Identifying Regional Differences in the Spanish Mortgage Market with Sheaf Methodology

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Abstract

The strong expansion of mortgage credit in Spain during the second half of the nineties was due to a decline in interest rates (a reduction that was greater in Spain than elsewhere in Europe) and also to a tremendous competition between financial institutions to increase market share. This expansive phase lasted until 2006, followed by a sharp turnaround in 2007. The aim of this paper is to illustrate the evolution of the mortgage market in different Spanish provinces. We have performed a comparative analysis of different regional trajectories using statistics on the number of monthly housing loans for the period between late 1995 and early 2012, applying sheaf methodology for the visual comparison of geographic time series. We conclude that the provinces that have been hit the hardest by the recent recession are those that reached the higher peaks during the expansionary cycle.

Keywords: Loan market, regional analysis, geographic time series, statistical graphics, interest rates, sheaf methodology.

JEL codes: H81, C23, R21.

1. Introduction

Credit to households can have different uses. The Bank of Spain makes a distinction between loans applied to the acquisition or renovation of a house, those used for purchasing durable consumer goods, and the rest, which include the acquisition of land, undeveloped property, securities and non-durable consumer goods. In 1993

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61.4% of all household credit was used for home purchases or renovations. Ten years later this percentage had risen to 73.3%\(^1\), and according to the Bank of Spain, in 2011 it had reached 82.2% of total household credit. This means that between 1993 and 2011 it experienced a 33% increase.

The expansion of credit for the acquisition of housing is closely linked to the growth experienced in the Spanish mortgage market after Law 2/1981 and the later Royal Decree 685/1982, which set the basis for an expansionary mortgage market. Mortgage credit started to grow at a strong pace, especially from 1995 onwards, and this growth continued until 2006. However, the turnaround came in 2007 and the number of new mortgages declined sharply.

This dynamic behavior of the mortgage market was reflected in the number of new mortgages. 480,713 new mortgages were granted in Spain in 1995, and by 2006 this number had risen to nearly 1,900,000. Economic factors aside, the expansion in credit that started in the mid 90s occurred mainly because of two key elements: a) a fierce competition between financial entities for market share, and b) a favorable evolution in interest rates – the drop in interest rates was bigger in Spain than in other European countries (Mayayo, 2005). For the 1991-1995 period, the average interest rate in mortgage loans with a term of more than three years was 13.3%. For the next five-year period, the average was 6.5, and the next two five-year periods show averages just barely over 4%.

We should remember that this combination of stiff competition between financial entities and low interest rates was the result of great transformations in the international financial world, which had direct results on European countries. The greater degree of competition between financial entities was related to the financialization\(^2\) process that had been in place since the 1980s, by virtue of which markets and financial logic acquired a growing relevance in determining economic activity. On the other hand, the financial system had experienced a sweeping transformation with the liberalization process\(^3\). In the past, credit had been subject to strict regulation in order to maintain financial stability. However, starting in the 1970s and 80s many developed countries deregulated their financial markets, resulting in increased competition between entities (Volcker, 1986; Blundell-Wiganll and Browne, 1991).

The gradual reduction in interest rates was a direct consequence of Spain joining the European Union. Interest rates, both long and short term, fell since Spain joined the EU. Short term interest rates were at nearly 20% in 1983, fell to 12% in 1986, and to 8% in 1994. Interest rates rose briefly in 1995, but fell again due to expectations of Spain joining the Monetary Union, and in 1998 and 1999 were even lower than those in the EU. Likewise, long term interest rates also experienced a dramatic

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\(^1\) For the 1984-2001 period see Nieto et al. (2001).
\(^2\) Bellamy Foster, 2007 and 2008, offers a comprehensive review of the use and meaning of the term in the Monthly Review.
\(^3\) For an analysis of the liberalization process of the Spanish banking system see Salas and Saurina (2003).
reduction from 1990 onwards, converging with Eurozone rates in 1999 at the 4–5% level. Such a reduction brought a significant relief in the financing costs of the Spanish economy. For Spanish citizens the reduction in mortgage rates was probably the most obvious benefit of joining the European Economic and Monetary Union (Piedrafita, Steinberg and Torreblanca, 2006).4

The reduction in interest rates ran parallel to changes in the supply of mortgages by financial entities. Two key elements need to be stressed: a) The financial entities extended mortgages terms and b) the loan-to-value ratio of mortgages grew significantly. Both circumstances are related to the expansion of financial entities after the liberalization process, which had forced to a deep revision of banking strategies. Many entities (particularly “Cajas de Ahorros”, savings and loans) followed a clear distinction between their areas of expansion and their traditional markets. The growth in the loan-to-deposits ratio was the result of an outright gamble by financial entities to expand via assets as opposed to gaining market share by collecting more deposits (Delgado, Saurina and Townsend, 2008). In turn, this resulted in looser mortgage qualification requirements, and, most notably, in higher loan-to-value ratios. On the other hand, the extension of mortgage terms allowed financial entities to offer lower monthly installments, attracting more potential clients. The consequence of this process was that a greater number of people qualified for mortgages, and the percentage of homeowners grew.

Mortgage activity fell significantly from 2006 onwards, with a substantial reduction in the number of new mortgages. Even by 2003 the rate of growth in new mortgages had slowed considerably, and by 2007 it turned negative5. In 2011 the number of new mortgages was similar to that of 2003, and 66% lower than those granted in 2006, at the height of the real estate boom.

No single cause can be identified for this trend reversal. On one side financial entities have enacted restrictive policies, leading to a credit crunch and stricter mortgage qualification requirements6. Real estate prices have been another fac-

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5 2007 was the year of the subprime (low-grade mortgage loan) crisis in the United States, marking what many analysts considered a change in the mortgage market cycle; it was also when law 41/2007 on mortgage market reform was passed in Spain.

6 Interesting data can be found in the Euro Area Bank Lending Survey (BLS), a periodical survey on the evolution of supply and demand conditions in the EMU credit market, carried out by Counsel to the Executive Board of the European Central Bank. It analyzes the perceived evolution of the demand and supply of credit, and the factors that explain the market’s behavior. For an in-depth explanation of the BLS see Martínez J. and Maza L.A. (2003). The “diffusion index” is created using results of this ECB survey as follows: all answers that show a tightening (either “considerable” or “to an extent”) of credit conditions are added up and all answers that state there is a loosening (either “considerable” or “to an extent”) are subtracted. The result is divided by the total number of answers and multiplied by 100. The index fluctuates between 100 (when all entities tighten their supply of credit) and -100 (when all entities loosen their credit conditions). Negative values indicate a contraction in credit supply while positive values signal an expansion. The answers to the survey refer only to changes in credit trends, not to absolute credit levels.
tor. Between 1995 and 2008 the price of housing in the free market grew by 203%. A significant group of people that would have normally become home-
owners for the first time were priced out of the real estate market; the younger segment of the population was particularly sensitive to the rise in housing prices (Márquez, 2008). The recent rise in Value Added Tax for new houses in the free market from 7 to 8% certainly will not help reverse the trend. After a time lag, the fall in demand that started in 2006, along with an adjustment process on the supply side resulted in a reduction of housing prices that started to become apparent in 2009.

On the other hand, economic conditions since the onset of the crisis have discouraged recovery in mortgage activity. The rise in unemployment that started in 2006 is an obstacle to homeownership for a great number of people, and hinders the capacity of many others to meet their mortgage payments.

Although the number of new mortgages fell in 2007, the total value of new mortgage loans did not start to decrease until 2008. One reason among others is that the rise in housing prices pushed up the average mortgage size. Although the total value of new mortgages did not begin to fall until 2008 it was already stationary in 2007.

Once we have described the evolution of Spain’s mortgage market we may ask ourselves if such behavior has been homogeneously followed in different Spanish provinces, or if we might find “sub-markets” with distinctive features. This article is based on the hypothesis that all provinces have followed the national pattern of behavior from an expansive cycle to a recessive one, so at least from that angle we can consider there is a certain degree of territorial homogeneity; however we will prove that there are important regional differences in the intensity of both expansion and contraction.

2. A Review of Current Bibliography

There are few studies on the evolution of Spain’s mortgage market from a regional perspective. A review of current bibliography yields some interesting works that include regional analysis in their assessment of the real estate market, yet few of them focus specifically on mortgage loans, a key element in the demand for housing.

Some studies employ regional analysis to identify real estate “sub-markets”. Variables such as the economy, specialization in specific housing types, geographic expansion and demographic factors are taken into consideration (Altuzarra Artola and Esteban Galarza, 2010). Regional analysis is also used in studies that try to explain the behavior of housing prices (López, 2002; Álvarez-Lois and Nuño Barrau, 2007) and to identify elements that influence housing demand (Rodríguez Hernández, J. y Barrios García, J., 2007).

There are also numerous studies abroad that feature regional analysis. Most of them focus on the existence and behavior of real estate “sub-markets” based on housing price dynamics (Reichert, 1990; Hancock, 1991; Drake, 1995; Ashworth and
Parker, 1997; Bourasa, Hamelink, Hoesli and MacGregor, 1997; Meen, 1999; Cook, 2003 and 2005; Alkay, 2008; Bramley, Leishman and Watkins, 2008; Chien, 2010). Along the same lines Englund and Ioannides (1997) adopted an international scope, comparing housing price dynamics in 15 OECD countries.

Regional analysis has also been approached from a theoretical point of view, with the objective of defining the concept of “sub-market” (Drake, 1995; Meen, 1996; Watkins, 2001).

To conclude this bibliographical review we must state that Spain is lacking in “sub-market” identification methods. There are some interesting studies abroad that use factorial analysis and cluster techniques to identify regional markets (Dale-Johnson, 1982; Bourasa, et al., 1997; Bourassa, et al., 2003).

The objective of this article is to cover the current gap in regional analysis of the Spanish mortgage market. We will use the recently proposed “sheaf of lines” methodology (Ferrán 2011a, 2011b and 2013) to compare geographical time series. The methodology is explained below.

3. Sheaf Methodology

The standard way of representing a time series is through a line chart, with a Cartesian coordinate system in which the x-axis represents time and the y-axis represents the values for the series. The consecutive points in the chart are linked together with segments, forming a line. The interpretation of the graph will help in detecting behavior patterns in the data’s time trajectory. A problem arises when comparing multiple time series, as can be the case in the comparison of geographical time series. Whether each series is represented separately or they all are superimposed and represented together in a single graph (either in their original scale or all converted to a common scale), the comparison is extremely complex as soon as the number of series exceeds a minimum. The objective of the sheaf methodology is to offer a graphic tool that enables the comparison of multiple time series. The key concept of the methodology is:

**Definition 1:** A set of $K$ different time series, all of them defined at the same periods, $t = 1, \ldots, T$, has a sheaf structure $K$ of straight lines if there is another time series $x_t$ that for each $c_{t,k}$ there are four coefficients $b_k, m_k, B_0$ and $B_1$, with at least $m_k$ different from zero, so that:

$$c_{t,k} = b_k + m_k \cdot x_t \quad \forall_{t,k} \quad \text{where} \quad b_k = B_0 + B_1 \cdot m_k \quad \forall_k$$

Let us observe that if $\{c_{t,k}\}$ has a sheaf structure of straight lines regarding $x_t$ then the sheaf vertex of the straight lines $c_{t,k} = b_k + m_k \cdot x_t$ is $(x_t, c_{t,k}) = (-B_1, B_0)$.

Using this definition as a starting point, the fundamental result of the sheaf of lines methodology is:
**Proposition 1:** Let \( \{C_{t,k}\}, k = 1,\ldots, K \) be a set of K different time series, all of them defined at the same periods \( t = 1,\ldots, T \), and with the same means:

\[
\bar{C}_k = \frac{1}{T} \sum_{t=1}^{T} C_{t,k} = \alpha \quad \forall k
\]

Let \( X_t \) be another time series and assuming that for each \( C_{t,k} \) there are five coefficients \( b_k, m_k, \mu_k, B_0 \) and \( B_1 \) with at least \( m_k \) different from zero, so that:

\[
C_{t,k} = b_k \cdot t + m_k \cdot X_t + \mu_k \quad \forall t, k
\]

being:

\[
b_k = B_0 + B_1 \cdot m_k \quad \forall k
\]

Then:

A) If \( C_{t,q}, C_{t,r} \) and \( C_{t,s} \) are any three time series of the \( \{C_{t,k}\} \) set such that \( m_q < m_r < m_s \) then \( d(C_{t,q}, C_{t,r}) < d(C_{t,q}, C_{t,s}) \), where \( d \) is the euclidean distance.

B) For any couple of time series from \( \{C_{t,k}\} \) set there is at least one point in their trajectory\(^7\) where they intersect. Moreover, the intersection points of these two trajectories are the intersection points for the rest.

C) If trajectories intersect in more than one point then the difference between any two is independent from the time series mean.

Also:

**Remark 1:** The set of time series \( \{c_{t,k} = C_{t,k} - C_{t-1,k}\} \) has a sheaf structure of K straight lines regarding \( x_t = X_t - X_{t-1} \) with vertex on \( (x_t, c_{t,k}) = (-B_1, B_0) \).

Given a group of \( J \) different time series \( \{Y_{t,j}\}, j = 1,\ldots, J \) (with a large \( J \)), all of them defined at the same periods, \( t = 1,\ldots, T \), the sheaf methodology builds a new set \( \{C_{t,k}\} \) of time series, \( k = 1,\ldots, K \) (with a small \( K \)) that verifies Proposition 1’s hypothesis with the objective of summarizing \( \{Y_{t,j}\} \) set structure. Representation of each series \( Y_{t,j} \) along with the other \( K \) series of the \( C_{t,k} \) set will make comparisons easier. For the extraction of the \( \{C_{t,k}\} \) set to make sense, and consequently for the methodology to work, the \( \{Y_{t,j}\} \) set must “have an underlying sheaf of straight lines structure”:

**Definition 2:** Let \( \{Y_{t,j}\}, j = 1,\ldots, J \) be a set of \( J \) different time series, all of them defined at the same periods, \( t = 1,\ldots, T \). We will say that the underlying structure of time series set \( \{Y_{t,j}\} \) is a sheaf of straight lines if there is another time series \( X_t \) such that, on one side, for each of the time \( J \) series the fit of the regression equation:

\[
(7) \text{ We will use the term trajectory for the continuous line that connects the sequence of points in the graphic representation of the time series.}
\[ \hat{y}_{t,j} = A_{0,j} \cdot t + A_{1,j} \cdot X_t + A_{2,j} \quad j=1,\ldots, J, \]

is adequate and, on the other, either the sequence of coefficients \(A_{0,1},\ldots, A_{0,J}\) is equal to zero or its degree of linear association with the sequence is statistically significant.

Let us observe that, if \(B_0\) and \(B_1\) are the coefficients of the regression equation:

\[ \hat{A}_{0,j} = B_0 + B_1 \cdot A_{1,j} \quad j=1,\ldots, J \]

then, according to Definition 1, the time series set \(\{\hat{y}_{t,j}\}\), where:

\[ \hat{y}_{t,j} = \hat{A}_{0,j} + A_{1,j} \cdot x_t \quad j = 1,\ldots, J \quad \text{being} \quad x_t = \nabla X_t = X_t - X_{t-1}, \]

has a sheaf structure of \(J\) straight lines regarding \(x_t\) with vertex on \((x_t, \hat{y}_{t,j}) = (-B_1, B_0)\).

In summary, given a set \(\{Y_{t,j}\}, j = 1,\ldots, J\), of \(J\) different time series (with a large \(J\)), all of them defined at the same periods, \(t = 1,\ldots, T\), which we assume has an underlying sheaf of straight lines structure, the methodology use \(K\) straight lines from the corresponding sheaf (with a small \(K\)) to build a new set \(\{C_{t,k}\}, k = 1,\ldots, K\), of time series that “summarizes” the \(\{Y_{t,j}\}\) set’s structure.
Figure 1. *Top Left:* Home mortgages time series trajectories; *Top right:* Homogeneized home mortgages time series trajectories; *Center left:* Summary time series set trajectories; *Center right:* $\exp Z_i$, Sevilla time series represented over $\{\exp C_{ik}\}$ set; *Bottom:* Principal components representation for distances between homogeneized provincial time series.

Source: Author’s research from INE data.
4. Applying the Sheaf Methodology to the Spanish Mortgage Sector

Let \( \{H_{t,i}, t = 1, \ldots, T = 197\} \) be the set of time series of the number of home mortgages granted each month in each of the fifty Spanish provinces, along with Ceuta and Melilla, from December 1995 to April 2012, both included (Figure 1, top left). The set of series \( \{C_{t,k}\} \) will be built using the Sheaf Methodology on set \( \{Y_{t,i} = \ln H_{t,i}\}\)\(^8\).

Let the average series be:

\[
Y_t = \frac{1}{52} \sum_{i=1}^{52} Y_{t,i}
\]

prior to building the \( \{C_{t,k}\} \) set we will set the scale of representation, which will be that of the average series, \( \alpha = \bar{Y} = 9,041 \). Let \( \alpha_j \) be the mean of \( Y_j \), then the time series (Figure 1, top right):

\[
Z_{t,j} = Y_{t,j} - \alpha_j + \alpha \quad j = 1, \ldots, 52
\]

are all on the same scale as the average series (\( \bar{Z}_j = \alpha, \forall j \)). Set \( \{C_{t,k}\} \) will be built on the values \( A_{0,j} \) and \( A_{1,j} \), coefficients of the regression equation:

\[
\hat{Z}_{t,j} = A_{0,j} \cdot t + A_{1,j} \cdot Y_t + A_{2,j} \quad j = 1, \ldots, 52
\]

Specifically, in terms of \( A_{1,j} \) range of values (Table 1), we will consider \( K = 6^9 \) coefficients in the form and \( m_1 = \min_j A_{1,j} = 0,1285 \) and \( m_k = m_{k-1} + \theta, k = 2, \ldots 6 \), where:

\[
\theta = (\max_j A_{1,j} - \min_j A_{1,j})/(K - 1) = (1,8516 - 0,1285)/(6 - 1) = 0,3446
\]

and, based on the values of \( A_{1,j} \) and \( A_{0,j} \) we will estimates the regression equation:

\[
\hat{A}_{0,j} = B_0 + B_1 \cdot A_{1,j} = 0.001 + (-0.001) \cdot A_{1,j} \quad j = 1, \ldots, 52
\]

If we denote \( b_k = B_0 + B_1 \cdot m_k \), each summary series will be associated to a pair of values \( m_k \) and \( b_k \) following the expression:

\[
C_{t,k} = b_k \cdot t + m_k \cdot Y - \beta_k + \alpha
\]

where \( \beta_k = g_k \) with \( g_{t,k} = b_k \cdot t + m_k \cdot Y \). The time series that are built this way (Figure 1, center left) are in the same scale as the time series \( Z_{t,j} \) and \( \{C_{t,k}\} \) set verifies Proposition 1.

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\(^8\) Hence, comparison between new housing construction projects in two different periods will be made in terms of their ratio.

\(^9\) Once we have applied the methodology we can change the value of K in terms of the solution obtained and repeat the process.
In order to analyze a province’s trajectory we can represent each time series \( \exp Z_{t,i} \) over the \( \{ \exp C_{t,k} \} \) set (Figure 1, center right). Alternatively, we can represent each time series \( Y_{t,i} \) over the \( \{ \exp C_{t,k} \} \) set, where:

\[
C_{t,k}^j = C_{t,k} - \alpha + \alpha_j, \quad k = 1, \ldots, 6
\]

Although the observed series for the number of mortgages in each province, \( H_{t,i} = \exp Y_{t,i} \), is represented over the \( \{ \exp C_{t,k} \} \) set (Figure 2), the common reference scale for each and all representations will be determined by scale of the \( \{ \exp C_{t,k} \} \) set.

To establish an order of provinces for the sequence of graphs in Figure 2 we will apply a Principal Components Analysis to the matrix of squared Euclidean distances between each pair of series of the \( \{ Z_{t,i} \} \) set. The lower part of Figure 1 provides a representation of the solution for the first two components (columns \( F_{1,i} \) and \( F_{2,i} \) of Table 1). Since the different province-points are globally correctly represented\(^{10} \), the interpretation of their position is quite reliable and, in consequence, so is the order for the provinces given by the imaginary line that runs through the cluster of dots from Lugo to Almería.

Since the \( \{ C_{t,k} \} \) set verifies Proposition 1, Remark 1 implies that the six lines \( c_{t,k} = C_{t,k} - C_{t-1,k} = b_k + m_k \cdot y_t \), with \( y_t = Y_t - Y_{t-1} \), are part of the sheaf of straight lines with vertex on:

\[
(y_t, c_{t,k}) = (-B_1, B_0) = (0.001, 0.001)
\]

\(^{10} \) The quality of a point’s representation is determined by its distance to the origin, its highest value being 1.
Table 1. $A_{0,i}$, $A_{1,i}$, $a_i$, $F_{1,i}$ and $F_{2,i}$ values for provinces

<table>
<thead>
<tr>
<th>PROVINCE</th>
<th>$R^2$</th>
<th>$A_{0,i}$</th>
<th>$A_{1,i}$</th>
<th>$a_i$</th>
<th>$F_{1,i}$</th>
<th>$F_{2,i}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almería</td>
<td>0.953</td>
<td>0.0032</td>
<td>1.852</td>
<td>9.526</td>
<td>0.099</td>
<td>0.844</td>
</tr>
<tr>
<td>Cádiz</td>
<td>0.969</td>
<td>-0.0005</td>
<td>1.181</td>
<td>9.961</td>
<td>0.918</td>
<td>0.317</td>
</tr>
<tr>
<td>Córdoba</td>
<td>0.980</td>
<td>0.0014</td>
<td>1.206</td>
<td>9.127</td>
<td>0.734</td>
<td>0.535</td>
</tr>
<tr>
<td>Granada</td>
<td>0.978</td>
<td>0.0011</td>
<td>1.117</td>
<td>9.411</td>
<td>0.798</td>
<td>0.395</td>
</tr>
<tr>
<td>Huelva</td>
<td>0.944</td>
<td>-0.0007</td>
<td>1.214</td>
<td>9.310</td>
<td>0.907</td>
<td>0.323</td>
</tr>
<tr>
<td>Jaén</td>
<td>0.942</td>
<td>0.0008</td>
<td>1.133</td>
<td>8.882</td>
<td>0.833</td>
<td>0.413</td>
</tr>
<tr>
<td>Málaga</td>
<td>0.891</td>
<td>-0.0008</td>
<td>1.322</td>
<td>10.356</td>
<td>0.847</td>
<td>0.406</td>
</tr>
<tr>
<td>Sevilla</td>
<td>0.991</td>
<td>0.0008</td>
<td>1.287</td>
<td>10.280</td>
<td>0.746</td>
<td>0.598</td>
</tr>
<tr>
<td>Huesca</td>
<td>0.960</td>
<td>-0.0007</td>
<td>1.083</td>
<td>8.283</td>
<td>0.967</td>
<td>0.076</td>
</tr>
<tr>
<td>Teruel</td>
<td>0.901</td>
<td>0.0038</td>
<td>0.879</td>
<td>7.106</td>
<td>0.254</td>
<td>0.184</td>
</tr>
<tr>
<td>Zaragoza</td>
<td>0.972</td>
<td>-0.0003</td>
<td>0.975</td>
<td>9.675</td>
<td>0.980</td>
<td>-0.094</td>
</tr>
<tr>
<td>Asturias (Ppdo de)</td>
<td>0.851</td>
<td>-0.0012</td>
<td>0.878</td>
<td>9.684</td>
<td>0.894</td>
<td>-0.331</td>
</tr>
<tr>
<td>Balears (Illes)</td>
<td>0.961</td>
<td>0.0005</td>
<td>1.218</td>
<td>9.916</td>
<td>0.840</td>
<td>0.455</td>
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<tr>
<td>Las Palmas</td>
<td>0.966</td>
<td>-0.0004</td>
<td>1.325</td>
<td>9.849</td>
<td>0.851</td>
<td>0.486</td>
</tr>
<tr>
<td>Santa C. Tenerife</td>
<td>0.973</td>
<td>0.0003</td>
<td>1.269</td>
<td>9.598</td>
<td>0.804</td>
<td>0.498</td>
</tr>
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<td>Cantabria</td>
<td>0.943</td>
<td>0.0008</td>
<td>0.899</td>
<td>9.247</td>
<td>0.907</td>
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<tr>
<td>Avila</td>
<td>0.837</td>
<td>0.0035</td>
<td>0.747</td>
<td>7.645</td>
<td>0.239</td>
<td>-0.041</td>
</tr>
<tr>
<td>Burgos</td>
<td>0.876</td>
<td>0.0002*</td>
<td>0.798</td>
<td>8.693</td>
<td>0.888</td>
<td>-0.372</td>
</tr>
<tr>
<td>León</td>
<td>0.856</td>
<td>-0.0012</td>
<td>1.007</td>
<td>8.952</td>
<td>0.942</td>
<td>-0.106</td>
</tr>
<tr>
<td>Palencia</td>
<td>0.439</td>
<td>-0.0035</td>
<td>0.761</td>
<td>7.847</td>
<td>0.637</td>
<td>-0.502</td>
</tr>
<tr>
<td>Salamanca</td>
<td>0.766</td>
<td>0.0010</td>
<td>0.745</td>
<td>8.405</td>
<td>0.763</td>
<td>-0.359</td>
</tr>
<tr>
<td>Segovia</td>
<td>0.823</td>
<td>-0.0007</td>
<td>0.992</td>
<td>7.873</td>
<td>0.918</td>
<td>-0.137</td>
</tr>
<tr>
<td>Soria</td>
<td>0.729</td>
<td>0.0016</td>
<td>0.649</td>
<td>7.084</td>
<td>0.708</td>
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*Not sig. at the 0.05 level.
Source: Author’s research from INE data.
In other words, the order for the time series $C_{t,k}$ is determined by the order of the straight lines $c_{t,k}$, which depends on the value of $m_k$, which in turn is the elasticity of each time series $C_{t,k}$ relative to the average time series $Y_t$: the time series $C_{t,k}$ share the same growth trend, and what distinguishes them is the elasticity of their fluctuations relative to that trend. When applying Sheaf Methodology we are assuming that what distinguishes the series of the set we are analyzing is the degree of elasticity of their fluctuations with regard to a common trend. This difference in elasticity relative to the average time series could be the result of a different response to changes in the values of another time series (i.e. in this case the time series for mortgage interest rates\(^\text{11}\)). The $C_{t,k}$ set is built in order to summarize the structure with a few time series.

On the other hand, due to Proposition 1’s section A the time series $C_{t,k}$ are characterized by being in order: the k-th series is more similar than the preceding series than any other, and also more similar to the next series than the rest. Note that in each and all of the graphs in Figure 2, the sixth summary time series (the one with higher elasticity) starts at a point slightly higher than the first mark on the scale axis (in the case of Lugo at a height of 1,431) and shows a strong and steady growth until halfway 2007\(^\text{12}\), almost reaching the height of the fifth mark (10,575 for Lugo); in late 2007 it plummets to values that are below its starting point. On the other hand, the first summary series (the one with smaller elasticity) starts growing slightly during the first years, and decreases also slightly in the last years, finishing at a value that is just above its starting point. The four remaining summary series lie between these two extremes.

When comparing the trajectories of different provinces (Figure 2) the first ones represented (Lugo, Alava or Cáceres, for example) are more similar to the first summary time series, while the last ones (Toledo and Almería, for instance) are closer to the sixth one. Except for Teruel, Ávila, Ceuta and Melilla, the rest of the provinces would lie between these two extremes. Note that these four provinces remain outside of the imaginary line that runs through the cluster of dots, from Lugo to Almería (lower part of Figure 1). Their structure, although quite consonant with that of the last provinces (the value reached before the trend is reversed is much higher than the starting point, which in turn is similar to the end point), is not as well represented by the summary time series set as the rest of Spanish provinces.

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\(^{11}\) Ferrán (2008) analyzes the effects of interest rate variation in housing loans on the demand for housing in Spain between the fourth quarter of 1988 and the second quarter of 2007.

\(^{12}\) The time values have been eliminated from the X-axis; however the graphs in Figure 1 show how the trend changed in mid 2007.
Figure 2. Home mortgages trajectories represented over summary time series set (from december 1995 to april 2012)

Source: Author’s research from INE data.
Source: Author’s research from INE data.
5. Conclusions

The sequence of graphs that results from applying sheaf of lines methodology to regional mortgage time series in Spain yields some very interesting insight on the regional evolution of the Spanish mortgage market.

In the first place we can assert that all Spanish provinces experienced an era of great mortgage expansion, albeit with some important differences. This expansionary period lasted until 2006 or 2007, depending on the region. The two extremes are Lugo, with a nearly flat trajectory and Almería, with the highest growth. From a global perspective the provinces in Spain’s Northwestern regions (Galicia, Asturias, Navarra, La Rioja, Castila y León, Madrid) show more moderate rates of growth, while those in the South (Extremadura, Andalucía, Castilla-La Mancha, Murcia, Valencia), Northeast (Cataluña and Aragón) or the islands (Canary Islands and Balearic Islands) experienced faster growth rates.

The Spanish mortgage market started cooling down in 2006, entering a prolonged contraction that is still underway; it is currently in a comatose state. There are important regional differences in behavior, similar to those in the expansionary cycle. Figure 2 graphs show that the provinces that reached the highest points during the expansionary phase are those most affected by the contraction.

Sheaf methodology is a very useful tool for making inter-territorial comparisons on the evolution of the Spanish mortgage market. Although in general terms we can assert that the distinction between an expansionary phase followed by a contraction can be observed both in aggregate and regional terms, it is also true there are significant regional differences in terms of intensity. The provinces that have suffered a more severe contraction were those where the boom was stronger during the expansionary phase. The interpretation of the sequence of graphs obtained through sheaf methodology shows that the group of provinces in Spain’s Northwest is different than the rest, with milder effects during both expansion and contraction.

Bibliography


(13) The province of Ávila should be discarded from this first group, while Cáceres, Zaragoza and Barcelona should be included. These are the first 23 provinces represented in Figure 2: from Lugo to Zaragoza.

(14) The provinces of Cáceres, Zaragoza and Barcelona should be discarded from this second group, while Ávila should be included. These are the provinces that are represented in Figure 2 from Badajoz onwards.
- 2011a, “Una metodología de minería de datos para la agrupación de series temporales: aplicación al sector de la construcción residencial”, Universidad Complutense de Madrid, doctoral dissertation
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