What does the relationship between aging and housing prices tell about local decline and wealth reshaping?

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Abstract

Assuming a life cycle economy perspective and using the link between demography and house prices, this article proposes a methodology to analyze the spatial reshaping of housing wealth caused by the elder-boom. The modification in housing wealth circulation across generations is also a spatial modification that carries consequences for local territories. While the losses are amplified for some departments, others benefit from this reorganization. Metropolization is insurance against important wealth losses, whereas for the nonmetropolitan departments, a combination of second-order factors is required to avoid housing wealth decline. Our results suggest that these evolutions are mainly structural and that the cyclical variables are of secondary importance. Compensation, by positive cyclical trend, for structural decline is not a circumstance that currently obtains in French case. Gentrification also appears to be strongly related to this change, in which various macrostructural inequalities are reinforced. As for the unemployment rate, this indicator poorly reflects the shift and can be misleading.

Keywords: Aging, Life-cycle, Housing wealth reshaping, Territories, Metropolization.

1. Introduction

Since the 1990s, France, like many developed countries, has experienced fundamental changes to its spatial structure. Among the multiple facets of this evolution are the following: globalization and Europeanization, changes of the planning logics, and the divide in dynamics between the metropolitan space and the peripheral. However, it remains critical important to emphasize that this new geography of spaces is not just economically significant; also central to the discussion are the contemporaneous global aging trend and, more specifically, the elder-boom breaking point. However, the relationships between the spatial, economic, and demographic changes are complex and difficult to disentangle. Which one causes the others? How should we understand these evolutions—from a cyclical perspective or as reflecting irreversible structural shifts? And if it is a mix of shifts and cycles, in what proportions?

This article deals with these issues at the junction between regional studies and life cycle economy. Housing prices are a particularly suitable mode of probing and documenting this subject, because they enjoy the advantage of simultaneous dependence on economic, demographic, and spatial factors. In this paper, we propose a methodology to analyze the spatial reshaping of housing wealth caused by the elder-boom, and we apply it to the French case. The relationship between demographic evolution and housing prices is used as a key indicator to identify and characterize various dynamics.

From a life cycle perspective, aging is seen to globally decrease housing stock wealth. However, it is possible to identify departments that reverse this global trend, as well as others where housing wealth losses are amplified. In other words, an important spatial wealth reorganization is taking place in France. These heterogeneous trends are analyzed in terms of various characteristics, as follows: the role of Paris, the role of the regional capitals, as well as littoral and border proximity. Then the spatial structure of this reshaping is compared to other macrostructures. Is it equivalent to the gentrification process or to the geography of unemployment? Are the losses concentrated in sparsely populated departments? Do difficulties in local housing affordability mirror the reshaping?

Section 2 is devoted to the literature review. Section 3 presents our methodology and illustrates each stage in the French case. The analysis for the whole set of departments and for various sub-groups is presented in section 4, and section 5 provides comparisons with others geographies. The last section offers concluding comments.

2. Literature review: Connecting regional decline to the elder-boom from the life cycle perspective applied to house prices

As Franklin and Leeuwen (2016) underline, “Building understanding of the myriad aspects of decline requires researchers positioned to wrangle with social, geographic, demographic, and economic components—all at once.” This observation carries direct consequences for our threefold literature review. The first part discusses geographic literature and the notion of the decline of space. The second part is related to the demographic field and the third to the economic theory using a lifecycle approach.

a. Cyclical and structural declines of spaces

Shrinkage studies are generally associated with two approaches: cyclic models composed of four stages (urbanization, disurbanization, counterurbanization, and reurbanization; Fol and Cunningham-Sabot 2010), and linear approaches based on three steps, in an “end-of-pipe” perspective (urbanization, stagnation/maturity, and decline).

Cyclical models are strongly related to economic cycles. They provide relevant insights with which to analyze suburbanization and deindustrialization dynamics, for instance.

Fishman (1987) indicates that suburbanization is the result of microeconomic and sociological factors. The microeconomic factors are due to residential strategies aimed at maximizing real estate investments. Le Goix (2016) also underlines the role of the welfare-based regime, in the case of American suburbanization, where public policies have been encouraging the planification of suburbs (Jackson 1985; Downs 1999). The sociological factors are due to the rise of individual mobility and residential strategies based on homogeneity (social, professional, confessional, etc.). In such a context, the decline of city centers and the growth of suburbs are the consequences of neighborhood evolutions regarding the potential capital gains and the devalorization of residential assets.

Deindustrialization, on the other hand, is more linked with macroeconomic factors (Friedrichs 1993). It can be explained by the shift from the industrial stage to the globalized stage, which substitutes Weberian localization logics with globalized logics of production chains. Declines in monofunctional spaces are the results of this change of paradigm, which has led to most of the studies on shrinking (Weaver 1977; Rybczynski and Linneman 1999), or the so-called German *Schrumpfende Städte* (Häussermann and Siebel 1988). More generally, deindustrialization is related to the correlation between urban life cycles and economic cycles. For example, Booth (1987) and Hall (1988) showed how the obsolescence of productive systems, corresponding to outdated innovations, could explain urban decline in certain cases, referring to the “creative destruction” of Schumpeter (1939).

These approaches do not consider urban decline as absolute or definitive but as conjunctural. In the case of suburbanization, the paradigm of a continuous urban growth trend at the scale of urban regions is not questioned, nor is the appreciation of general house prices at the upper scales and from a long-term perspective. In the case of deindustrialization, the decline is cyclic and corresponds to a structural adjustment in relation with a post-Weberian transition of productive systems, or a critical transition between two cycles after a temporary misfire of one cycle.

However, demographic changes (aging, elder boom, second demographic transition) are challenging these views. They force structural modifications in the local housing economy and the irreversible decline of spaces to be considered (Franklin & Leeuwen 2016, Sardon 2004, Van de Kaa 1987). From another perspective, Fol and Cunningham-Sabot (2010) also point out the structural and irreversible evolution of the systemic relationship between spaces due to globalization. Thus, the contemporaneous decline or rise of spaces, especially of urban spaces, cannot be analyzed as simply the expression of cyclical trends.

b. Local territories, the metropolization process, and the elder-boom

Aging is a global change of societies and territories (Lutz et. 2008). All OECD countries have been experiencing it at different scales (Fougère & Mérette 1999; Sardon 2004), from local rural territories (Burholt and Dobbs 2012) to urban metropolitan areas such as Tokyo (Abe 2015; Languillon 2016) and macro-regions such as Eastern Europe (Lintz et al. 2007; Hoff 2011). Even emerging and developing countries are concerned by the phenomenon, such as China (Peng 2011) and Russia (Gavrilova and Gavrilov 2009). Two continuous elements may explain aging: longer life expectancies, which increase the number of people older than 65, and lower birth rates, which lead the young and working populations to shrink. Some scholars even speak about an hypothetical second demographic transition (Van de Kaa 1987) based on the continuous decrease of birth rates and the timid but structural increase of death rates in super-aging societies (Hino and Tsutsumi 2015; Christensen et al. 2015). But the role of the so-called “baby boom,” which is now becoming an “elder boom,” is also a very important factor, maybe the most important one. It acts discontinuously and introduces a strong break.

The elder-boom is not a ubiquitous phenomenon and is not spatially homogeneous. It is due to local demographic differences in natality as well as mobility and various migrations at the local, national, and international scales. The Japanese case have been well-analyzed as a pioneer of aging changes. Rural exodus, especially of the young population, is the main cause for super-aging of more than 50 percent of the national territory.[1] At the metropolitan scale, several factors occurred simultaneously: the bursting bubble and the decline of land prices (Noguchi 1994; Scoccimarro 2007), public policies and economic incentives for the qualitative regeneration of city centers (Languillon 2015), and new high-rise residential tower developments (Koizumi et al. 2011). These factors explain the arrival of young working and gentrifying populations, especially couples with children, from urban fringes to city centers (Scoccimarro 2007). This movement is correlated with the rise of vacant houses in peripheries, including in the Tokyo metropolitan area (Kubo et al. 2013).

As Tokyo testifies, the elder-boom and metropolises interact; the migrations of young people due to the reinforced attraction of these cities for education and jobs tend to accelerate the aging process in rural territories. The metropolises tend to become younger than the rural peripheries or other regions, except in their urban fringes. However, heterogeneous effects are observable even within the metropolitan areas, such as the planned, gated communities. In opposition to the spontaneous

[1] Japanese call *kasô* municipalities that have lost more than 10 percent of their population between two decennial censuses; Pelletier 2008

dereliction of residential economy in the urban fringes, those aging enclaves tend to protect the value of real estate assets and the dynamism of the local economy, including services, leisure, and commercial activities (Townshend (2002), Le Goix (2005), Andel and Liebig 2002).
If spaces and people were homogenous, the aging effect would be simple and negative. But for various reasons, many existing situations reverse this trend locally. The concern, then, is to find a way to deal simultaneously with the structural changes of aging and globalization, the local contrarian dynamics, and the optimization of the urban process. We chose to use real estate prices as a key indicator, based on the life-cycle theory, to get a synthetic view on this ongoing reshaping.

c. Life-cycle economy and house prices

The life-cycle theory indeed posits an interesting relation between population aging and asset prices (Ando and Modigliani 1963, Diamond 1965). The basic idea consists of assuming that people invest in multiple assets during their working age and later convert them into retirement income. They are first buyers and then sellers. If the ratio between the working population and retired people stays constant across years, the supply and demand for assets will be unchanged, and their prices should not be affected. However, important prices variations are expected if the structure of the population shifts. In particular, an aging trend should generate important capital and property market outflows, which should lead to declining asset and housing prices, also called a “meltdown”. The central point for us lies in the fact that housing price meltdowns are spatially observable and mirror a wealth circulation (Davezies 2008).
Many authors have found evidence of meltdowns in bond and stocks markets (Abel 2003; Jamal and Quayes 2004; Campbell et al. 2007), with varying magnitudes across countries (Ang and Maddaloni 2005; Poterba 2001, 2004). Yet, this phenomenon can sometimes be difficult to detect (Marekwica et al. 2011) because individuals are not the only market participants. For housing markets, the situation presents two favorable particularities: contrary to the capital markets, households are the main participants, and if a property is an investment, it is also a consumption good. This strongly household-oriented market is thus a good case study with which to analyze the occurrence of meltdowns due to an aging population.
Two periods can be distinguished in the real estate literature: before 1995 and after 2005. Regarding the first period, the reference article of Mankiw and Weil (1989) studied the impact of important demographic shifts (namely the baby boom and baby burst) on the real estate market in the United States. They concluded that stronger demand from a larger working population makes real property prices surge and that prices decline when this cohort retires. Their findings were challenged by Hendershott (1991) and Holland (1991) with econometric arguments related to their model specification. However, by integrating these critics, Di Pasquale and Wheaton (1994) and Lee et al. (2001) continued to find evidence of the relationship between demographics and housing demand. A second critique was made: some authors pointed to the fact that Mankiw and Weil’s findings could be specific to the United States. Engelhardt and Poterba (1991), following the same approach with Canadian data, did not find any significant relationship. Whereas, for Japan, Ohtake and Shintani (1996) noted that the demography’s influence was limited in time and affected the housing stock more than it did to the prices.

Thereafter, between 1995 and 2005, the publications on that topic became less frequent. Here, it is of special importance to remark that these ten years are very specific for the issue. They correspond to the moment when all of the baby boomers belonged to the working population and were thus potential housing buyers. This is also the exact period when house prices increased strongly in numerous OECD countries. This interval ends with the years 2005–2006, which represent a structural break; the number of retired people began to drastically increase at this point, heralding the elder-boom period.

In the literature, these two major elements allowed the previous results to be revised in a much more positive sense. After 2005, papers that criticized the relationship between aging and house prices became scarcer. The empirical studies also became clearly positive for numerous countries: Fortin and Leclerc (2002) for Canada, Neuteboom and Brounen (2007) for the Netherlands, Shimizu and Watanabe (2010) and Hirayama (2010) for Japan. For Japan, Nakamura and Saita (2007), contrary to Ohtake and Shintani (1996), also found that the influence exerted by demographic changes on real estate prices was greater in the long run than in the short run. At the same time, Nishimura (2011) and Takáts (2012) redeveloped a theoretical model. The research of Takáts (2012) deserves special attention because it validates the empirical relationship from a panel data approach for 21 countries during the period 1970–2009.

3. Methodology

We base our methodological approach on the theoretical relation that Takáts (2012) brought to the fore. In a life-cycle perspective, he developed an overlapping generation model in an economy with a single asset – housing. The price variation of housing and, more precisely, its return r, can be expressed as the sum of economic growth g and demographic growth d.

$$r \approx g + d \qquad (1)$$

The relevance of this relation hinges on the capacity to distinguish between the economic and demographic effects, at least at the first order.

Our approach consists of three stages:

- The first stage consists of generating a robust and parsimonious empirically estimated version of the relationship (1).
- In the second step, keeping factor g constant, or eventually capitalizing on its smaller role ($g \ll d$), the relation of interest becomes $r \approx d$ (conditionally to g). On that basis, we can define the line of constant prices.
- The third stage refines the analysis by reintroducing factor g, for two reasons. First, the relation (1) is, indeed, an approximation of a second order relation: $r = g + d + g*d$. Even if crossed term $g*d$ is much smaller, it can still play a role. Moreover, in situations where factor g cannot be overlooked, it is important to complete the analysis that results from approximation $r \approx d$, which can be realized via a principal component analysis approach.

In this section, we implement and discuss these three stages further. At each level, a methodological discussion is developed and then illustrated by our case study: the French departments, between 2000 and 2014.

a. Step 1 : Estimating a panel model

i. Principles

This research aims to disentangle the respective influences on the regional declines of economic factor g, relative to structural and demographic factor d. Housing price evolutions function as proxies for local evolutions. Although the contemporaneous elder-boom context tends to reinforce the attention furnished to factor d, the effect of g and d on r must be simultaneously considered.

This first step consists of estimating an empirical and robust version of the theoretical relation (1). A panel approach is required to analyze the regional variations. The selection of variables representing factors g and d can vary according to the availability of the data. However, key points must be satisfied. The demographic evolution must be characterized in absolute terms, with the evolution of the total population (TPOP), and in relative terms, with the evolution of an aging ratio (OLDDEP[2]). Subsequent analysis hinges on these two variables, which are the same variable selected for consideration by Takáts (2012). Additional demographic variables can be included as control variables. Regarding factor g, the regional GDP evolution is the natural candidate, if available, but local revenue evolutions are also relevant. Control variables representing financing conditions and the new supply of real estate new supply, among others, are also worthy of consideration. Of course, the panel model must be parsimonious and its estimation robust.

[2] Number of people older than 60 divided by the number of persons between 20 and 60

ii. Case study

A. Data and panel model in the case of the France

For the case study, we implement a model comparable to that of Essafi and Simon (2017), who studied the relationship between housing prices and demographic factors on a national scale. Their article emphasizes the housing policy consequences and, more specifically, the generational rivalry that may result from home ownership in France. The present article can be distinguished from the study conducted by Essafi and Simon (2017), because of its focus on regional dynamics.

The panel consists of 94 departments (NUTS3), between 2000 and 2014, that correspond to 1222 observations. The dependent variable is the evolution of housing prices, at a departmental level, measured by hedonic indexes (PMAI for houses, PAPP for apartments). French notaries render these indexes, which they use their database to compute. The database coverage ratio varies from 40% to 80% of the whole transactions, across the departments. A hedonic approach is employed to calculate the indexes considered to be reliable

The explanatory variables (shown in Table 1B), are first associated with the demographic aspects (factor d): TPOP for the total population and OLDDEP for the old dependency ratio, which is defined as the number of people older than 60 years, divided by the number of persons between 20 and 60 years of age. The divorce rate (DIV), which could affect demand, is incorporated as a control variable. As for the economic variables (factor g), we choose household income (REV) and the interest rate for fixed-rate mortgages (TEG), while controlling for the newly-built houses (OFF) that could affect supply.

The relevant specification, inspired by the one articulated by Takáts(2012), in his model, is as follows:

$$\begin{aligned}\Delta \ln \mathrm{PAPP}_{\mathrm{it}}\ (\text{or } \Delta \ln \mathrm{PMAI}_{\mathrm{it}}) \\ = \alpha + \alpha_i + \beta_1\, \Delta\ln \mathrm{REV}_{\mathrm{it}} + \beta_2\, \Delta\ln \mathrm{TPOP}_{\mathrm{it}} + \beta_3\, \Delta\ln \mathrm{OLDDEP}_{\mathrm{it}} \\ + \beta_4\, \Delta \ln\mathrm{OFF}(\mathrm{APP\ or\ MAI})_{it} + \beta_5\, \Delta\ln \mathrm{TEG}_{\mathrm{t}} + \beta_6\, \Delta \ln \mathrm{DIV}_{\mathrm{t}} + \varepsilon_{\mathrm{it}} \qquad (2)\end{aligned}$$

The subscript i refers to individuals and t, to years. All variables under consideration are derived from the departmental level, except for the interest rate (TEG) and the divorce rate (DIV), neither of which are available on this scale. The fixed effects are also at the departmental level.

The estimations are presented in Table 1A. They corroborate the importance of the demographic variables for housing price dynamics, as suggested by the literature. The relationship is strong and robust in the case of France. The main variables are the total population; TPOP; and the aging ratio, OLDDEP; the former has a positive impact on prices, and the latter has a negative impact. Income and divorce rate are of secondary importance, whereas the interest rate and the intensity of construction are almost nonsignificant. For ease of interpretation, the model used in the rest of this article is slightly modified from its classical specification (2), substituting ΔLnOLDDEP in the equation for ΔOLDDEP. The series stays stationary, and this modification does not change the coefficients obtained for the other variables or their significance, as indicated in table 1A.

B. Robustness checks

In this section, we discuss various aspects involved in checking the robustness of the panel estimation: the stationarity of the variables, the nature of individual departmental effects, and

whether it is compelling to rely on a co-integration approach. A discussion of the reverse causality that potentially obtains between the prices and demographic variables is also included.
The model is written in first difference of logarithm for stationarity reasons. According to the HT and IPS tests, the variables in level present unit roots but are stationary in log-difference (Annex, Table A1). In the panel, the individual departmental effects are significant for apartments and houses, according to the Fisher test, and the specification for fixed effects is more relevant, according to the Hausman test (Annex, Tables A2a and A2b).
Regarding a potential co-integration relationship, the Pedroni tests have been implemented. They tend to reject this hypothesis. To confirm the absence of a co-integration relationship between a short-term and a long-term dynamic, FMOLS (fully modified ordinary least squares) estimations have been calculated (Table A3). The results for the long-term dynamic are very close to the direct estimation. Moreover, we should not forget that the series are on an annual basis, and they present a low volatility level and strong momentums, making the identification of a co-integration relationship with a clear short-term dynamic difficult. On that basis, we decided to keep the direct estimation.
At an intra-departmental or a metropolitan scale, the literature documents a potential reverse causality (Saks 2008, Glaser et al. 2005). An important price variation could indeed lead to a negative migration, with the household looking for better affordability conditions. Consequently, it could affect the variables TPOP and OLDDEP in a given city or for its direct neighbors and maybe for other cities, resulting in biased estimations. However, our regional scale of analysis strongly reduces this risk of bias. When this kind of movement occurs, it does so part of the time within a metropolis and therefore within the department itself, the metropolis being generally included in a department. The only possible exception would be the Parisian metropolis, as it covers several departments.
As for inter-departmental movements, they are generally limited in France (the average absolute annual migration rate is 0,35%, the rate varying between a minimum of -1% and a maximum of 1,30%). The correlation between the migration rate and price variation at the departmental level from 2010 to 2015 is -0,12 but is non-significant (p = 0,232). When we remove the Parisian region, the correlation becomes positive at a level of 0,24 (p = 0,026). We also calculated the Moran index for the prices to identify a potential spatial autocorrelation; this hypothesis was rejected (Cf. Table A4). All these elements indicate that no significant reverse causality exists at this scale.

b. Step 2 : Line of constant prices

i. Principles

The second stage consists of reducing the relation $r \approx g + d$ to $r \approx d$ and more specifically, to the relation between house price variations and relevant variables TPOP and OLDDEP. In the panel estimation, this signifies that the estimated constant and coefficients for these two variables are kept as they are, while the rest of the equation is zeroed out. Assuming that the errors terms are null, we obtain the following relation:

$$\Delta \ln \mathrm{PAPP}_{it} \; (\text{or } \Delta \ln \mathrm{PMAI}_{it}) = \hat{\alpha} + \widehat{\beta_2} \; \Delta \ln \mathrm{TPOP}_{it} + \widehat{\beta_3} \; \Delta \mathrm{OLDDEP}_{it} \qquad (3)$$

This simplification is acceptable in two cases. The first corresponds to a situation where, the economic variables are either insignificant or have small coefficients. It demonstrates that price dynamics are essentially determined by demographic variables. The second case hinges on the assumption that variations of the economic variables are null (factor g). In such a case, the analysis is determined for a given level of the economy.

ΔlnTPOP corresponds to the annual percentage of variation of the total population, while ΔOLDDEP corresponds to the annual absolute increase of the aging ratio. In the plane (Δln TPOP, ΔOLDDEP), by zeroing out the left side of equation (3), we can thereby determine a line signifying where TPOP's positive effect on prices is nullified precisely by OLDDEP's negative effect on prices. If a department is on the line, prices remain constant. To the right of the line, the total population's positive impact is stronger than aging ratio's negative impact; prices consequently increase. To the left of the line, the aging effect is stronger than the total population effect, resulting in a decrease to prices. It is also interesting to note that, as the distance of the department from the line increases, so does its price.

Given that they result directly from the panel estimation, the line of constant prices depends on the set of individuals and the period of estimation. If this issue can be regarded as a robustness issue, where the line's stability could be examined by varying the set of individuals and the period; however, it is more relevant to address this point with reference to the desired scope of analysis. In fact, positioning an individual in relation to the line represents its specificities, relative to a reference group. In other words, this methodology consists of a within-group heterogeneity analysis. From a planning policy perspective, choosing national-level constituents to form the reference group seems reasonable, although this choice can be adapted according to the researchers' specific motivations. This argument also applies to selection of the estimation period. However, for this second dimension, it is also important to calibrate the panel, using a period of time that is not characterized by overly homogeneous demographic trends. A minimum level of volatility is required to correctly capture the impact of the demographic variables on housing prices.

ii. Case study

A. Line of constant prices and segmentation in three groups in the case of France

As indicated above, for the French panel estimation, the main variables are TPOP and OLDDEP. The other variables are of secondary importance, or even insignificant. The reduction of the relation $r \approx g + d$ to $r \approx d$ is, consequently, very appropriate. Our interest in this case study is driven by a desire to understand how demographic trends, and more specifically, the elder-boom, have heterogeneous impacts on housing wealth evolutions across French departments. The line of constant prices[3] is computed from the panel estimation for the whole set of departments. Regarding the period, we selected the boundaries [2000; 2014] to ensure sufficient demographic volatility; as discussed in the next sub-section, the periods [2000; 2006] and [2007; 2014] are, indeed, different. In the French case, we elected to develop our analysis by defining three areas in the plane (ΔlnTPOP, ΔOLDDEP) (Figure 1A). The first one, noted Z_1, is the portion to the left of the line and to the left of the vertical axis: the population decreases, aging is strong, and prices decline. The second one, noted Z_2, corresponds to the portion on the left of the line but on the right of the vertical axis. Here, the population increases but not enough to compensate for the aging; housing

3 As the lines of constant prices for houses and apartments are very close, we choose to work with a single line, the bisector of the two lines.

prices slightly decline. The third one, Z_3, is on the right side of the line and on the right side of the axis. The population effect exceeds the aging effect, so prices rise. If the distinction between the areas to the right and the left of line, respectively, can be determined mathematically, by the sign of the residuals, this results in a more arbitrary segmentation of the left side, between Z1 and Z2. We decided to introduce this split, because of the approximately equal number of individuals in these two areas. However, the main reason for this choice is that the local development policies tend to differ between departments that maintain an increasing population and those characterized by a shrinking total population. This segmentation may be less relevant in other case studies; for instance, it would be less relevant if the number of departments losing population were small, or if the area Z2 were reduced on account of the proximity of the line of constant prices and the vertical axis.

B. The elder-boom breaking point

The fundamental relation (3) brings a major regime shift to the fore. The scatterplots of Figure 1 represent the annual demographic evolution of the 94 departments for various sub-periods. For the period 2000 to 2006, the OLDDEP ratio is approximately constant, and its variations are globally close to zero (figure 1A). Regarding the total population, the dispersion is wider; a few departments lost population, while others quickly increased at an annual rate greater than 1 percent.

The year 2006 for France was a breaking point. The baby boom in France began in 1945 and lasted almost up to 1970. As the OLDDEP ratio measures the number of people older than 60 divided by the number of people aged between 20 and 60, its evolution has changed since the year 2006 because of the baby-boom cohorts reaching the age of 60. Figure 1B is associated with the period 2007 to 2014. As we can see, the scatterplot shifts upward and to the left: aging becomes strong, and the population increases less. During the period 2000–2006, almost all of the departments were to the right of the line of constant prices, meaning that the dynamics of housing prices were bullish everywhere. But after 2006, the line splits the departments between those with bullish trends and others with bearish trends.

In the following analysis, we retained the period 2010–2014 to mirror the contemporaneous tendencies of this new real estate environment characterized by aging. Another option would have consisted of using forecast scenarios for the demographic data. Figure 1D presents the scatterplots for the period 2015 to 2025 when using these scenarios.[4] As we can see, the dispersion is smaller. The main problem with this choice is that the forecasts depend on hypothetical assumptions that may or may not be reliable. For instance, it is difficult to clearly anticipate what the results of the metropolization policies in France will be in the next ten years or what their effects will be on mobility. On that basis, the period 2010–2014 is preferred.

[4] Median scenario established by the National Statistical Institution [INSEE]

c. Step 3 : Reintroducing the second-order specific dynamics

i. Principles

Capitalizing on capacity to distinguish between the two factors, g and d, we reduced the relation (1) to its demographic components, to focus the analysis on the structural effects of the elder-boom. However, the limits involved in this simplification must be evaluated. In cases where g is of second order, relative to d (g<<d), even if the economic variables are secondary, it remains critical to qualify their roles. Similarly, in Takáts (2012), the relation (1) actually consists of a second-order crossed term: $r \approx g + d + g*d$. If, in first approximation, g*d can be neglected, relative to g and d, qualifying the effects also matters. The role of this third step is therefore to precise the potential second-order specific dynamics. Moreover, in cases where g cannot be neglected, relative to d; to wit, when the analysis is proceeds via consideration of the economic environment as constant, this third stage also assumes a confirmatory role. It consists of implementing a principal component analysis[5] , along with a greater set of variables, to check whether and how factorization occurs between the g-variables and the d-variables. This technique also offers a means of characterizing the departments as a whole and within relevant subgroups.

ii. Case study

For the French panel model, the long-term structural demographic variables appear to be the main drivers, whereas the economic variables seem to be of secondary importance. Eighteen variables (cf. table 1B), reflecting the demographics, socioeconomics, and housing market features are used to implement the principal component analysis to confirm it. The goal is to enable observation of how the variables factorize. Two dimensions emerge (cf. table 2).

The first dimension is “demographic, real estate, gentrified” (DREG), which is positively characterized by the demographic variables (important and increasing population, younger, limited aging) and housing market features (high real estate prices, low vacancy and ownership rates, high level of construction). It is completed by socioeconomic variables associated with gentrification (high GDP and revenues, high percentage of executives, unequal living standards). The second one, UNPREM, is more centered on economic factors (high unemployment and poverty rate, low revenues, equal life standard) with negative or null net migration; its reduced form was termed UNP (high unemployment and poverty rates). In one situation, the UNP/UNPREM is replaced by another group of variables, termed MMASR (small or medium departments in terms of population and GDP, positive net migration, low unemployment, and high secondary residence rate).

The DREG dimension, in fact, does correspond with the previously discussed structural spatial changes and factor d. It is invariably the first component, regardless of segmentation and accounts for between 37 and 56 percent of the variance. The UNPREM dimension corresponds to the

[5] This technique consists of restructuring data to identify patterns in a set of variables (Child 2006). Some uses can include data transformation, hypothesis testing, and mapping (Rummel 1970). This technique can reduce the number of variables; this is known as dimensionality reduction (Bartholomew, Knott, and Moustaki 2011). The new factors are linear combinations of the initial variables. They permit an easier understanding of the data and also facilitate interpretations (Rummel 1970). By placing variables into meaningful categories, principal component analysis converts measures into the underlying concepts that were not initially observable. This can be realized either within an exploratory framework or a confirmatory approach.

cyclical and economic aspects or, in other words, to factor g; it captures between 15 and 32 percent of the variance. This limited variance is coherent, given the minor role of the economic variables in the panel model. These results suggest that, for the case of France, on the whole, the simplification $r \approx d$ is acceptable, because $g \ll d$. They tend to confirm that the ongoing spatial changes are mainly structural.

Last, it is also compelling to note that the poverty and unemployment dynamics are invariably orthogonal to the real estate and demographic dynamics, whereas the gentrification process always correlates with the price-demography dynamic.

4. Spatial trends of the housing wealth circulation caused by the aging shock in France

What can the spatialization of the life cycle theory applied to real estate prices tell us about regional decline? This section presents the new information we are able to attain from this perspective, by applying the above methodology, in the case of France.

a. Economic localization of the aging process: Standard, contrarian, or amplified?

The scatterplot and map 2A represent the evolution of the real estate prices for 94 French departments. The portion of the plan Z_1 corresponds to an important loss of housing wealth, for Z_2 the loss is moderate, whereas for Z_3 wealth increase. As the global trend is negative, the existence of the contrarian departments Z_3 means that their wealth loss is endured by the Z_1-departments, which concentrate the negative effects of aging.

The Z_1-departments are mainly rural ones that have never really experienced high positive trends in the long-run during the last two centuries. They are located in the center of France and in some parts of the east. Enclaving, in particular railway enclaving, their distance from metropolises, and industrial crises are the common admitted explanatory factors. However, a key point is that aging pursues and amplifies this trend, in absolute but also relative terms, i.e. more harshly than it does for the other departments. The medium group is formed by departments that are closer to the metropolises or even sometimes hosting a regional capital, departments on the Channel Coast or those not too far from a coast, and departments on the northeastern border. They endure wealth decreases but in a limited manner. The third set includes the departments of the Parisian region, the ones hosting metropolises, the Atlantic and Mediterranean littorals, and almost all of the southeastern departments. Here, the global dynamic is reversed; prices increase and housing wealth becomes concentrated in these contrarian departments.

The PCA results for the full set of departments[6] clearly corroborate these elements (see table 2). The structural DREG factor is the first one and captures half of the variance. In this group, we can consider that $g \ll d$ and regard the approximation $r \approx d$ as acceptable. Almost all of the positive[7] examples belong to Z_3 and correspond to metropolitan, littoral, or border departments, whereas the negative examples belong to Z_1. We now refine the analysis for various subgroups.

b. Extended Parisian region

The extended Parisian region is made of three concentric groups of departments, in a center-periphery logic with a decreasing gradient. In the first group, we find Paris and its ring of small and very urbanized surrounding departments. They approximately constitute the zoning of the "Grand Paris" metropolis development project. The second ring is made of urban departments that are directly connected to the center with a dense public transport network. Their size is more important, and some of the furthest areas can be considered rural. The administrative region, Île-de-France, includes the first two groups but not the third one. We included it in the analysis to test

[6] The Parisian departments have been removed from the full set for stability reasons and ease of interpretation.

[7] The positive (negative) examples correspond to the departments close to the axis, in the same (opposite) direction.

the direct extension of the Parisian influence. This last ring is made of departments that belong to other regions. An important portion of these spaces can be qualified as rural, but significant transport connections with Paris and urban zones also exist; moreover, one of these departments hosts a regional capital. As we can see in Figure 2B, the magnitude of aging clearly differentiates the three groups. At the national scale, the departments of the first group are even among those less concerned by aging.

As expected, the administrative region increases or maintains its housing wealth homogeneously in the first group and heterogeneously in the second. This is also true for the west of the third group. Traditionally, the wealth inside Paris and the region is west-skewed. Here, also, aging tends to reinforce the existing pattern by increasing the integration of the western part. In opposition, although their distance to Paris is less than 100 km, the eastern departments did not succeed in reversing the meltdown, with no department belonging to Z_3 and one department even belonging to Z_1 (the others belonging to Z_2). It also must be noticed that the DREG in the Parisian region gives less importance to the population increasing and is completed by negative net migration. This is coherent, as some people try to leave Paris when they retire or during the second half of their career. The role of the cyclical factor UNP is smaller (17 percent of explained variance). Classically, it opposes a suburb in the north with a high poverty rate (Seine-Saint-Denis) with a very middle- and upper-class department in the west (Yvelines). It is worth noting that, even within the Parisian region, $g \ll d$, which means that the approximation $r \approx d$ can be considered.

c. <u>Departments with regional capitals</u>

In the previous case, the scope was regional, with a DREG factor far ahead the UNP. We now consider metropolitan areas with the departments hosting regional capitals. This set is formed by eleven units, excluding Paris. The line of constant price separates the observations into two groups; the first group is positioned in Z_2 or very close to the line, while the second group clearly belongs to Z_3. There is no regional capital in Z_1. The metropolis status acts as bulwark against important housing wealth losses caused by aging and even helps to reverse it locally. The second group mainly corresponds to the technopoles arc.[8]

Even within the metropolises group, DREG is the first structuring factor and explains 40 percent of the variance. Aging cannot be reduced to a simplistic opposition between rural and urban areas; it produces effects on all types of territories, including the most urbanized, and is always the strongest factor. This point is crucial. However, some specificities appear for metropolises. The economic factor UNPREM is important (32 percent), and some variables are transferred from the first to the second factor (increasing population, revenues, and unequal living standards). The two factors can be considered as having almost equal structuring power for the metropolises. Consequently, the simplification $r \approx d$ is relevant only given the assumption that we are observing a constant economic environment.

It is also interesting to remark that the Z_2 group is heterogeneous. It is composed of departments with a poor DREG dynamic[9] but also of departments with a bad UNPREM dynamic that are almost

[8] Rennes, Nantes, Bordeaux, Toulouse, and Lyon

[9] Côte-d’Or, Loiret, Bas-Rhin

on the line of constant price.[10] These latter departments have been hit by industrial crises (in the steel, mining, textile, and chemical industries) and experienced failures of industrialisation policies in the 1970s and 1980s. The Z_3 group is made up of attractive metropolises with smaller social issues and increasing population. For the French regional capitals, good DREG and UNPREM trends can add up, but no case shows compensation (a bad UNPREM dynamic compensated by a good DREG dynamic or the opposite). Identifying regional capitals in other countries where such compensation occurs could be a relevant research topic.

d. Littoral departments

Compared with the metropolises group, aging is higher on average for the littoral departments without being in the Z_1 area. If these departments limit the housing wealth losses due to the aging process, however, they must gather a combination of factors to become contrarian, including proximity to a technopole or a metropolis, better weather conditions to maximize the Sun Belt effect (Channel littoral compared to the Atlantic and Mediterranean littorals), and an absence of past industrial crises. It is also interesting to note the split of the Mediterranean littoral; while the rich and old departments of the east only maintain their housing wealth, the younger departments of the west increase it significantly (working-class populations and mass tourism characterize the western part, and there is also a notable difference in terms of planning as well: unplanned for the east, planned for the west.

The DREG factor presents some particularities. The role of real estate prices is slightly reduced and partially transferred to the third factor. Moreover, the population increase no longer participates in DREG. This latter variable acts in a specific manner for the littoral departments. Its dynamic differs because of the inflow of newly retired people and the higher mortality rate due to significant local aging. As long as the flow continues, the population is steadily replenished, allowing these departments to maintain their housing wealth and population. The best example of this situation is the city of Nice on the French Riviera, whose population has stayed constant and is already quite old, at an average of 43 years old (lowest point on the graphic).

The second factor, UNPREM, classically opposes the departments with economic difficulties in the North or on the west Mediterranean littoral with the good economic situations observable on the upper part of the Atlantic littoral. The third factor regroups high real estate prices and a high percentage of secondary residences. While prices always participate to DREG, they also exhibit a link with another dimension here. Littoral departments are the only case for which a price effect is detected without being associated with the DREG.

For this group of departments, as well as the group presented in the next sub-section, the distinction between g and d is less strict. Some specific dynamics may exist, while general dynamics may present variations. However, overestimation of these specificities must be contained; the factor DREG remains primary, and these other particularities are generally of the second order.

e. Border departments

The border departments constitute the last group. Several elements are positioned in the Z_3 area. They correspond to littoral or metropolitan departments, but there is also a specific sub-group

[10] Bouches-du-Rhône, Nord, Seine-Maritime

bordering the Italian and Swiss frontiers near Geneva. This positive effect does not exist for the German frontier, at least at the departmental scale. It is also possible to find elements in Z_1; a border is not by itself insurance against housing wealth losses.

While the first factor is once more the DREG (47 percent), things are different for the second one. It still corresponds to a cluster of economic variables (factor g), but here the combination changes. The MMASR points to the small or medium departments in terms of population and GDP, with a positive net migration, a low unemployment rate, and a high percentage of secondary residences. Its positive examples belong to the sub-group close to Geneva mentioned above and have to be interpreted in terms of the economic activity generated by the border. However, the range of the border effect is generally small—less than 30 km—and is therefore not enough to affect a whole department. The MMASR economic model is in fact completed by the touristic activity and the winter sports, as suggested by the presence of secondary residences. The third factor also corresponds to the secondary residences but this time on the Mediterranean littoral.

5. To what extent does the aging-price geography correspond to others logics?

In this last section, we briefly discuss the similarities and differences of the aging-price logic with other factors. For each case, an indicator is used to classify the departments into thirds and to compare them with the Z_1, Z_2, and Z_3 groups (cf. figure 3).

a. <u>a Size effect?</u>

The correspondence between value circulation caused by aging and the population size is good (Figure 3A). Almost all of the Z_1 departments have a small population, whereas all of the populated departments belong to Z_2 or Z_3. In other words, the aging shock tends to amplify the disparities between dense and sparse departments by means of their housing wealth evolutions. However, a few exceptions exist with small departments where the wealth evolution is positive. These singularities can be explained either by proximity to an important metropolis or by the concentration of industrial districts in a Marshallian perspective.

b. <u>a Gentrification effect?</u>

Gentrification—namely, the substitution of low-income populations by middle or upper-classes—is a well-known subject in the urban literature.[11] A ratio based on the socio-professional categories is computed at the departmental level.[12] Here, the correspondence is also strong: lowly gentrified departments belong to Z_1 or Z_2, while highly gentrified departments in general belong to Z_3 (Figure 3B). This means that middle and upper classes tend to avoid housing wealth losses due to the aging process, whereas departments with numerous people in the less privileged classes tend to overpay. The exceptions—the lowly gentrified departments avoiding losses—are quite similar to the previous case.[13] The littoral department of Vendée is also an exception, with its entrepreneurship culture, its dynamic industrial sector, and the proximity of a metropolis.

Globally, regarding size and gentrification, the anomalies can be easily explained by the littoral and border aspects, the metropolis effects, and a few additional agricultural or industrial local specificities. Another point deserves a comment: while the urban literature documents the gentrification process at the intra-urban scale, it is interesting to remark that it would also act at a wider scale.

c. <u>an Unemployment effect?</u>

Is it possible to find a simple relationship between value circulation caused by aging and unemployment? The previous results relative to the UNPREM have already given some indications. For all of the segments, this factor was never correlated to the DREG factor and was always the second one. Given this orthogonality, it is no surprise that figure 3C exhibits no clear relation. In each area, Z_1, Z_2 or Z_3, it is possible to find departments with low, medium, and high unemployment rates. The map comparison is also eloquent. All of the cases are possible; some

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[11] Meligrana and Skaburskis 2005 for Canada, Boterman et al. 2010 for Amsterdam, Pattaroni et al. 2012 for Paris, etc. Hochstenbach and Boterman (2017) also recently studied its intergenerational determinants.

[12] The ratio of farmers, artisans, merchants, entrepreneurs, employees and workers to executives and intermediate and higher intellectual professions.

[13] Landes, Aude, and Tarn-et-Garonne

regions can benefit from a good price-demography dynamic with low unemployment (the northwest area), while others can have negative trends accumulate (“Centre” region). But it is also possible to find examples with a good price–demography dynamic and an important unemployment rate (Mediterranean departments, especially the western departments), or a bad price–demography dynamic but a low level of unemployment (the south center area). As a consequence, the use of unemployment level to drive a policy to spatially redistribute housing wealth would be misleading. The relationship between regional decline and the labor market is indeed complex (Batey 2016).

d. <u>an Affordability effect?</u>

Literature about housing affordability is multifaceted and there is clearly not a single way to assess it (Jing 2014). However, as most of the definitions focus on the relationship between housing expenditure and household income, it is acceptable to define housing affordability as the ability of a household to meet its housing need, considering its income, the house prices or rents levels, and the tenure choice. For the particular case of home buyers, affordability is basically related to accessibility of homeownership (Yi 2004).

In order to assess housing affordability, an index was constructed at the departmental level. Two series were used: a price index $Ind_i(t)$ and the borrowing capacity[14] $E_i(t)$ for the average household in the department “i.” Both were normalized at 100 for the year 2010. The affordability index is the ratio between $E_i(t)$ and the price index $Ind_i(t)$.

$$Aff(t) = \frac{E_i(t)}{Ind_i(t)} \qquad (4)$$

If the borrowing capacity increases faster than the price, the index also increases; housing becomes more affordable. If the borrowing capacity increases less compared to the price or even decreases, the index falls; housing becomes less affordable. Figure 3D represents the affordability variations between 2010 and 2014.

As expected, the affordability worsens in general for the departments in Z_3, especially when aging is reduced. Conversely, in Z_1, the real estate purchasing capacity evolutions are favorable or intermediate. If a correspondence exists, however, it is less clear compared to the correspondences with size or gentrification, and the exceptions are more frequent. Thereby, three departments in the “Centre” region[15] simultaneously present a bad price–demography dynamic and affordability

[14] The calculation of the local borrowing capacity is made with the formula $E_i(t) = \frac{M_i(t)}{r(t)} * \left[1 - (1 + r(t))^{-D(t)}\right]$. This formula gives, for a fixed-rate mortgage, the borrowing amount associated with a monthly payment $M_i(t)$ for an interest rate r(t) and a duration D(t). The rate and the duration are constant across the departments because the series are not available at this level on a regular basis. This simplification is acceptable because rates and mortgage duration are quite homogeneous between regions in France. The monthly local payment is deduced from the departmental median household revenue multiplied by 30%. Banks generally do not allow households to obtain loans that involve more than 30% of their income in France.

[15] Departments of Cantal, Aveyron and Allier.

deteriorations. In other words, purchasing become more difficult for its inhabitants,[16] and prices are expected to decrease in the long run. These situations would deserve to be considered carefully by the public policies. On the other side, it is possible to find departments where the long-term price-demography dynamic is positive and where the affordability evolutions are also positive, paradoxically. These situations can be explained from a diffusion perspective. By themselves, they do not have the best features, but all are close to departments with these good features: either a metropolis proximity or a metropolis proximity reinforced by a littoral dynamic. In the Southeast, a group of five contiguous departments simultaneously benefits from the proximity of several metropolises, reinforced by the littoral areas and the border proximities.

[16] In these departments, the property exchange rate is also low, with inheritances playing an important role.

6. Conclusion

In this paper, to analyze the local decline dynamics caused by the elder-boom, we developed a methodology based on a spatialization of the life cycle approach. A relationship between demographic evolutions and housing prices served as a key indicator that facilitated the identification and characterization of various dynamics. This methodology was applied to the French case and we now summarize its outcomes.

The spatial manifestations of the current wealth reshaping are strongly heterogeneous in France, with certain departments confronting intensified losses of wealth and others capitalizing on the changes. It benefits the Parisian region, the metropolises, the Atlantic and Mediterranean littoral areas, and almost all the southeastern departments. It also tends to intensify the existing contrasts, in particular to the detriment of the sparsely populated departments, those in the center and northeast, and those of the far east of the extended Parisian region compared to their western equivalents.

Being a metropolis is clearly the main insurance against important housing wealth losses, even though it is not a guarantee to automatically benefit the most of this implicit wealth reallocation. For the non-metropolitan departments, a combination of second-order factors is required to locally reverse the meltdown, including proximity to a metropolis, littoral areas eligible for Sun Belt dynamics, proximity to a border, existence of an important touristic activity, and the presence of Marshallian districts. However, none of these single factors is enough by itself to reverse the trend.

Gentrification is a direct and emblematic avatar of this change and, as a result, has to be considered as a long-term and structural phenomenon. We found that the middle or upper classes tend to avoid housing wealth losses, while departments with numerous workers and employees tend to overpay them. Further studies are required to better understand how gentrification can be the consequence of the elder-boom breaking point. The preceding rise of the housing prices induced by the demand of the numerous future retirees, combined with the fact that the middle and upper classes are then the only potential buyers at these high price levels, is likely the missing key.

Regarding the economic and cyclical variables, they appear to be relatively independent of this shift and of secondary importance—with the exception of the metropolises, where the magnitude of the economic factor is almost equal to the magnitude of the demographic factor. If the structural and cyclical dynamics can accumulate, there is no case where a bad structural dynamic is compensated for a good cyclical dynamic. As a consequence, unemployment is not a relevant indicator to track this contemporary reshaping. Using it for a public policy to counterbalance the negative effects would be misleading. It would result in ignoring territories and people being strongly hit by the phenomenon.

To conclude, it is important to underline that this modification in the housing wealth circulation across generations due to the elder boom is also a spatial modification that carries consequences for the local territories. The redistribution between departments can be spontaneous, through the tourism industry or local diffusion processes. However, not all the disadvantaged departments benefit from these corrective mechanisms. This issue calls for national and European involvements to limit the drawbacks and to manage these changes in a globally relevant way (Carbonaro et al. 2016).

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Table 1A: Panel Regression Models for Apartments and Houses

	Apartments		Houses	
	Model with D(LN(OLDDEP))	Model with D(OLDDEP)	Model with D(LN(OLDDEP))	Model with D(OLDDEP)
REV	0.61***	0.55***	0.73***	0.69***
TOTPOP	5.11***	4.79***	4.55***	4.34***
OLDDEP	-1.77***	-3.75***	-1.93***	-3.97***
DIV	0.29***	0.28***	0.27***	0.27***
OFF	0.02***	0.02***	0.13***	0.12***
TEG	0.01 (n.s.)	0.02 (n.s.)	0.12 (n.s.)	0.10 (n.s.)
Adjusted R^2	44%	45%	62%	62%

Note: Panel models for apartments and houses prices. 2000 to 2014. Annual frequency.
$^{*}p < .10$
$^{**}p < .05$
$^{***}p < .01$

Table 1B: Variables and Databases

Variables	**Source**
Hedonic indexes for apartments (PAPP) and houses (PMAI)	Notarial databases, INSEE
Collective and individual new housing constructions (OFFAPP / OFFMAI)	Sit@del
Total GDP (2014)	Oxford Economic
Household annual income (REV)	Direction générale des finances publiques
Mortgage interest rates (national level, TEG)	CSA
Percentage of secondary residences (2014)	INSEE
Percentage of vacant residences (2014)	
Rate of ownerships (2014)	
Poverty rate (2014)	
Ratio of total income received by the 20% of the richest individuals, to the 20% of the poorest individuals (2011)	
Unemployment rate (2014)	
Ratio of the high socio-professional categories to the lower socio-professional categories (2014)	
Total population (TPOP)	
Aging ratio (OLDDEP)	
Migratory balance (2012)	
Divorce rate (national level, DIV)	

Note: All of the variables are at the departmental level, except TEG and REV (national level).

Table 2: Principal Component Analyses

Axis	Axis characterization	Explained variance (%)	Positive example	Negative example
Full set of departments less the extended Parisian region				
F1	- **DREG**	50%	Ain, Alpes-Maritimes, Bas-Rhin, Bouches-du-Rhône, Gironde, Haute-Garonne, Haute-Savoie, Hérault, Ille-et-Vilaine, Isère, Loire-Atlantique, Nord, Rhône, Var	Allier, Ariège, Aveyron, Cantal, Creuse, Haute-Marne, Indre, Lot, Lozère, Meuse, Nièvre, Orne
F2	- **UNP**	15%	Bouches-du-Rhône, Nord, Pas-de-Calais	Haute-Savoie, Savoie, Vendée
F3	- High percentage of secondary residences	11%	Aude, Hérault, Pyrénées-Orientales, Var	Côte-d'Or, Haut-Rhin
Extended Parisian region				
F1	- **DREG** • reduced role of increasing population - Negative net migration	56%	Hauts-de-Seine, Paris, Val-de-Marne	Aisne, Aube, Yonne
F2	- **UNP**	17%	Seine-Saint-Denis	Yvelines
Departments of the regional capitals (Paris excluded)				
F1	- **DREG** • reduced role of increasing population and vacancy rate • no role of revenue and unequal life standard	40%	Haute-Garonne, Rhône	Côte d'Or, Loiret
F2	- **UNPREM** - Constant or decreasing population	32%	Bouches-du-Rhône, Nord, Seine-Maritime	Haute-Garonne, Loire-Atlantique
Littoral departments				
F1	- **DREG** • reduced role of real estate prices, unequal life standard • no role of increasing population, vacancy rate	37%	Bouches-du-Rhône, Gironde, Loire-Atlantique, Nord	Aude, Côtes-d'Armor, Manche
F2	- **UNPREM**	22%	Aude, Nord, Pas-de-Calais	Loire-Atlantique, Vendée

F3	- High percentage of secondary residences - High house prices	17%	Alpes-Maritimes, Pyrénées-Orientales, Var	Eure
Border departments				
F1	- **DREG**	47%	Alpes-Maritimes, Haute-Garonne, Haute-Savoie	Ardennes, Ariège, Meuse
F2	- **MMASR**	21%	Hautes-Alpes, Haute-Savoie, Savoie	Nord
F3	- High percentage of secondary residences	11%	Alpes-Maritimes, Pyrénées-Orientales	Ain

Note: A positive (negative) example is a department close to the axis and in the same (opposite) direction.

Component	Description
DREG: Demographic, Real Estate, Gentrified	- Important and young population, not affected by aging, with increasing population - High real estate prices, low vacancy rate, low ownership rate, high level of construction - Rich departments in terms of GDP and revenues - High percentage of executives - Unequal life standard
UNPREM (UNP)	- High unemployment and poverty rate (= **UNP**) - Low average revenues - Equal life standard - Negative or null net migration
MMASR: Medium, Migration, Activity, Secondary residences	- Small or medium population and GDP - Positive net migration - Low unemployment - High percentage of secondary residences

Figure 1: Population Data Several Sub-Periods

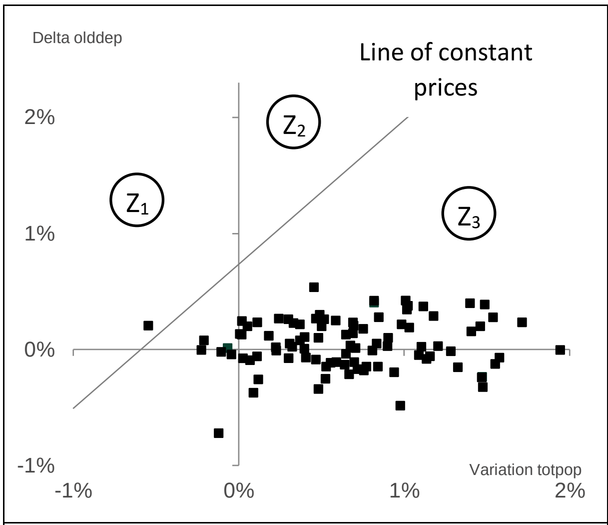


Figure 1A : 2000 – 2006

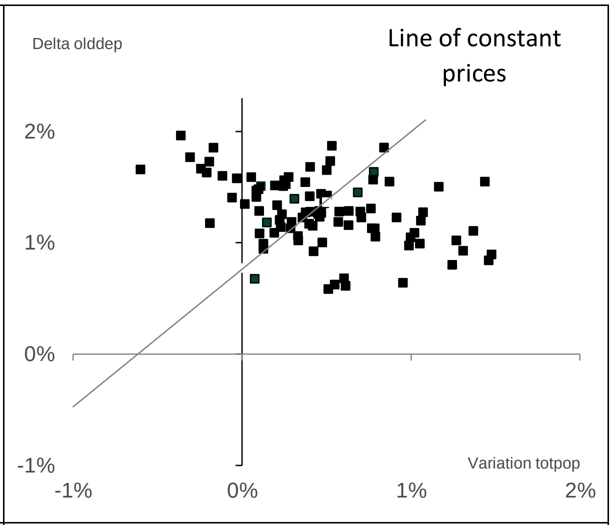


Figure 1B : 2007 – 2014

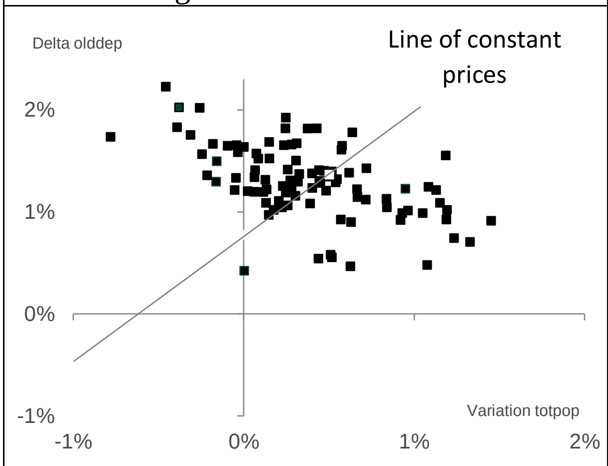


Figure 1C : 2010 – 2014

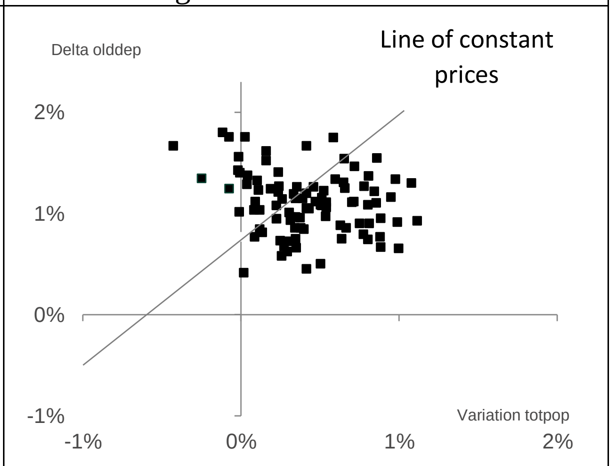


Figure 1D : 2015 – 2025

Figure 1. Population data for several sub-periods. Variations are calculated on an annual basis. Z_1 is the portion on the left of the line and on the left of the vertical axis. Z_2 corresponds to the portion on the left of the line but on the right of the vertical axis. Z_3 is on the right side of the line and on the right side of the vertical axis.

Figure 2: Geography of Demographic-Price Relation

Figure and map 2A : Full set of departments

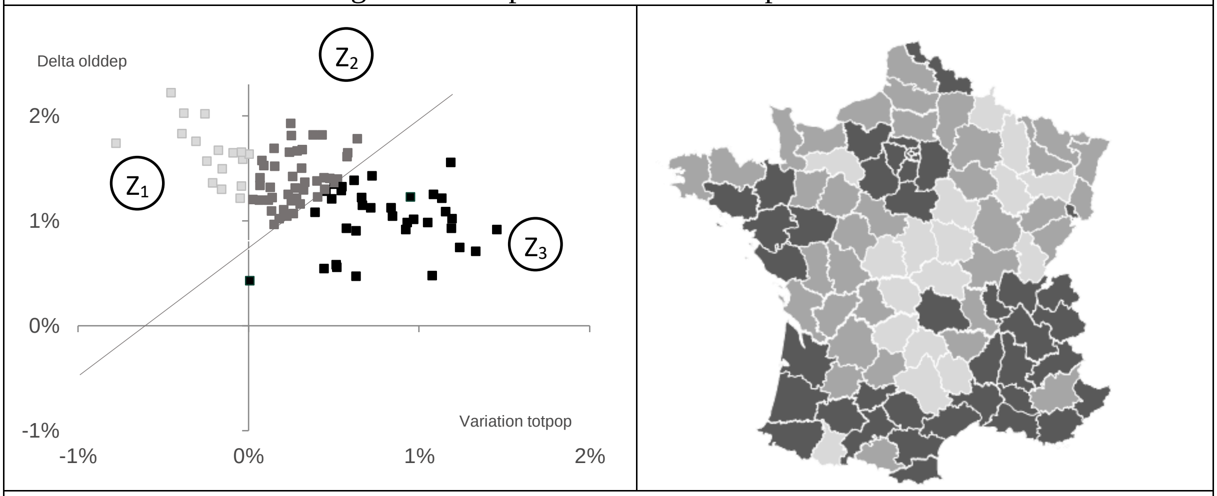


Figure and map 2B : Extended Parisian region

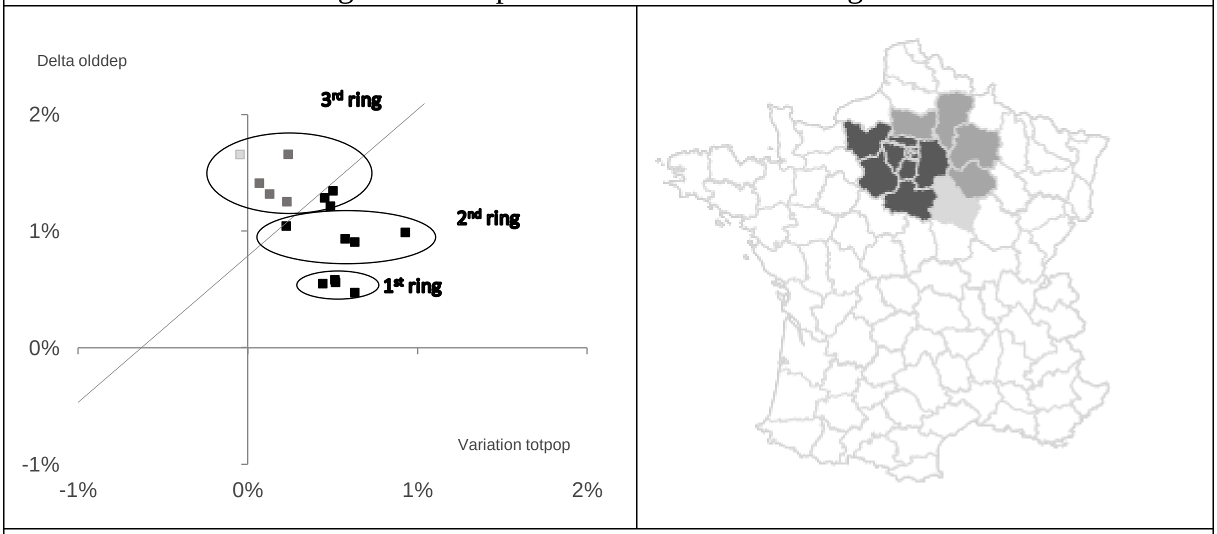


Figure and map 2C : Departments with regional capital metropolises

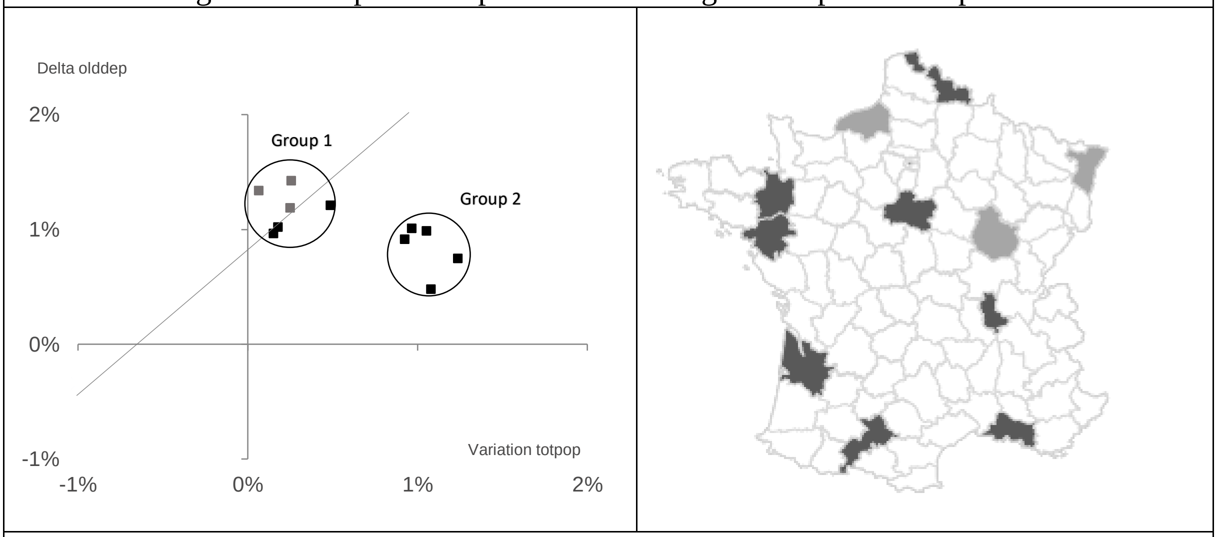
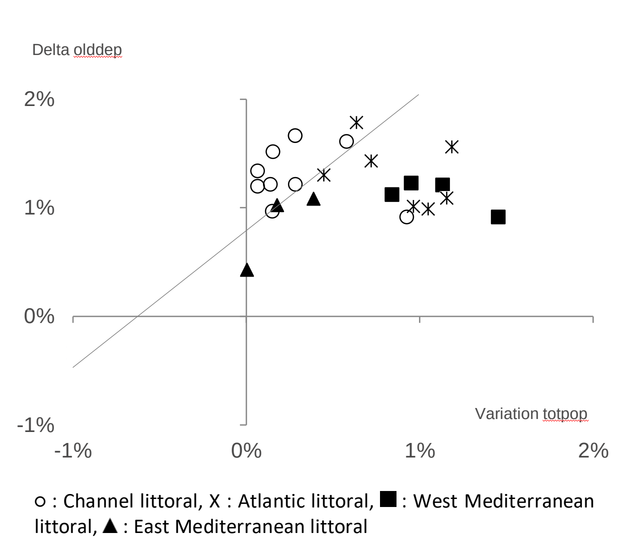


Figure and map 2D : Littoral departments



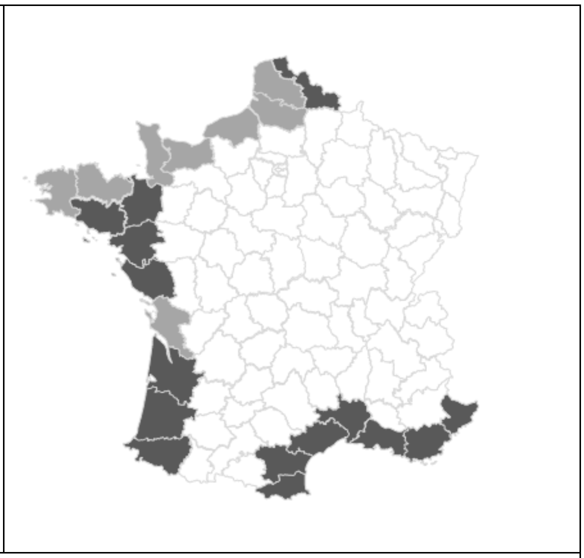
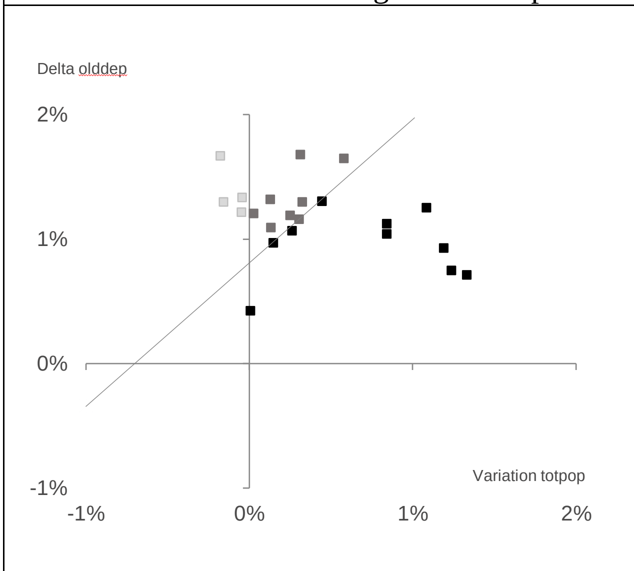


Figure and map 2E : Border departments



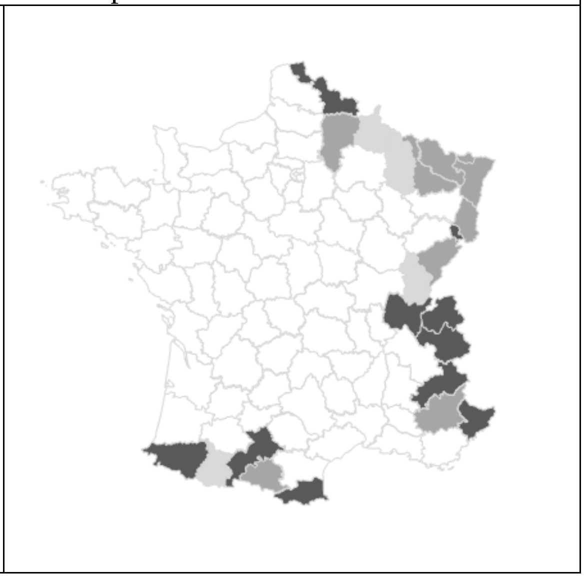


Figure 2. Geography of demographic–price relationship. The variations are calculated on an annual basis. The colors in maps represent Z_1 (dark), Z_2 (medium), and Z_3 (light). White is for out-of-sample units.

Figure 3: Comparison with others geographies

Figure 3A : Population size

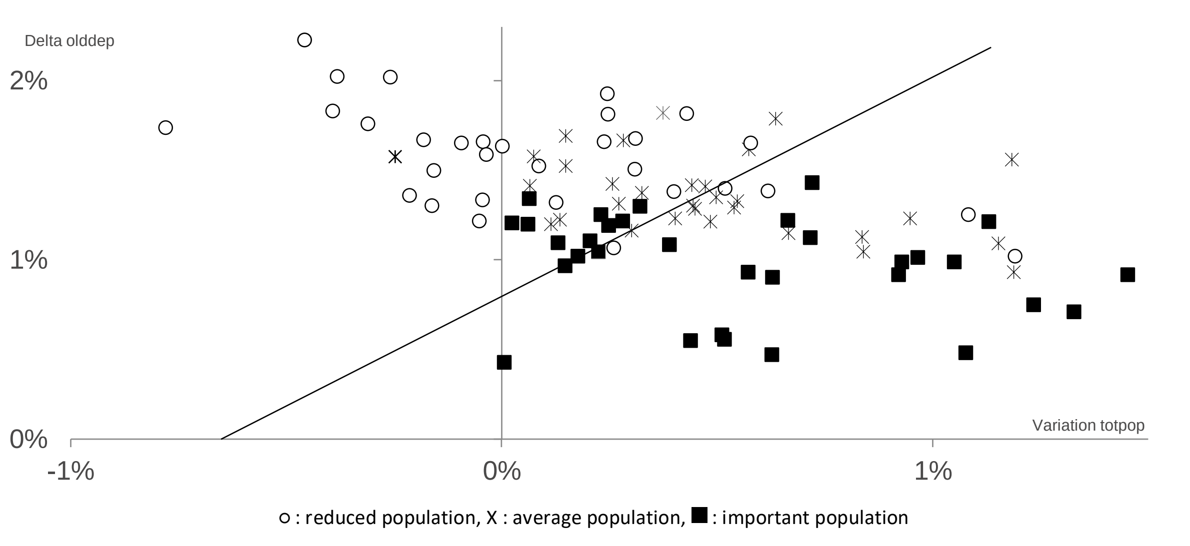


Figure 3B : Gentrification

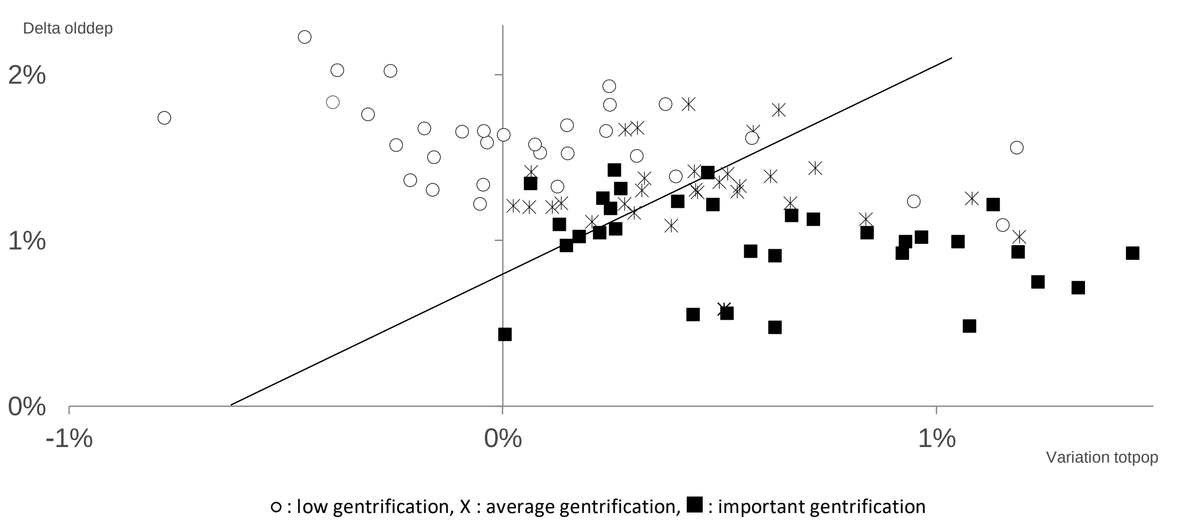
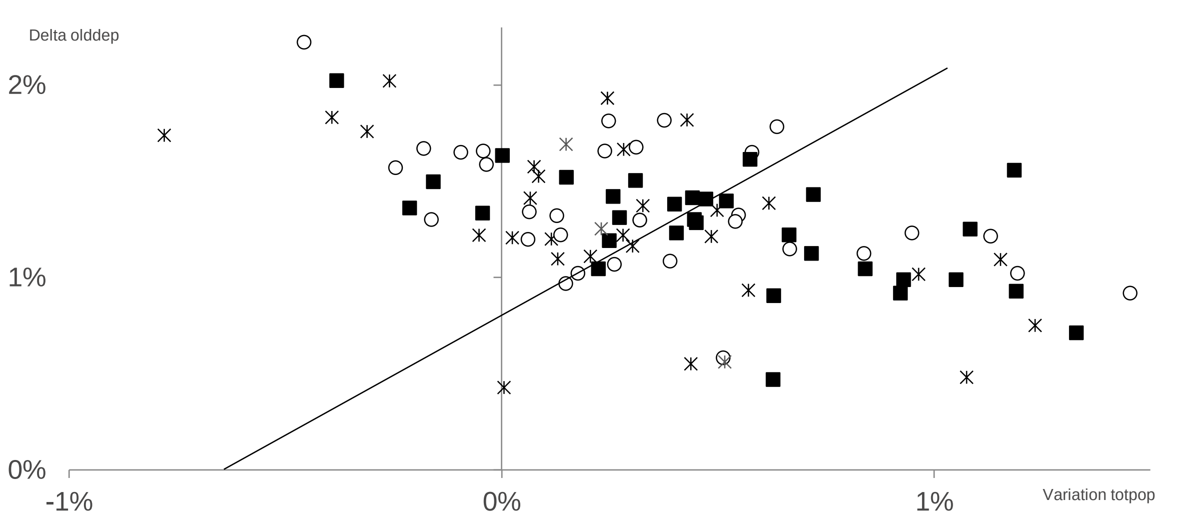


Figure 3C : Unemployment



○ : high unemployment, X : average unemployment, ■ : low unemployment

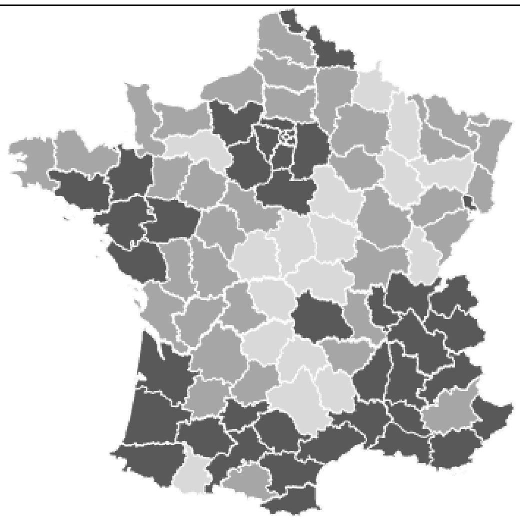
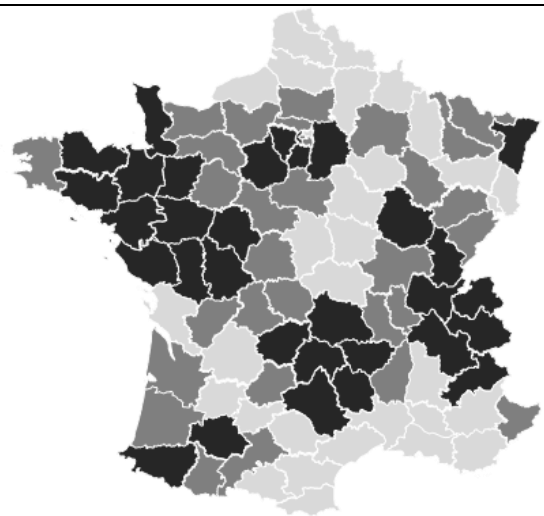
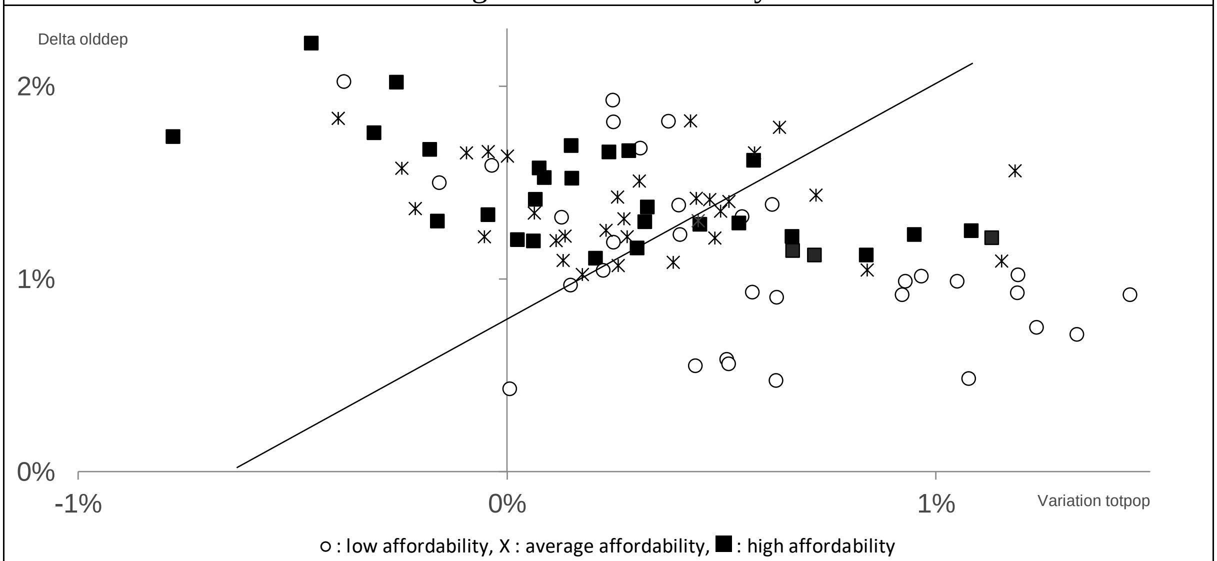
Price-demography segmentation	Unemployment segmentation
	

Figure 3D : Affordability



○ : low affordability, X : average affordability, ■ : high affordability

Figure 3. Comparison with other geographies. In each case, the 94 departments are split into three groups of the same size according to the mentioned factor; Population size, gentrification, unemployment, and housing affordability.

Econometric appendix

Table A1: Harris-Tzvalis (HT) and Im, Pesaran, Shin (IPS) stationarity tests

Variables	In level (ln)		1ère difference (Δln)	
	Common AR (HT)	Panel specific AR (IPS)	Common AR (HT)	Panel specific AR (IPS)
LnPAPP	0.77 (1.00)	3.75 (0.99)	0.38 (0.00) ***	-6.44 (0.00) ***
LnPMAI	0.63 (1.00)	6.39 (1.00)	0.15 (0.00) ***	-3.9 (0.00) ***
LnTPOP	0.87 (1.00)	9.9 (1.00)	0.44 (0.00) ***	-1.18 (0.1) *
LnOLDDEP	0.87 (1.00)	9.6 (1.00)	0.28 (0.00) ***	-1.47 (0.07) **
LnDIV	0.61 (0.99)	4.5 (1.00)	-0.03 (0.00)	-2.8 (0.00) ***
LnREV	0.84 (0.98)	12 (1.00)	0.15 (0.00) ***	-7.09 (0.00) ***
LnTEG	0.79 (0.36)	-2.25 (0.01)**	0.2 (0.00) ***	-12.5 (0.00) ***
LnOFFAPP	0.15 (0.00) ***	-1.04 (0.14)	-0.33 (0.00) ***	-4.68 (0.00) ***
LnOFFMAI	0.55 (0.00) ***	0.96 (0.83)	-0.25 (0.00) ***	-6.15 (0.00) ***

Table A2a: Fisher tests for the individual effects

Fisher test for apartments:

```
. xtreg dlnpappdefl dlntotpop dlnolddep dlnrevmen dlntotoffapp, fe

Fixed-effects (within) regression               Number of obs      =      1222
Group variable: dep                             Number of groups   =        94

R-sq:  within  = 0.4902                         Obs per group: min =        13
       between = 0.3229                                        avg =      13.0
       overall = 0.3640                                        max =        13

                                                F(4,1124)          =    270.19
corr(u_i, Xb)  = -0.5853                        Prob > F           =    0.0000

------------------------------------------------------------------------------
 dlnpappdefl |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   dlntotpop |   7.052164   .7753554     9.10   0.000     5.530857     8.57347
   dlnolddep |  -2.165372   .1256737   -17.23   0.000    -2.411954   -1.918791
   dlnrevmen |   .3454611   .1007657     3.43   0.001     .1477512    .5431711
dlntotoffapp |   .0275123   .0030547     9.01   0.000     .0215187    .0335059
       _cons |   .0292011   .0055187     5.29   0.000      .018373    .0400292
-------------+----------------------------------------------------------------
     sigma_u |   .0306818
     sigma_e |  .04854206
         rho |  .28546313   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(93, 1124) =     1.44           Prob > F = 0.0052
```

Fisher test for houses:

```
. xtreg dlnpmaidefl dlntotpop dlnolddep dlnrevmen dlntotoffmai, fe

Fixed-effects (within) regression               Number of obs      =      1209
Group variable: dep                             Number of groups   =        93

R-sq:  within  = 0.5689                         Obs per group: min =        13
       between = 0.3050                                        avg =      13.0
       overall = 0.4297                                        max =        13

                                                F(4,1112)          =    366.82
corr(u_i, Xb)  = -0.5478                        Prob > F           =    0.0000

------------------------------------------------------------------------------
 dlnpmaidefl |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   dlntotpop |   6.084088   .7088013     8.58   0.000     4.693349    7.474827
   dlnolddep |    -2.3512    .115166   -20.42   0.000    -2.577168   -2.125233
   dlnrevmen |   .5654337   .0922193     6.13   0.000     .3844902    .7463771
dlntotoffmai |   .0235517   .0027727     8.49   0.000     .0181114     .028992
       _cons |   .0277047   .0050684     5.47   0.000     .0177601    .0376493
-------------+----------------------------------------------------------------
     sigma_u |   .0294657
     sigma_e |  .04389735
         rho |  .31061318   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(92, 1112) =     1.51           Prob > F = 0.0020
```

Table A2b: Hausman tests for fixed or random effects

Hausman test for apartments:

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
    dlntotpop |    7.052164     1.510561        5.541603        .708287
    dlnolddep |   -2.165372     -2.29758        .1322076       .0508991
    dlnrevmen |    .3454611     .4459827       -.1005216       .0037958
  dlntotoffapp |    .0275123     .0272955        .0002169            .
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =      106.07
                Prob>chi2 =      0.0000
                (V_b-V_B is not positive definite)
```

Hausman test for houses:

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
    dlntotpop |    6.084088     .7088235        5.375265       .6482431
    dlnolddep |     -2.3512    -2.460626        .1094261       .0467995
    dlnrevmen |    .5654337     .6720302       -.1065965            .
  dlntotoffmai |    .0235517     .0233324        .0002193            .
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =      142.32
                Prob>chi2 =      0.0000
                (V_b-V_B is not positive definite)
```

Table A3: FMOLS estimations

For apartments:

Dependent Variable: LNPAPPDEFL				
Method: Panel Fully Modified Least Squares (FMOLS)				
Date: 02/04/16 Time: 23:18				
Sample (adjusted): 2001 2012				
Periods included: 12				
Cross-sections included: 94				
Total panel (balanced) observations: 1128				
Panel method: Pooled estimation				
Cointegrating equation deterministics: C @TREND				
Coefficient covariance computed using default method				
Long-run covariance estimates (Bartlett kernel, Newey-West fixed bandwith				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNOLDDEPRATIO	-1.328742	0.131470	-10.10683	0.0000
LNTOTPOP	6.695322	0.621537	10.77221	0.0000
LNREVMEN	1.232729	0.124616	9.892183	0.0000
LNTOTOFFAPP	0.046589	0.004442	10.48761	0.0000
LNTEGF	0.290480	0.028666	10.13343	0.0000
LNTXDIV	0.753947	0.046067	16.36621	0.0000
R-squared	0.957652	Mean dependent var		5.029902
Adjusted R-squared	0.948901	S.D. dependent var		0.222172
S.E. of regression	0.050222	Sum squared resid		2.355787
Durbin-Watson stat	1.257185	Long-run variance		0.001930

For houses:

Dependent Variable: LNPMAIDEFL				
Method: Panel Fully Modified Least Squares (FMOLS)				
Date: 02/04/16 Time: 23:21				
Sample (adjusted): 2001 2012				
Periods included: 12				
Cross-sections included: 93				
Total panel (balanced) observations: 1116				
Panel method: Pooled estimation				
Cointegrating equation deterministics: C @TREND				
Coefficient covariance computed using default method				
Long-run covariance estimates (Bartlett kernel, Newey-West fixed bandwidth				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNOLDDEPRATIO	-1.679068	0.124769	-13.45743	0.0000
LNTOTPOP	5.752526	0.579384	9.928689	0.0000
LNREVMEN	1.133148	0.113375	9.994694	0.0000
LNTOTOFFMAI	0.121085	0.012182	9.939605	0.0000
LNTEGF	0.260145	0.026774	9.716405	0.0000
LNTXDIV	0.605703	0.041938	14.44268	0.0000
R-squared	0.954654	Mean dependent var		4.999045
Adjusted R-squared	0.945280	S.D. dependent var		0.180809
S.E. of regression	0.042295	Sum squared resid		1.652932
Durbin-Watson stat	1.185110	Long-run variance		0.001575

Table A4: Moran test

MORAN.I	*Apartments*	*Houses*
Obseved	-0.0001706477	-0.000302987
Expected	-0.0007604563	-0.0007686395
Sd	0.0004510245	0.0004544014
P value	0.1909721	0.3054762