. At the macro level, the real estate market is closely connected with the financial and real sector. Moreover, the trend of the real estate cycle coincides with that of the economic development. Real estate prices can be considered to be a leading indicator of the general business cycle (MAVRODIY 2005). As a result the real estate market is significant for a country`s economic situation. As shown in Figure 1 there has been a dramatic increase of house prices over the period from 2006 to 2008. Afterwards there has been a gradual decline in average house prices from July 2008 - July 2009. After that the curve exhibits steady behaviour.

Fig. 1:
Average House Prices in Scotland for the period January 2006 – October 2011

Figure 2 shows the number of monthly transactions recorded by the ROS for the period January 2006 – October 2011, without seasonal adjustment. Traditionally, there is a slight increase in sales in October, as buyers seek to complete transactions prior to the year's end, and 2011 proved no exception, with volumes up 2.5% over October. The graph in Figure 2 also shows that the Scottish housing transaction market has fallen since 2006/2007, with about 55% fewer sales in 2011. There was a big crash in October 2007. According to LSL Property Services / Acadametrics[1], the main reason why sales are now at these lower levels is due to the dearth of first time buyers. The original purchasers continue to experience difficulties in raising the increased level of deposits now required by the lenders.

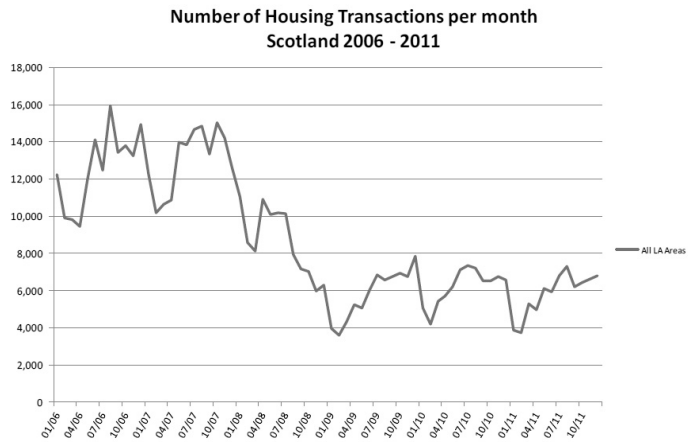

Fig. 2:
The number of housing transactions by month in Scotland, January 2006 – October 2011

2.2 Historic Data

To be able to make a clear and distinct statement about the cause of the changes in the Scottish house prices, it is important to work with historical data. In this context historical means data which were collected over 10 years by the ROS. The ROS is responsible for compiling and maintaining registers relating to property and other legal documents. Their main aim is to record and safeguard rights, whilst providing open and efficient access to important information. For this reason the ROS have documented and stored Scottish house prices over fluctuating economic years. The ROS provided their database for the spatial analysis conducted in this research. House prices in Scotland went through ups and downs from year to year (see Figure 1). These changes are reflected in the data and therefore they are very suitable for this study.

For visualizing spatial historical data it is necessary to give them key dates, data stamps or spatio-temporal composites. Key dates, sometimes referred as time slices, are collections of spatial objects grouped according to specific valid dates. A valid date means that the data has to be recorded before a specific threshold date. Moreover the data is not allowed to be e.g. 41.30.1988. For each layer of time slice data, all of the spatial objects must be represented according to their state at the specified time. This approach is especially useful if most of the objects have some degree of changes that occur in between the time slices

[1] http://www.lslps.co.uk/

and if the number of time slices are limited (BEMA 2009). For this research work, the time slices in Geoinformationsystems (GIS) are made in regular intervals to mesh them with other data. As a result the maps represent the data at particular moments in time.

2.3 Spatial Interpolation of Dynamic House Prices

Spatial interpolation is an important procedure for raster data modelling and an important way of creating new data sets. Interpolation predicts values for cells in a raster from a limited number of sample data points in a vector point file. It can be used to predict unknown values for a large number of attributes, including elevation, rainfall, chemical concentrations, noise levels, and so on. The main use of interpolation is to create continuous raster surfaces from point data. It calculates the value of an attribute at unsampled locations from measurements made at sampling points. This means, that it fits a surface to a set of points (Figure 3).

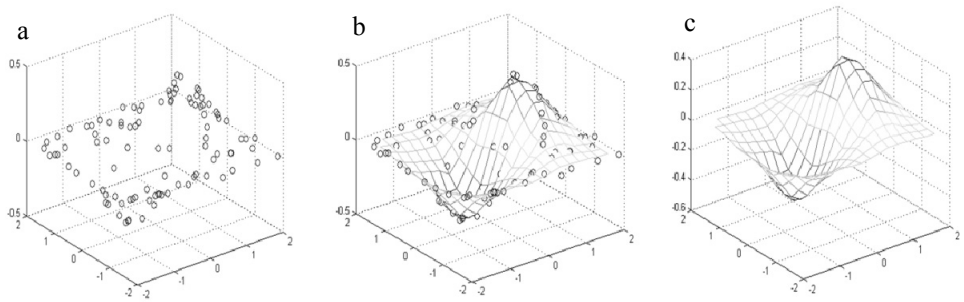

Fig. 3: Picture a, b and c show the working process of Interpolation; Picture a is the original point data set, picture b is the interpolation including the original dataset and picture c shows the final interpolation of the point data set

The assumption behind interpolation is that spatially distributed objects are spatially auto correlated, which means that things that are close together tend to have similar characteristics. These characteristics of spatial data are expressed in Tobler's law (sometimes also called the "First law of geography"): "Everything is related to everything else, but nearby things are more related than distant things" (TOBLER 1970). For instance, if it is raining on one side of the street, you can predict with a high probability that it is also raining on the other side of the street. However, there is a lower probability that it is raining across town and an even lesser probability that it is raining in the adjacent county. Using the above analogy we can conclude that values of points close to sampled points are more likely to be similar than those that are farther apart. This is the basic concept of interpolation.

Many different interpolation methods exist and they depend on how the interpolated points are calculated from the existing points to create the surface. For this research work, the diffusion interpolation with boundaries, inverse-distance weighting (IDW), and a deterministic, ordinary kriging are applied (KENNEDY 2004).

3 Data Processing and Different Ways of Interpolation

The spatial analysis is performed using data from the Registers of Scotland (ROS), which is necessary to verify, clean and process the data. The data were originally provided as an .xls file. In order to use the data in ArcMap, which is a commercial Geoinformation software by ESRI, it was necessary to first remove certain special characters, such as forward slashes or the £ symbol from the original .xls file. The main reason is that ArcMap cannot handle data which consists of forward slashes or other symbols except for points. It is thus necessary to reformat the date cells in the .xls file from "02/04/2004" to "02.04.2004" and the house price field from "195000 £" to "195000". After this simple reformatting the data are ready for visualization and the X / Y – coordinates can be added to visualise each house price as a point on the map. Moreover the datasets have been divided into two parts, one from 2003 – 2008 and one from 2009 – 2013. The first dataset is much larger and includes 51,205 transactions, whereas the second dataset includes "only" 25,772 transactions. This means that in the years from 2009 – 2013 less housing transactions were completed.

The whole dataset consists of 67,000 points. For this research work it was necessary to make comparable layers from the house prices of the Kingdom of Fife over a 10 year period. Therefore, the dataset was divided into 10 layers (one layer each for a single year). For the visualisation of the data it is necessary to have similar class sizes across the maps for the individual years. Otherwise it would not be possible to make a valid comparison across the ten maps. Therefore, the layer which contains the data from all 10 years was chosen and the house prize variable was classified into five different classes. The same five classes were then applied to each of the ten maps.

As mentioned in chapter 2.3, spatial interpolation is an important procedure for raster data modelling. The main use of interpolation is to create continuous raster surfaces from point data. Depending on how the points are calculated from the surface, several different interpolation methods exist. The *diffusion interpolation* is also called spline with barriers. This method applies a minimum curvature method, as implemented through a one-directional multigrid technique that moves from an initial coarse grid, initialized as the average value of the input data, through a series of finer grids until an approximation of a minimum curvature surface is produced at the desired row and column spacing. *Inverse-distance weighting (IDW)* interpolation implements the assumption that things that are close to one another are more alike than those that are farther apart. To do so, IDW calculates the weights w_i so that the closer the measured values are to the prediction location x, the larger the weight they receive and the more influence the values have on the predicted value z(x). *Deterministic ordinary Kriging* weights come from a graph called a semivariogram. This graph is developed by looking at the spatial structure of the data. To create a continuous surface or map of the phenomenon, predictions are made for locations in the study area based on the semivariogram and the spatial arrangement of measured values that are nearby. The main aspect which distinguishes kriging from IDW is that kriging also uses a statistical model which includes probability. After applying all three interpolation methods to our dataset, the best results were achieved with the method of deterministic ordinary Kriging, due to its calculation with an additional statistical model.

4 Results

This research work focused on exploring the change of house prices in the Kingdom of Fife from 2003 – 2013. In order to determine spatio-temporal patterns of house prices within the study area, hotspot analyses, interpolation techniques, a morphing procedure and a calculation of average house prices were conducted. The main pattern which was found is that the house price hot spot in the south east of Fife disappeared around the time period 2008 to 2013, and the hot spot in north east of Fife increased at the same time. Also, the house prices for Fife as a whole increased from the year 2003 to 2013. There was a short crash from 2007 to 08, but afterwards house prices started to increase again. In order to best understand and depict the results of the analysis, three different kinds of visualisation were used (showing a point pattern from 2003, showing the average house prices from 2003, 08, 12 and the before mentioned Interpolation techniques). The first one is the visualization in the form of a point pattern. The house price data is categorized into five classes and is depicted in Figure 4. Furthermore it is recognizable that the house prices have risen in most counties. An increase in housing prices in St. Andrews is also apparent (Figure 5).

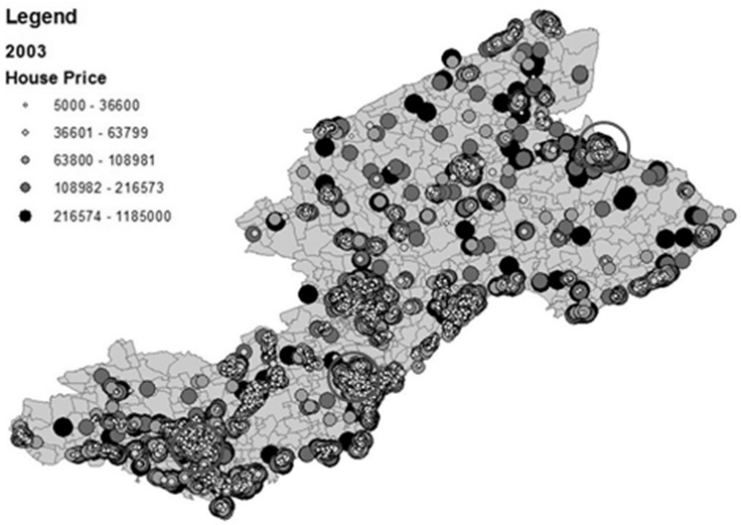

Fig. 4: The whole house price point dataset from 2003 categorized in 5 classes; the circle on the left side of Fife shows Dunfermline, the middle one Kircaldy and the one on the right side St. Andrews.

The second visualisation method was to show the average house prices of Fife in the years 2003, 2008 and 2013. These results are shown in Figure 5. The three main cities Dunfermline, Kircaldy and St. Andrews are pointed out by circle.

Fig. 5: Spatio-temporal changes of house prices in Fife for the years 2003, 2008, and 2012. The circles mark the main towns Dunfermline (left), Kircaldy (middle) and St. Andrews (right).

Figure 5 represents the average house prices in Fife for the years 2003, 2008 and 2012. Out of this map it is recognizable that not only the hot spots have shifted, but also that the house prices have risen in general. As Figure 5 depicts, the highest price for a building in 2003 was £ 1.185,000, in 2008 it was £ 1.420,000, and in 2012 the highest cost for a building was £ 1.450,000.

The final visualization, which also shows the most recognition, was produced with three different kinds of interpolations, namely, diffusion interpolation with boundaries, IDW and Kriging (see chapter 3). For better visualization, these analyses were conducted in ArcScene instead of ArcMap, which is also a software package by ESRI to make 3D maps and for creating special analyses like our used interpolation techniques. The results of all techniques from the year 2003 are shown in Figure 6, and represent the distribution of the average house prices.

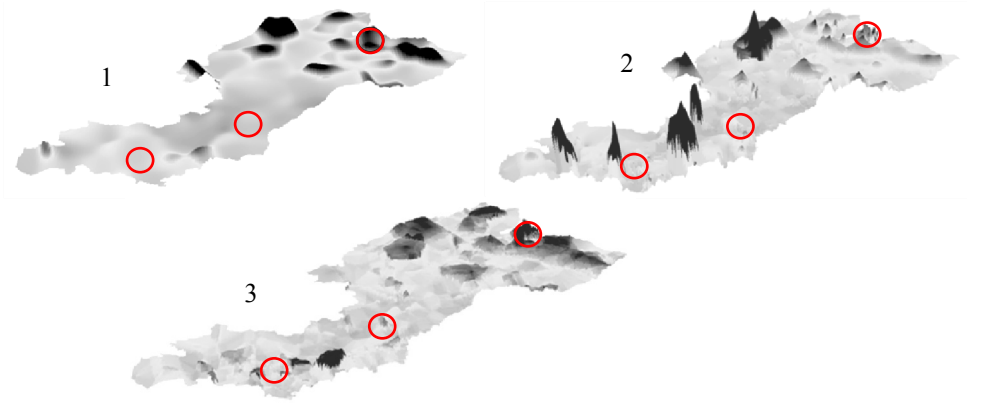

Fig. 6: The three different interpolation techniques which were used. Diffusion Interpolation with Boundaries (1), IDW (2) and Kriging (3) from house prices in 2003. The circles mark Dunfermline (left), Kircaldy (middle) and St. Andrews (right)

As it is recognizable from Figure 6, Kriging is the most accurate method of interpolation. Therefore, visualizations were also performed for the years 2008 and 2012 and are depicted in Fig. 7. As you can see, the high house prices in the south east of Fife disappear, and the prices in the north east rose.

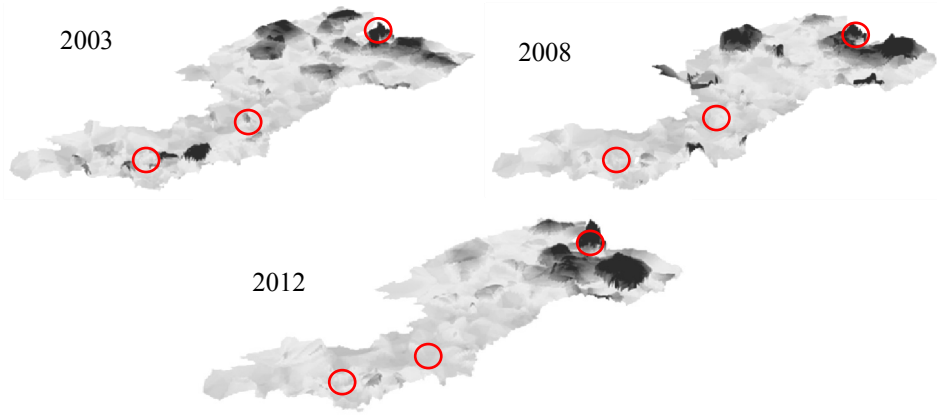

Fig. 7: The most accurate interpolation technique of Kriging was used for 2003, 2008 and 2012. The circles mark Dunfermline (left), Kircaldy (middle) and St. Andrews (right)

In general, the different visualization techniques have helped to identify the main pattern in house prices, which have occurred during the ten year observation period in the Kingdom of Fife. The house prices have been increasing and moved to the north east of the Kingdom. The hotspot in Dunfermline (located in the south-east of Fife) which existed in 2003

disappeared in 2013, while the house prices in St. Andrews (north east Fife) have grown rapidly since approximately 2008. It is also a fact that the more expensive house prices are near the main roads, which connect the bigger cities in the south east and middle Fife. Also, the house prices in the surrounding of the University of St. Andrews increased. This may be due to the students which attend the University. These students can afford high estate prices and therefore the agencies increase their prices from year to year.

The main reason for the increasing house prices is the high unemployment rate, which started to increase in 2008. Many people needed to sell their houses. This fact is confirmed by the information in the datasets. This is an indication that in the first dataset more real estates were sold due to the pressure of newly unemployed people needing to sell their property. Unfortunately, the size and the type of the real estates have not been collected in this research project. Naturally house prices depend on the size of a property and there are areas in Fife where bigger and newer houses can be found. Therefore, the house prices in these areas are higher than in districts where houses do not possess such a high quality. It is believed that including the size and the type of real estates would not drastically change the pattern observed in this paper, but it would make the results more accurate.

5 Conclusion and Outlook

With the help of different spatial analysis and different visualisation methods two main patterns have been identified. These are that the hot spots from the south east of Fife have disappeared, and that the house prices rose in general. The statistical methods which have been used for this research project are hot spot analyses and three different ways of interpolation, namely, Interpolation with barriers, IDW and Kriging. Moreover, different kinds of visualization techniques have been used, i.e. calculating the average house price and a morphed map. In conclusion it can be said that the methods applied in this study were appropriate for the analyses, and that all of these techniques show the same patterns like a shift in the hot spot from the south east to north east of Fife and the general increase in the house prices.

In future, new housing attributes should be added to the database. Such new attributes may include the house size, the building date of the house, and the type of the real estate. With the help of these attributes more accurate changes in house prices could be made. Another interesting method to apply and test would be Geographically Weighted Regression (GWR). These GWR analyses could help to improve the statistics and increase the model´s accuracy. Moreover it is also helpful for identifying the spatial patterns apparent in the study area. One pattern that may be shown is that newer houses command a higher listing price per square foot according to the data analyzed. Furthermore, the topic discussed in this research is really complex and it would be interesting to undertake more and specific spatio- temporal analysis to further investigate changes of house prices. In addition these changes could improve the decision making process for new house owners and property investors.

Acknowledgments

The first author would like to acknowledge the support of the Centre for Geoinformatics at the University of St. Andrews, who hosted her internship, during which this research was done. She would also like to thank the Registers of Scotland for providing the data needed for this research.

References

BERMAN, M. L. (2009), Modelling and visualizing historical GIS data [online]. Harvard University, http://www.fas.harvard.edu/~chgis/work/docs/papers/CGA_Wkshp2009_Lex_9apr09.pdf (accessed: 25.11 2013).

FIK, T. J., LING, D. C. & MULLIGAN, G. F. (2003), Real estate economics modelling spatial variation in housing prices: a variable interaction approach. FL.

KENNEDY, H. (2004), Data in three dimensions: a guide to ArcGis 3D analyst.

MAVRODIY, J. (2005), factor analysis of real estate prices [online], National University Kyiv-Mohyla Academy. http://kse.org.ua/uploads/file/library/2005/mavrodiy.pdf (accessed: 25.11 2013).

TOBLER W. (1970), A computer movie simulating urban growth in the Detroit region. Economic Geography, 46 (2), 234-240.

http://www.economicsonline.co.uk/Competitive_markets/House_prices.html (accessed: 25.11.13).

http://www.lslps.co.uk/documents/house_price_scotland_dec11.pdf (accesssed: 25.11.2013).

http://geospatial.referata.com/wiki/First_Law_of_Geography (accessed 25.11.2013).

http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#//009z00000075000000 (accessed 25.11.2013).

http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/How_Spline_with_Barriers_works/009z00000079000000/ (accessed 25.11.2013).