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Spatial Autoregressive Models for House Price Dynamics in Italy

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Abstract

This paper elaborates a Spatial Autoregressive and Spatial Error Model (SAR-SE Model) to investigate the Italian house price dynamics. House prices in real terms have been modelled for the period 1995-2008 in all the 103 Italian provinces along with affordability ratio, persistency term, some social-economic variables and credit market variables. One of the key results of this paper, is the evidence on house price spatial autocorrelation, verified through the Baltagi, Song and Koh (2003) LM test. On the contrary, no evidence of housing price overvaluation has been found, in comparison with the fundamental values determined by interest rates, households income, rents, employment and construction cost.

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1. Introduction

In many OECD countries house prices in real terms raised sharply since the mid '90s. As shown by Morana and Beltratti (2009), in the period 1999-2007 house prices increased at an yearly average real rate of about 5% in the US, Euro Area and Canada, and at a yearly rate closed to 9% in the UK. Over the same time period, the average real income growth has been between 2% and 3% whereas nominal interest rates and inflation have been low (3% to 5% and 2% to 2.6%, respectively) and broad liquidity has grown at generous rates (6% to 8%). The housing market has started turning negative in 2007, as real prices have started decreasing in the US, and afterwards many other countries show similar patterns.

In Italy, in the same period (1999-2007) real house prices increased by a 3.8% per year and the Affordability Ratio, that is the ratio between house prices and incomes, shown a 20% increase (see Figure 1.). The Price-Rent Ratio otherwise kept a stable profile in the period so the revaluation process that is taking place can't be considered a bubble with certainty. Moreover the Affordability Ratio at 1999, according to IMF study (2005), is below the long-run level computed considering a larger temporal horizon (see Figure 2.). There is also a significant spatial variation in house prices at the local level.

For these reasons the use of fundamental theory in an econometric model and the necessity of analyzing "locally" instead of "nationally" is needed to test whether such an Italian house price bubble effectively exists.

In fact, the recent global housing price "boom" may be justified by fundamental[1] dynamics but it could be related to non fundamental based mechanisms as "irrational exuberance" (Shiller, 2005; 2007; 2008[2]), or mispricing related to the combination of inflation and money illusion (Brunnermeier and Julliard, 2008). This "irrational exuberance" (Shiller, 2005; 2008) may lead to an exponential increase in house prices up to levels significantly higher than ones compatible to fundamentals. Stiglitz (1990) defined "speculative bubble" as a continuing rise in the price of an asset sustained by the belief that the asset's price will continue to rise, although it is already high in comparison to fundamentals. The greater the mismatch vis-à-vis the long-term trend, the more likely the bubble will be followed by a sudden and sharp contraction in demand, with an associated price drop[3]. Many economists analyzed the recent boom at international level and the empirical evidence is mixed. Some studies underline the cumulated overvaluation in housing prices of about 30% since 2004, not only for the US, but also for some other OECD member countries (Girouard et al., 2006; Finicelli, 2007; Gros, 2007). Jacobsen and Naug (2005) did not find any evidence of housing price overvaluation in the US at national level, compared with

[1]The term "fundamentals" refers to the size of the market, consumer characteristics (household income, preferences -as measured by socioeconomic/demographic characteristics- and expectations) and housing production variables (operating and capital costs, land prices, and geographic and government growth constraints). In absence of speculative bubble, a substantial portion of house price dynamic could be explained by fundamental economic variables.

[2]Shiller in a recent publication (2008) identifies the causes of the recent US crisis. He blames the sub-prime crisis on the irrational exuberance that drove the economy's two most recent bubbles - in stocks in the 1990s and in housing between 2000 and 2007. He shows how these bubbles led to the dangerous overextension of credit now resulting in foreclosures, bankruptcies and write-offs, as well as a global credit crunch. He underlines that, at the moment, one of the major troubles is the credit rationing which rapidly propagates the crises to the real sector.

[3]Inker, the GMO chief investment officer for quantitative equities in global developed markets, has analyzed many bubbles that have occurred in the last 80 years, identifying 28 bubbles. Every one of the 28 bubbles went back to trend, no exceptions, but this recent bubble is different from the previous ones (Inker, 2006, 2008).

fundamental values determined by interest rates, households income, unemployment and housing supply. Otherwise McCarthy and Peach (2004) analyse US housing market in recent years and find little evidence to support the existence of a national home price bubble. Himmelberg et al. (2005) analyze, differently from the previous cases, the US real estate market at local level (46 metropolises) and, although a speculative bubble in all US metropolitan areas considered did not emerge, the US cumulative house price increases were relevant in many metropolises, suggesting a house price boom in many cities. Nevertheless, most academic studies on the Real Estate market focus on house price dynamics at national level[4] in order to evaluate the existence of a house price boom. However, house prices are inherently a local phenomenon and, therefore, national-level data may obscure important economic differences between cities. At this local level (provincial[5]),[6] for Italy, Caliman (2006, 2008, 2009) did not find any evidence of housing price overvaluation, compared with fundamental values. According to the International Monetary Fund (IMF) procedure, in order to test whether such a bubble effectively exists, a comparison between current prices and estimates of the trend values compatible with fundamentals is necessary. If the difference is slight, the discrepancy between the two values could be put down to uncertainty in the accuracy of estimates whereas if the difference is big, the danger of a speculative bubble is real. The main aim of this paper is to develop the previous works by Caliman (2006, 2008, 2009) on the Italian house market exposure to a house price boost through the use of Spatial Autoregressive and Spatial Error Model (SAR-SE Model). To achieve this goal the dataset of the macroeconomic variables at a provincial level for the period 1999-2008 has been created. Secondly, we analyzed different spatial specifications of house price models in order to select the best formulation of the spatial house price models. Finally, we performed the selected spatial model in order to verify the smaller Italian exposure to house price bust.

The remain of the paper is organized as follows. Section 2 describes the alternative spatial model and the estimation procedure suggested by spatial econometrics. Section 3 analysis the selected model. In Section 4 the dataset is described. Section 5 comments the empirical findings. Finally section 6 concludes the paper.

2. Methodology

The typology of models developed in this paper must take into account both the problem of spatial dependence and the problem of serial error dependence.

In fact, not only does "location" play an important role in explaining real estate prices, but also "time" matters in the determination of property prices. Spatio-Temporal models jointly consider both spatial and temporal effects and have the potential in explaining the evolution of housing prices. (see Gelfand et al., 1998, 2003, 2004; Can and Megbolugbe, 1997; Pace et al., 1998, 2000; Sun et al., 2005; Smith and Wu, 2009 for Spatio-Temporal analyses). Lately, Smith and Wu (2009) evaluate the impact of community development projects on housing price trends.

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[4] For the Italy see for example Nucci (1996).

[5] Italian provinces are the second of the three local government administrative levels in Italy: regions, provinces, municipalities. Consulente Immobiliare (the real estate data source, used in this work) elaborates house prices for the municipalities which are capitals of each province.

[6] Even if some authors provide disaggregate information on the influence of some spatial or geographical variables on Italian house prices (see, for example, Cannari et al., 2000), no paper (with the exception of Caliman 2006 and 2009), to the best of our knowledge, has ever considered the presence of a speculative bubble over time.

They propose a new modelling approach that is capable of accommodating both and have the potential in explaining the evolution of housing prices (see Gelfand et al., 1998, 2003, 2004; Can and Megbolugbe, 1997; Pace et al., 1998, 2000; Sun et al., 2005; Smith and Wu, 2009 for spatiotemporal analyses). The model allows for both the spatio-temporal lag effects of previous sales in the vicinity of each housing sale, and for general autocorrelation effects over time.
In particular for the present work the model chosen is the *time-space recursive* one:

$$y_{it}= \lambda y_{i\ t-1} + \rho[\mathbf{Wy}_{t-1}]_i + f(z) + \varepsilon_{it} \quad (1)$$

where $[\mathbf{Wy}_{t-1}]_\iota$ is the *i*-th element of the spatial lag vector applied to the observations on the dependent variable (y_i) in the previous time period (using a *N* by *N* spatial weights matrix for the cross-sectional units), $f(z)$ as a generic designation for the regressors (which may be lagged in time and/or space) and ε_i is the error term. The estimation of panel data models that include spatially lagged dependent variables and/or spatially correlated error terms follows as a direct extension of the theory developed for the single cross-section. In the first case, the endogeneity of the spatial lag must be dealt with, in the second, the non-spherical nature of the error variance covariance matrix must be accounted for. Two main approaches have been suggested in the literature: the maximum likelihood estimation (see, among others, Ord, 1975; Mardia and Marshall, 1984; Anselin, 1988; Anselin and Bera, 1998, Kelejian and Prucha, 1999b) and the method of moments (e.g., Anselin, 1988, 1990; Kelejian and Robinson, 1993; Kelejian and Prucha, 1999a, 1999b).

3. The adopted model

The adopted model considers as house price drivers all the "classical" explanatory variables or fundamentals adding persistency and reversibility (see, among the others, Capozza et al. 2004). The model explores house price dynamics, using data from 103 provinces between 1995 and 2008. The persistency factor is used to determine how well the past price of an asset predicts its future price. Whereas reversibility denotes the capability of re-establishing the original condition after a change, in this context, reversibility means stability of the long-run trend, the so called ''dynamic equilibrium'' or ''equilibrium path''. The equilibrium path is the locus of house prices which are compatible with fundamentals. Thus, house price reversibility implies that a house price increase, which creates a misalignment in house price indicators (such as price/rent ratio, affordability ratio, etc.), will be follow by a house price reduction[7]. Differently from the previous works by Caliman (2006, 2008, 2009[8]) we consider spatial effects directly in the model specification (Meen, 1996, 1998, 2001). The spatial effect arises when the statistical unit, each province, is characterized by a specific geographic location (which can generate migration flows and the ripple effects[9]). The model that has been applied postulates that residential house prices at provincial level are determined by the following factors:

[7]In the literature the affordability ratio, measuring the accessibility of house purchase given the medium level of the income, is used as a proxy variable for the long-run trend. This simplification is also used in this study.
[8]In these works the theoretical model is an adaptation to the Italian context of the one formulated by Terrones et al. (2004), which compares house price indexes on an international scale.
[9]The submarkets' existence causes heterogeneous diffusion of the revaluation process with local propagations like wildfire, the so-called ripple effect. The ripple effects denote the existence of some cities, metropolises or provinces which anticipate housing booms (busts) propagating the revaluation (devaluation) process to neighbouring areas, in this case to neighbouring provinces (in

- Past real house price growth measures the persistency of the revaluating house price process; i.e. the current rise is serially correlated with the past growth;
- Past affordability ratio (the ratio of house prices to per capita income) considering reversibility: if the house prices show long-run reversion to fundamentals, then house prices tend to drop when they are out of line with respect to income levels. Thus, its coefficient must be negative;
- Economic Fundamentals: the house price dynamic is positively influenced by rental growth trends (higher rents guarantee higher housing investment returns, inducing a house price revaluation and vice versa) and negatively affected by interest rates (lower interest rates increase households' capacity to borrow);
- Other fundamentals influencing house prices: the credit dynamics (credit market evolution and liberalization , e.g. a rise of Loan to Value - LTV to 100%, and an extension of credit access to "atypical" workers), the past growth of real stock prices (Mibtel, that is the main Italian Stock Market Index, in term of volume growth and bust dummy, introduced to account for partial substitution between houses and shares in investment portfolios), the population growth in local house submarkets (as proxy for the growth rate of households), the number of employees (as individuals prefer to purchase a house in areas with high job opportunities) and residential population growth, some dummies reflecting the evolution of the sector-related Italian legislation, the other user costs of housing[10] (i.e. the municipally-levied property tax *Imposta Comunale sull'Immobile* - ICI, mortgage interest).

Therefore the proposed model is a semilog-model[11], similarly to the Terrones one (2004), described by the following equation:

$$log(HP_t) = \alpha + \gamma Gr\_HP_{t-1} + \rho \quad SAR_{t-1} + AR_t\beta_1 + \ {}_1X_t \ \beta_1 + \log(\ {}_2X_t\ )\beta_2 + \ {}_2X_t \ \beta_2 + \varphi_t \qquad (2)$$

$$SAR_{t-1} = Wlog(Gr\_HP_{t-1}) \qquad (3)$$

Where *W* is the spatial weight matrix (inverse distance matrix) and:

$$\varphi_t = \delta W \varphi_{t-1} + \varepsilon_t; \qquad \varepsilon_t \sim N(0, \sigma^2 I_N); \qquad HP_t = (HP_{1t}, \dots, HP_{Nt})' \qquad (4)$$

$${}_1X_t \ = (Gr\_RENT_t, Gr\_LOAN_t, Gr\_EMPLOYEES_t, Gr\_POPULATION_t, Gr\_INCOME_t) \qquad (5)$$

is the $iT \times 5$ matrix of the quantitative variables, whereas:

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fact when house prices increase substantially in a certain city then more individuals become commuters and choose to live away from the city of work, in the suburbs or in the neighbouring provinces). The propagation magnitude tails off as the distance from the ''drawing'' city increases.

[10] For a definition of user cost see Poterba (1992).

[11] Chronologically, four classes of price model may be identified in real estate literature: early ad hoc models which contained a limited theoretical structure (panel model, autoregressive model, etc.), mark-up models which link house prices to construction costs; a reduced form models derived from housing demand and supply equations and the life cycle models (dynamic optimisation problem of consumer utility), further "hedonic" models have been developed (Meese and Wallace, 2003). In this work, as the previous ones (Caliman, 2006, 2009), we adopt an ad hoc model. The functional forms, used in the literature, are several (for spatial literature see Pace et al., 2000). In this work we select the semi-log form because it improves the goodness of fit. On the contrary this specification produces coefficient estimates that are not elasticities (differently to log-linear model).

$$_2X_t = (INTER_t, Mean\_Volume\_MIB30_{t-1}) \quad (6)$$

is the $iT \times 2$ matrix of the quantitative variables, whereas:

$$_3X_t = \left(MIB30\_Bust_t, \mathrm{RE\_NEGOTIATION_t}, \mathrm{EURO_t}, \mathrm{ICI_{first_t}}, \Delta\mathrm{CONSTR\_COST_t}\right) \quad (7)$$

is the $iT \times 4$ matrix of the dummy variables and of the ICI for the first-buyer. A detailed description of the variables is produced in to Appendix A.

4. The Database

The dataset is a panel of the 103 Italian provinces over the period 1995-2008 (1994 values have been gathered for the computing of the autoregressive component and house price long-term parameters).

The main source of housing data is the "Consulente Immobiliare" (CI) published by "Il Sole 24 Ore" and updated twice a year. The house prices estimated using CI data refer to unoccupied "standard" residential properties[12] between 60 and 120 square meters (645.85 - 1291.71 square feet)[13]. Although CI classifies prices as functions of location (downtown, inner city or outskirts) and obsolescence (new and recent houses), models have been estimated using only the downtown values because they resulted to be more reactive to the independent variable changes and because of the existence of important compensative effects among downtown, inner city, caused by a strong inter-areas migration. The rents, obtained from the same source, are expressed in thousands of euro per square meter, annually based, and refer to 60-120 squared meters houses. The absence of many variables describing housing supply locally and the delay in the publication of these variables (3-5 years) made possible the inclusion of only one index, that is the annual construction cost of residential property index, provided by ISTAT at regional capital city level. The Tagliacarne Institute and Unioncamere provided the data related to real household disposable income per capita (annual) in each province, which has been used to compute the affordability ratio. Some difficulties has been overcome to make homogeneous the two different time series coming from these two Institutions. The dataset also included the number of employees and the population growth in the province. The residential population has been provided by HFA (Health For All) by ISTAT and the employed population has been provided by Istituto Tagliacarne. The dataset also contained the long term loan interest rate (disaggregated by region as provided by the Bank of Italy). The main Italian Stock Market Index, the Mib30 has been introduced as it can be considered an investment choice alternative to house buying. Another variable qualifying the credit market is the flow of long-run loans towards households in order to purchase properties (annual series provided at a provincial level by the Bank of Italy). The inclusion of this regressor is justified because loan flow does not only depend on the interest rate but it is also a function of how the credit market changes over the years modifying the household accessibility to credit. The last group of the variables included in the dataset are the

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[12] The standard residential unit refers to multi-unit high rise residential market (Sun et al., 2005). Differently from Sun et al. (2005) it's impossible to implement hedonic models as CI does not publish single residential unit prices with their characteristics but only the province level aggregate data.

[13] CI elaborates and publishes its correction factors according to not standard property characteristics (e.g. terrace, penthouse, two bathrooms or more, panorama, etc.)

ones which can be included in the user cost. This also contains the ICI (Local Tax on properties). An online database (ANCI, National Association of Italian Municipalities) which incorporates three time series for each province (annual data) is available: the rate of ICI for first-time buyers; the rate of ICI for second-time buyers; the deductibility of ICI for first-time buyers.
Missing values have been treated using the traditional statistical techniques (see, among the others, Allison, 2002 and Rubin, 2002). Appendix B reports the main descriptive statistics of the key variables measured at a provincial level. Focusing the attention on the logarithm of House Prices (lHP) from 1995 to 2008 it can be outlined that, along with the expected increase of the mean value across the 107 Italian Provinces, the range (max – min) moved from 1.745 (8.430 – 6.685) up to 2.001 (8.904 – 6.905) along with a standard deviation rising from 0.338 up to 0.381. Therefore the overall increase in the house prices is not uniform on all provinces with different intensities at provincial level. This justifies the necessity of analyzing "locally" instead of "nationally" house price phenomenon in Italy.

5. Econometric issues and empirical results

The adopted model is a Spatial Lag - SAR and Spatial Error - SEM model (or *time-space recursive*) in order to take into account a spatial lag and spatially autocorrelated (and possibly not spherical) innovations[14]. House price spatial autocorrelation has been confirmed through the Baltagi et al. (2003) LM test (see Table 1.). In this study, housing prices tend to be spatially autocorrelated because neighbourhood provinces demonstrate similar socio-economic background, measured by analogous income levels, employment rates, construction costs, rents.
The spatial autoregressive model with spatial error term has been estimated through the Maximum Likelihood technique (ML)[15] using the splm library for spatial panel data models elaborated by Millo and Piras (2008; 2009) in R. Three are the models which have been estimated: Spatial model containing also a spatial autoregressive component (Model 1.); a SER model in which spatial effects are captured only in the spatially delayed error term (Model 2.); a third model estimated with Fixed Effect (Model 3.), used as based model in order to capture the improved goodness of fit. The empirical results (Table 2.) confirmed, first of all, the improvement of goodness of fit (measured in terms of squared correlation between the estimated values and observed values) of the Model 1. with respect to the Model 2. and the Model 3. (for this model many estimated coefficients are insignificant and the signs are incoherent). Secondly, empirical results for the Models 1. and 2. are robust (the coefficients have resulted to always be stable in these two models and their sign is consistent with the theoretical model). The results, finally, confirmed the fundamental justification of Italian house prices[16]. The reversibility factor

[14] House prices tend also to experience spatial heterogeneity, which is believed to be indicative of geographical segmentation of real estate. The heterogeneity problem has been taken into account in Caliman (2008) and different estimates have been done for Italian real estate submarkets. As the estimates were not relevantly affected by this problem in the present work we decided to overcome the discussion.
[15]The previous works used GMM techniques. Some authors sustain the bigger efficiency of the ML estimator than GMM one. Egger et al. (2009), through some Monte Carlo simulations gave a validation of that idea.
[16] This result is in line with the IMF study (2008): Italy's "house price gap" can be considered "medium" or "small". The "house price gap" is the unexplained increase in house prices and could be interpreted as a measure of overvaluation and, therefore, used to identify which countries may be particularly prone to a correction in house prices.

implies a gradual but significant realignment of market prices at levels compatible with fundamentals and controls for the persistency factor, reducing the risk of a sudden fall in property prices. According to the procedures adopted by IMF researchers (Terrones et al., 2004) "the increase in house prices during the expansion phase are compared with the model's predictions". The differences between observed increases of house prices (registered for 103 Italian provinces during the expansion phase, 2000-2007) and their estimated values (based on house prices from 1994 to 2008, a period which contains also a contraction phase), divided by observed values, are satisfying (an average fitting error of 0.073% of the actual values). The increases reported during the expansion phase are quite large but not exceptional so that, on average, the model can explain most of the increase in house prices during the expansion phase (2000-2007). Secondly, the real house price dynamics in Italian provinces are weakly persistent with a serial correlation coefficient of 0.05 which implies that there is a little tendency in real house prices to rise after that they have risen the previous year. Moreover, the real house prices have shown a reversion towards the prices which are compatible with the fundamentals. If house prices are out of line with income, there is a gradual tendency for this realignment.

The economic fundamentals and the time variant dummies (describing the evolution of sector-related Italian legislation) show the expected sign of the coefficient and are significant. For instance, the mortgage renegotiation possibility introduced in 1998 caused an increment of 0.087 on average. Differently from Caliman (2009) the introduction of the Euro has determined a positive global effect. This dummy has a bivalent effect: on the one hand there is the revaluation effect of euro introduction, on the other hand its introduction produced the stabilization of the interest rate and the interest convergence to lower levels (this had radically modified the expectations). Thus the inclusion of spatial effects and the dataset updating seems to have modified the global effect of the EURO dummy: it seems that the revaluation effect instead of its consequent change in expectations is prevailing. A positive correlation of house prices with respect to the growth of employees is confirmed. A florid job market, which characterizes some provinces, produces individual migration flows to these provinces and therefore sustains their house prices. The population growth has also a positive effect on house prices. In fact this variable can be considered as a proxy of the demand growth (or the possible buyers). An increase of income per capita growth induces a house price increase, too. This variable, in fact, measures the accessibility of house purchase. The index of the construction cost of a residential building is not significant in all the estimations so it's neglected. This is consistent with the greatest part of the studies on the British Real Estate market, and inconsistent with the analyses on the American Real Estate market. Empirical results show also that the elasticity of house prices with respect to credit dynamics is statistically significant and positive; and the elasticity with respect to interest rate is 0.5, so a rate reduction of 1% leads to increases of 0.5% in the real house prices. The ICI first buyer elasticity has a negative effect. The stock market crash dummy is significant and negative, that is a stock Exchange bust induces an upsurge in house prices. The rent dynamics affect positively and significantly house prices. Thus a higher housing investment returns induce a house price revaluation. Finally, empirical results confirm that the SAR regressor is significant and its inclusion allows an improvement of goodness of fit, that is the house price spatial autoregressive component constitutes a relevant regressor for the model.

6. Concluding remarks

In this paper a *time-space recursive* model for the Italian housing market has been performed in order to test the existence of spatial effects and to evaluate the Italian exposure to house price bust. Two main insights emerge from our analysis:

1. First, the Italian house price dynamics show spatial dependence and autocorrelation.
2. Second, Italian house price dynamics are justified by fundamentals.
3. Third, the spatial model improve the goodness of fit and confirm the great part of the previous empirical results (Caliman, 2008, 2009).

In the estimated model, only two fundamentals(the interest rate drop and the consistent rent increase) explain the bulk of Italian house price increases during the expansion phase (2000–2007). Furthermore the differences between the house prices reported by the Italian provinces during this expansion phase (2000–2007) and the model’s estimates, normalized through the observed values, are very small: an average fitting error of 0.073 % of the actual values. Therefore, not only does the model explain most of the increases in house prices during this expansion period (1995–2003), but these increases are in the main justified by fundamentals. Furthermore the estimated reversibility factor controls the persistency and shows a gradual and partial realignment with the long run affordability ratio. These facts constitute further evidence of the low Italian exposure to a possible house price bust.

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FIGURES

Figure 1 *– Real House Price Variation (Left scale), Price Rent Ratio and Affordability Ratio (Right scale, both) for the period 1995 – 2008 (ours elaborations on the collected "provincial" data).*

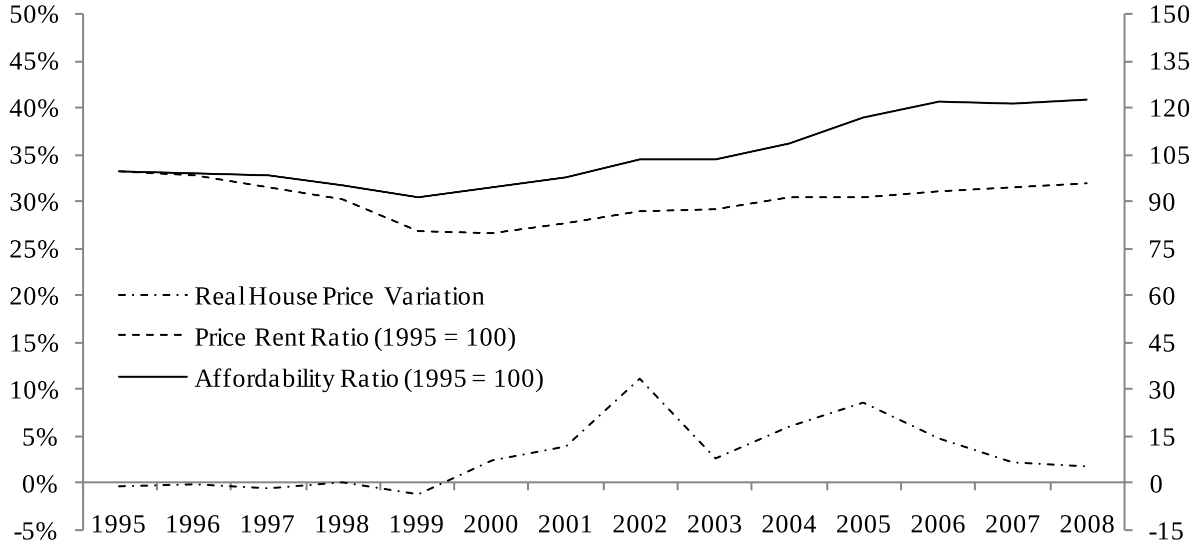
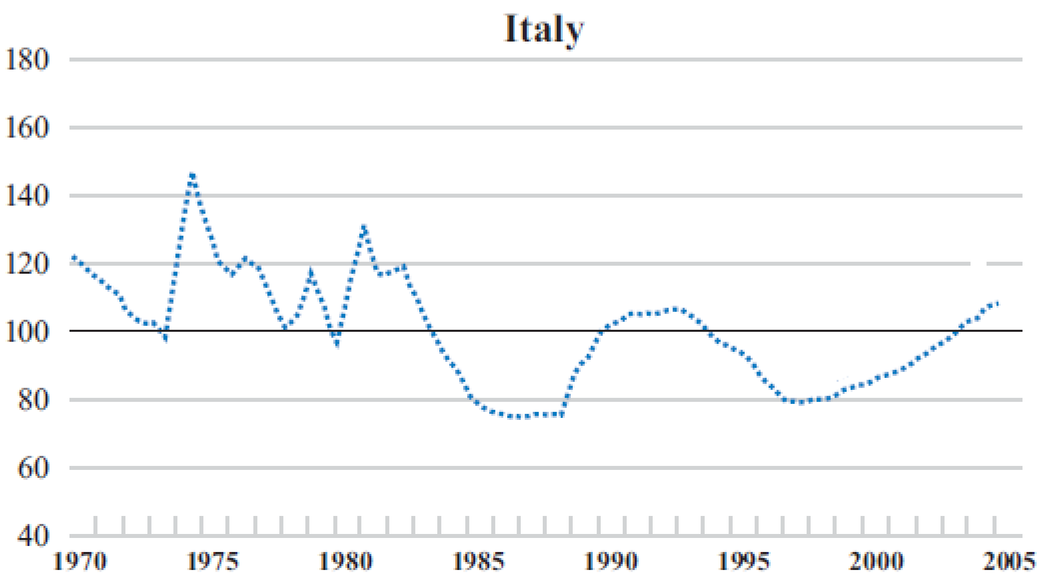


Figure 2 *– Price-to-Income Ratio or Affordability Ratio (Sample average = 100) for the period 1970 – 2005 [IMF, 2005].*



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APPENDIX A

All the economic variable has been actualized at 1995 values through Consumer Price Index - FOI produced by ISTAT at provincial level, in this way the provincial house prices have been expressed in base year 1995 (real terms) becoming comparable among the provinces (so that the inflation differences among the provinces are considered):

- $HP_{i,t}$ are the real house prices of the *i* provinces at time *t* (t = 1995, 1996, …, 2003) ;
- $SAR_{i,t-1}$ is the spatial autoregressive component, computed in the *i*-th province at time *t*-1 multiplying the lag-house price growth for the spatial weight matrix;
- $Gr\_HP_{i,t-1}$ is the persistency factor, in growth term, for residents in the *i*-th province at time *t*-1;
- $AR_{i,t-1}$ are the affordability ratios for residents in the *i*-th province at time *t*-1;
- $SAR_{i,t-1}$ is the spatial autoregressive component the *i*-th province at time *t*-1;
- $Gr\_RENT_{i,t}$ are the real rent growth rates for residents in the *i*-th province at time *t*-1;
- $Gr\_LOAN_{i,t}$ are the growth rates of the long-run period bank loans borrowed by consumer in order to purchase houses for residents in the the *i*-th province at time *t*-1;
- $INTER_{it}$ are the interest rates on long-term loans to families in the *i*-th province at time *t*;
- $Mean\_Volume\_MIB30_t$ is the average closing volumes in year *t*;
- $Gr\_EMPLOYEES_{i,t}$ are the growth rates of the number of employees in the *i*-th province at time *t*;
- $Gr\_POPULATION_{i,t}$ are the growth rates of residents in the *i*-th province at time *t*;
- $Gr\_INCOME_{i,t}$ are the growth rates of income per capita in the *i*-th province at time *t*;
- $ICI\_first_{i,t}$ is the rate of ICI taxation for first-time buyers for residents in the *i*-th province at time *t*;
- $EURO_t$ is a temporal dummy variable which considers many events occurred in 2002, legislative evolution (suppression of INVIM[17], law December 28th 2001 n. 488), introduction of Euro.
- $RE\_NEGOTIATION_t$ is a dummy variable introduced to take into account the recent possibility of mortgage renegotiation (agreement signed on May 11th 1998 between ABI, the banker association, and consumer associations);
- $\Delta COSTR\_COST_t$ are the regional construction cost variations from time *t-1* to time t reported in every province included into the considered region;
- $MIB30\_Bust_t$ is a dummy variable introduced to consider the Stock Exchange bust[18].

[17] The INVIM - Imposta Incremento Valore Immobili was a capital gains tax.

[18] The bust dummy is a dicotomic variable which takes value one if the annual negative variation of MIB 30 is bigger than 15% and zero otherwise.

APPENDIX B

Table B.1 - *Descriptive Statistics of the main macroeconomic variables (Years 1995-2003).*

VARIABLES		***lHPit***		***lARit-1***		***lRENTit***		***lLOANit***		***lINTERit***		***lICI_Fit***	
1995	**(a) & (b)**	7,285	0,338	-1,154	0,525	3,964	0,240	7,891	1,073	2,173	0,104	1,628	0,124
	(c) & (d)	6,685	8,430	-2,631	0,025	3,482	4,724	5,121	11,652	1,970	2,394	1,386	1,946
	(e) & (f)	0,753	1,278	-0,272	0,160	0,784	0,673	0,499	1,295	0,283	-0,993	-0,093	0,035
	(g) & (h)	7,249	7,267	-1,190	-1,145	3,904	3,952	7,702	7,874	2,152	2,172	1,609	1,628
1996	**(a) & (b)**	7,279	0,330	-1,145	0,556	3,980	0,257	7,872	1,001	2,006	0,104	1,630	0,117
	(c) & (d)	6,649	8,281	-2,742	0,095	3,381	4,734	5,351	11,313	1,803	2,227	1,386	1,825
	(e) & (f)	0,507	0,675	-0,386	0,297	0,631	0,400	0,596	1,681	0,283	-0,993	-0,338	-0,511
	(g) & (h)	7,272	7,267	-1,125	-1,129	3,949	3,970	7,731	7,848	1,985	2,005	1,609	1,634
1997	**(a) & (b)**	7,271	0,320	-1,174	0,560	4,006	0,279	8,031	1,012	1,818	0,094	1,612	0,124
	(c) & (d)	6,611	8,217	-2,881	0,080	3,343	4,725	5,553	11,564	1,619	2,042	1,386	1,946
	(e) & (f)	0,421	0,517	-0,412	0,442	0,226	-0,294	0,784	1,787	0,258	-0,657	-0,225	-0,465
	(g) & (h)	7,263	7,260	-1,164	-1,157	3,981	4,002	7,865	7,994	1,805	1,818	1,609	1,613
1998	**(a) & (b)**	7,268	0,304	-1,211	0,581	4,041	0,304	8,205	0,987	1,563	0,089	1,611	0,123
	(c) & (d)	6,734	8,186	-3,005	0,043	3,333	4,876	5,957	11,588	1,374	1,776	1,386	1,946
	(e) & (f)	0,499	0,678	-0,458	0,393	0,109	-0,306	0,646	1,537	0,461	-0,572	-0,248	-0,449
	(g) & (h)	7,277	7,255	-1,171	-1,193	4,036	4,039	8,074	8,178	1,547	1,561	1,609	1,611
1999	**(a) & (b)**	7,253	0,311	-1,199	0,581	4,140	0,316	8,498	1,006	1,316	0,098	1,600	0,123
	(c) & (d)	6,709	8,236	-2,915	0,144	3,367	5,002	6,059	12,088	1,171	1,537	1,386	1,946
	(e) & (f)	0,548	0,646	-0,394	0,353	0,086	0,162	0,670	1,699	0,433	-0,948	-0,144	-0,493
	(g) & (h)	7,270	7,239	-1,149	-1,183	4,151	4,137	8,346	8,469	1,288	1,313	1,609	1,600
2000	**(a) & (b)**	7,275	0,314	-1,184	0,572	4,174	0,324	8,455	1,036	1,530	0,094	1,592	0,126
	(c) & (d)	6,680	8,243	-2,877	0,108	3,580	5,178	6,222	11,889	1,352	1,770	1,386	1,841
	(e) & (f)	0,455	0,445	-0,419	0,415	0,376	0,312	0,735	1,341	0,316	-0,492	-0,207	-0,911
	(g) & (h)	7,269	7,263	-1,159	-1,169	4,173	4,164	8,301	8,418	1,509	1,529	1,609	1,592
2001	**(a) & (b)**	7,311	0,312	-1,197	0,559	4,170	0,327	8,594	1,044	1,459	0,083	1,582	0,128
	(c) & (d)	6,736	8,252	-2,909	0,062	3,555	5,152	6,392	12,213	1,300	1,653	1,253	1,833
	(e) & (f)	0,460	0,451	-0,457	0,699	0,416	0,263	0,817	1,462	0,395	-0,237	-0,143	-0,664
	(g) & (h)	7,305	7,298	-1,174	-1,180	4,152	4,159	8,400	8,548	1,443	1,458	1,609	1,582
2002	**(a) & (b)**	7,415	0,307	-1,098	0,551	4,232	0,343	8,743	1,072	1,409	0,080	1,587	0,137
	(c) & (d)	6,855	8,346	-2,746	0,177	3,591	5,233	6,527	12,520	1,131	1,588	1,253	1,946
	(e) & (f)	0,507	0,541	-0,455	0,718	0,529	0,512	0,800	1,697	-0,133	0,280	0,009	-0,516
	(g) & (h)	7,404	7,402	-1,049	-1,082	4,213	4,218	8,604	8,699	1,408	1,410	1,609	1,585
2003	**(a) & (b)**	7,436	0,344	-1,081	0,524	4,246	0,380	8,840	1,058	1,278	0,064	1,592	0,139
	(c) & (d)	6,752	8,493	-2,658	0,175	3,612	5,443	6,769	12,642	1,098	1,410	1,253	1,946
	(e) & (f)	0,571	0,739	-0,383	0,522	0,885	1,393	0,912	1,846	-0,399	1,267	-0,042	-0,558
	(g) & (h)	7,435	7,423	-1,037	-1,069	4,237	4,222	8,710	8,792	1,281	1,280	1,609	1,591

Legend:
(a) – Average value, (b) – Standard Deviation, (c) – Minimum, (d) – Maximum, (e) – Skewness,
(f) – Kurtosis, (g) – Median, (h) – 10% trimmed mean.

Table B.2 - *Descriptive Statistics of the main macroeconomic variables (Years 2004-2008).*

VARIABLES		*lHPit*		*lARit-1*		*lRENTit*		*lLOANit*		*lINTERit*		*lICI_Fit*	
2004	**(a) & (b)**	7,492	0,366	-1,030	0,523	4,258	0,411	8,896	1,008	1,296	0,019	1,597	0,122
	(c) & (d)	6,762	8,669	-2,649	0,233	3,396	5,499	6,983	12,825	1,264	1,338	1,253	1,792
	(e) & (f)	0,733	1,040	-0,357	0,412	0,754	1,094	0,907	2,169	0,521	-0,126	-0,473	-0,446
	(g) & (h)	7,450	7,474	-0,975	-1,018	4,217	4,236	8,797	8,854	1,292	1,295	1,609	1,599
2005	**(a) & (b)**	7,569	0,383	-0,953	0,524	4,337	0,393	9,016	1,045	1,296	0,015	1,594	0,125
	(c) & (d)	6,780	8,754	-2,628	0,301	3,601	5,523	6,816	13,403	1,274	1,337	1,253	1,841
	(e) & (f)	0,654	0,815	-0,346	0,581	0,847	1,089	1,040	2,994	1,000	0,990	-0,393	-0,465
	(g) & (h)	7,538	7,554	-0,936	-0,942	4,301	4,315	8,884	8,970	1,295	1,295	1,609	1,595
2006	**(a) & (b)**	7,613	0,372	-0,938	0,533	4,356	0,378	9,162	1,037	1,453	0,013	1,584	0,131
	(c) & (d)	6,939	8,817	-2,659	0,351	3,606	5,533	7,076	13,115	1,431	1,486	1,253	1,833
	(e) & (f)	0,758	0,958	-0,310	0,471	0,821	1,090	0,739	1,856	0,685	0,731	-0,289	-0,433
	(g) & (h)	7,568	7,594	-0,910	-0,926	4,331	4,335	9,036	9,128	1,452	1,452	1,609	1,586
2007	**(a) & (b)**	7,634	0,377	-0,922	0,529	4,360	0,373	9,251	1,063	1,679	0,013	1,583	0,139
	(c) & (d)	6,927	8,889	-2,644	0,379	3,628	5,565	6,978	13,309	1,652	1,707	1,253	1,946
	(e) & (f)	0,722	0,989	-0,274	0,501	0,758	1,110	0,830	2,055	-0,378	0,231	-0,023	-0,362
	(g) & (h)	7,610	7,616	-0,938	-0,910	4,332	4,341	9,119	9,212	1,682	1,679	1,609	1,582
2008	**(a) & (b)**	7,651	0,381	-0,909	0,527	4,366	0,376	9,301	1,086	1,773	0,011	1,586	0,140
	(c) & (d)	6,905	8,904	-2,612	0,380	3,686	5,529	6,826	13,459	1,757	1,801	1,253	1,946
	(e) & (f)	0,678	0,890	-0,247	0,424	0,667	0,874	0,836	2,237	1,000	0,320	-0,076	-0,361
	(g) & (h)	7,627	7,634	-0,933	-0,897	4,345	4,348	9,175	9,257	1,769	1,772	1,609	1,585

Legend:
(a) – Average value, (b) – Standard Deviation, (c) – Minimum, (d) – Maximum, (e) – Skewness,
(f) – Kurtosis, (g) – Median, (h) – 10% trimmed mean.

Table B.3 - *Descriptive Statistics of the main macroeconomic variables (Years 1995-2003).*

VARIABLES		***lE_RATIOit-1***		***lICI_Sit***		***lICI_Dit***		***ΔCONSTit***		***lY_DEF***	
1995	**(a) & (b)**	-1,068	0,208	1,642	0,125	4,532	0,000	1,839	1,626	8,439	0,747
	(c) & (d)	-1,931	-0,787	1,386	1,946	4,532	4,532	-1,968	3,986	6,782	10,958
	(e) & (f)	-1,278	2,202	-0,149	-0,103	1,015	-2,040	-0,657	-0,286	0,768	1,339
	(g) & (h)	-0,993	-1,053	1,609	1,643	4,532	4,532	2,198	1,928	8,349	8,407
1996	**(a) & (b)**	-1,038	0,182	1,691	0,103	4,532	0,000	1,948	1,255	8,424	0,745
	(c) & (d)	-1,566	-0,742	1,386	1,856	4,532	4,532	-0,183	5,042	6,767	10,941
	(e) & (f)	-0,840	-0,041	-0,869	0,507	1,015	-2,040	0,548	0,046	0,761	1,339
	(g) & (h)	-0,974	-1,028	1,705	1,699	4,532	4,532	2,000	1,896	8,331	8,392
1997	**(a) & (b)**	-1,033	0,175	1,728	0,125	1,262	4,229	2,331	0,948	8,445	0,743
	(c) & (d)	-1,548	-0,772	1,386	1,946	-3,912	5,043	0,025	4,321	6,801	10,959
	(e) & (f)	-0,775	-0,194	-0,478	0,388	-0,421	-1,857	-0,515	0,807	0,767	1,347
	(g) & (h)	-0,968	-1,024	1,723	1,732	4,638	1,338	2,492	2,348	8,357	8,412
1998	**(a) & (b)**	-1,028	0,174	1,742	0,134	0,185	4,323	-1,109	0,863	8,480	0,744
	(c) & (d)	-1,540	-0,759	1,386	1,946	-3,912	5,331	-2,523	0,326	6,835	11,017
	(e) & (f)	-0,806	-0,131	-0,536	0,114	0,101	-2,027	0,125	-1,298	0,788	1,418
	(g) & (h)	-0,971	-1,019	1,775	1,748	-3,912	0,140	-1,108	-1,116	8,390	8,447
1999	**(a) & (b)**	-1,015	0,179	1,762	0,139	4,696	0,151	1,268	0,937	8,452	0,743
	(c) & (d)	-1,555	-0,751	1,386	1,946	4,638	5,379	0,017	3,679	6,800	11,003
	(e) & (f)	-0,872	0,009	-0,640	0,113	3,057	9,302	0,565	0,094	0,794	1,476
	(g) & (h)	-0,957	-1,006	1,792	1,770	4,638	4,671	1,314	1,206	8,367	8,419
2000	**(a) & (b)**	-1,005	0,177	1,788	0,136	4,634	0,869	2,441	1,195	8,459	0,744
	(c) & (d)	-1,556	-0,712	1,386	1,946	-3,912	5,554	0,030	4,397	6,809	11,003
	(e) & (f)	-0,858	0,060	-0,946	0,873	-9,466	94,147	-0,917	0,223	0,795	1,467
	(g) & (h)	-0,940	-0,996	1,792	1,799	4,638	4,687	2,690	2,472	8,377	8,427
2001	**(a) & (b)**	-0,976	0,167	1,804	0,128	4,300	1,871	1,936	1,312	8,508	0,746
	(c) & (d)	-1,495	-0,692	1,386	1,946	-3,912	5,554	0,022	4,711	6,863	11,065
	(e) & (f)	-0,854	0,059	-1,035	1,191	-4,204	16,188	0,521	-0,099	0,798	1,479
	(g) & (h)	-0,920	-0,968	1,792	1,815	4,638	4,688	1,788	1,890	8,419	8,476
2002	**(a) & (b)**	-0,965	0,165	1,829	0,121	4,225	2,042	3,271	2,144	8,513	0,740
	(c) & (d)	-1,474	-0,689	1,386	1,946	-3,912	5,554	-3,792	5,814	6,856	11,049
	(e) & (f)	-0,865	0,090	-1,432	2,682	-3,776	12,662	-1,821	2,792	0,794	1,486
	(g) & (h)	-0,920	-0,957	1,856	1,841	4,638	4,603	3,829	3,501	8,417	8,481
2003	**(a) & (b)**	-0,973	0,170	1,851	0,119	4,392	1,687	2,824	2,545	8,518	0,737
	(c) & (d)	-1,453	-0,677	1,386	1,946	-3,912	5,554	-0,067	12,089	6,852	11,039
	(e) & (f)	-0,641	-0,259	-1,871	4,206	-4,749	21,321	1,769	4,682	0,785	1,465
	(g) & (h)	-0,931	-0,967	1,872	1,866	4,638	4,694	2,314	2,551	8,439	8,486

Legend:
(a) – Average value, (b) – Standard Deviation, (c) – Minimum, (d) – Maximum, (e) – Skewness, (f) – Kurtosis, (g) – Median, (h) – 10% trimmed mean.

Table B.4 - *Descriptive Statistics of the main macroeconomic variables (Years 2004-2008).*

VARIABLES		*lE_RATIOit-1*		*lICI_Sit*		*lICI_Dit*		*ΔCONSTit*		*lY_DEF*	
2004	**(a) & (b)**	-0,967	0,162	1,781	0,142	4,700	0,154	4,189	1,914	8,522	0,739
	(c) & (d)	-1,354	-0,760	1,386	1,946	4,638	5,379	0,030	7,478	6,839	11,052
	(e) & (f)	-0,790	-0,553	-0,868	0,355	2,894	8,300	-0,120	-0,105	0,781	1,464
	(g) & (h)	-0,899	-0,958	1,792	1,791	4,638	4,675	4,620	4,237	8,430	8,491
2005	**(a) & (b)**	-0,969	0,162	1,804	0,137	4,634	0,869	3,535	2,223	8,523	0,739
	(c) & (d)	-1,323	-0,764	1,386	1,946	-3,912	5,554	-0,986	9,980	6,840	11,060
	(e) & (f)	-0,760	-0,762	-1,174	1,270	-9,469	94,174	0,415	1,439	0,783	1,458
	(g) & (h)	-0,893	-0,961	1,792	1,817	4,638	4,688	3,796	3,468	8,432	8,491
2006	**(a) & (b)**	-0,952	0,159	1,822	0,129	4,377	1,682	2,919	1,323	8,550	0,743
	(c) & (d)	-1,313	-0,749	1,386	1,946	-3,912	5,554	0,031	4,714	6,854	11,111
	(e) & (f)	-0,780	-0,723	-1,279	1,697	-4,766	21,424	-0,525	-0,440	0,765	1,382
	(g) & (h)	-0,885	-0,944	1,856	1,834	4,638	4,681	2,919	2,977	8,449	8,520
2007	**(a) & (b)**	-0,941	0,174	1,841	0,121	4,303	1,873	3,639	1,737	8,555	0,745
	(c) & (d)	-1,337	-0,582	1,386	1,946	-3,912	5,554	0,039	7,290	6,827	11,113
	(e) & (f)	-0,675	-0,552	-1,621	3,245	-4,197	16,154	-0,103	-0,281	0,749	1,365
	(g) & (h)	-0,874	-0,937	1,872	1,855	4,638	4,689	3,789	3,651	8,488	8,525
2008	**(a) & (b)**	-0,943	0,170	1,858	0,120	4,389	1,686	3,276	1,394	8,561	0,745
	(c) & (d)	-1,375	-0,690	1,386	1,946	-3,912	5,554	0,028	5,219	6,831	11,121
	(e) & (f)	-0,919	-0,383	-1,999	4,585	-4,751	21,332	-0,543	-0,227	0,748	1,356
	(g) & (h)	-0,863	-0,934	1,902	1,874	4,638	4,691	3,139	3,346	8,491	8,531

Legend:
(a) – Average value, (b) – Standard Deviation, (c) – Minimum, (d) – Maximum, (e) – Skewness, (f) – Kurtosis, (g) – Median, (h) – 10% trimmed mean.

APPENDIX C

Table 1 - *Results of Tests on the SAR-SE models applicability assumptions.*

TEST	Statistic Value	p-value	Alternative Hypothesis
Baltagi, Song and Koh LM*-lambda conditional LM test	LM*-λ = 16.8799	< 2.2e-16	Spatial autocorrelation
Pesaran CD test for cross-sectional dependence in panels	z = 38.5675	< 2.2e-16	Cross-sectional dependence
Scaled LM test for cross-sectional dependence in panels	z = 104.1123	< 2.2e-16	Cross-sectional dependence

Table 2 - *Spatial panel random effects ML models parameters and significance levels.*

	Model 1			Model 2			Model 3		
Coefficients:	Estimate	(t-value)	Sign.	Estimate	(t-value)	Sign.	Estimate	(t-value)	Sign.
(Intercept)	4.588189	9.212	***	4.48442	9.266	***	1.38E-01	5.8202	***
Gr_HP_{t-1}	0.481011	4.7495	***	0.476179	4.7068	***	1.40E+00	37.295	***
AR_t	-0.414872	-10.448	***	-0.395822	-10.2944	***	-4.05E-04	-0.0056	
Gr_INCOME_t	0.575204	1.9253	.	0.544786	1.8397	.	1.42E-01	11.6939	***
$\log(INTER_t)$	0.496269	11.6029	***	0.494023	11.7531	***	7.08E-05	0.012	
Gr_LOAN_t	0.058159	2.2986	*	0.05925	2.3446	*	-2.18E-02	-4.0896	***
MIB30_BUST	-0.077071	-3.8428	***	-0.076374	-3.8886	***	5.89E-02	9.1797	***
$\log(Mean\_Volume\_MIB30_t)$	0.117751	4.8536	***	0.118061	4.964	***	5.21E-02	0.8575	
$Gr\_POPULATION_t$	0.80851	3.1671	**	0.79752	3.1231	**	3.96E-02	0.5801	
$Gr\_EMPLOYEES_t$	1.054551	3.5783	***	1.056798	3.5868	***	1.23E-01	20.0258	***
EURO	0.221317	10.0859	***	0.220043	10.2341	***	1.38E-02	0.7932	
Gr_RENT_t	0.397344	5.2455	***	0.398541	5.2623	***	-6.83E-03	-1.2062	
ICI_first_t	-0.04249	-3.2176	**	-0.04276	-3.2341	**	2.97E-02	3.2743	**
RE_NEGOTIATION	0.086745	2.514	*	0.085373	2.5237	*			
$\log(SAR_{t-1})$	0.04482	1.7162	.						

Approx. Signif. codes: ‘***’ ≅ 0; ‘**’ ≅ 0.01; ‘*’ ≅ 0.05; ‘.’ ≅ 0.1; ‘ ’ > 0.1

Model 1 Spatial panel random effects ML model

Model 2 Spatial panel random effects ML model

Model 3 Oneway (individual) effect Within Model