The price of climate: revealed preferences of French consumers

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Abstract

We use the hedonic price method to study consumer preferences for climate (temperature, very hot or cold days, and rainfall) in France, a temperate country with varied climates. Data are for (i) individual attributes and prices of houses and workers and (ii) climate attributes interpolated from weather stations. We show that the French households value warmer temperatures while very hot days are a nuisance. Such climatic amenities are attributes of consumers' utility function; nevertheless, global warming assessments by economists, such as the Stern Review Report (2006), ignore these climatic preferences. The social welfare assessment is changed when the direct consumption of climate is taken into account: from the estimated hedonic prices, we calculate that GDP rises by about 1% for a 1 °C rise in temperature.

JEL classification: D12

Introduction

We investigate the hedonic prices of climate in France.[1] Climate change impacts GDP through the capitalization of such prices in land rents and/or wages; it cannot be ignored, then, when assessing the macroeconomic effects of warming.

The Stern Review Report (Stern *et al*., 2006) is a major milestone in economic studies of global warming. It has been approved by many economists but criticized by many specialists in the field (see, among others, the literature reviews by Nordhaus, 2007 and Weitzman, 2007). The criticisms pertain to ethical issues (how to treat future generations?) and to economic theory, especially the discount rate and uncertainty. Consumers' climatic preferences are ignored in this debate. Yet there are grounds for believing that, in their private behavior, inhabitants of temperate countries put a positive value on warmer temperatures, while very hot or very cold days are a nuisance: empirical studies (conducted mostly in the U.S.) converge toward these two findings. All in all, the positive effects of warming prevail over the negative ones. Such climatic amenities (and nuisances) are attributes of consumers' utility functions. Two consequences follow from this.

First, at the macroeconomic level, allowing for the value of these attributes modifies economic welfare. In particular, the non-egalitarian effects of global warming might be greater than the effects sometimes estimated (see Stern *et al*., 2006): inhabitants of temperate countries (e.g. France, U.K.), where the mean temperature will rise, will see their welfare increase whereas inhabitants of hot countries (e.g. Mexico, Egypt), where heatwaves will be

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more marked, will see their welfare decline. These direct effects must be added to the indirect effects (sea-level rise, loss of biodiversity, disturbance of ecosystems, etc.) of global warming; otherwise, the international climate negotiations would be distorted.

Second, at the microeconomic level, the contradiction between private optimum and social optimum might be greater than in the standard case (congestion, pollution, etc.). In the standard case, economic agents allow for the private consequences of their behavior and ignore the social consequences, but the individual and social effects have the same signs. Insofar as global warming improves the private optimum of consumers in temperate countries while diminishing the global social optimum, the two effects have opposite signs. It will therefore be more difficult to get citizens in temperate countries, which are big producers of greenhouse gases, to accept public policies combating global warming. These private effects must be taken into account in public announcements and campaigns to heighten awareness of the hazards of warming. Otherwise, such talk would be given little credence by people who feel an improvement in their own private welfare.

Here we study consumer preferences for climate (mean annual temperatures, mean January and July temperatures, summer heatwaves, coldest winter days, annual and monthly rainfall) in France, a temperate country with varied climates. We use the hedonic price method (Rosen, 1974) to determine the marginal price of climatic attributes. These are capitalized in wages and/or land rents. This enables us to assess the rise in welfare brought about by an increase in temperatures, with no need to estimate a demand function for temperature (Freeman, 1979). Our contribution to the debate on global warming, although limited to just one country, shows that omitting the direct effect of warming on consumer utility leads to errors in calculating welfare.

We use individual data from housing surveys by French National Institute for Statistics and Economic Studies (*Institut national de la statistique et des études économiques*, INSEE). Econometric estimates are made on real-estate values (12,298 owner-occupiers and 12,062 tenants) and on 19 063 wage-earners. Climatic variables are required for the entire country to be matched with these data. They are obtained by interpolation by local regression and kriging of readings from weather stations.

Section 1 summarizes the economic literature on climate and presents the micro-economic analysis. The econometric models, economic and climatic data are covered in Section 2. The results are presented and discussed in Section 3. Section 4 concludes.

1. Climate in economics

Two strands of economic literature deal with climate. The first estimates the price of climate for consumers, generally by hedonic price models estimated on individual data. The second assesses the consequences of warming and the policies for reducing greenhouse-gas emissions on an aggregate or even global scale.

1.1. The hedonic price of climate

To the best of our knowledge, estimations of the hedonic price of climate date back to Hoch and Drake (1974). Prominent work was done in the domain by Cragg and Kahn (1997; 1999). In many other studies since Henderson (1982), climatic attributes are variables selected to measure among other things the quality of life or to control for spatial heterogeneity (e.g. Blomquist *et al.*, 1988). Recently, debate about climate change has led to examination of the effects of climate on welfare at a global scale (Maddison, 2003; Rehdanz and Maddison, 2005). The effect of climate on population migrations also has a long history (Graves, 1976; 1980; Graves and Linneman, 1979). Cheshire and Magrini (2006) have recently shown the impact of climate on the growth of urban populations in Europe.

That research shows that January and July temperatures command significant hedonic prices (capitalization in wages is negative for winter and positive for summer), as is generally the case with rainfall, wind speed, and hours of sunshine. In the U.S., a variation of one standard deviation in any one of these attributes accounts for 2% to 3% of wages. While capitalization of climatic attributes in wages has often been investigated, their capitalization in real-estate values has been rising recently.

Little work has been done in Europe. In a study of Italy, Maddison and Bigano (2003) conclude that July temperatures and January rainfall have a negative effect on welfare and that the number of days of clear skies has a significant effect in Milan. Maddison (2001) shows that mean annual temperatures and rainfall are significant in a housing-price function in the U.K. Rehdanz and Maddison (2008) show that German households prefer warmer winters with less rainfall.

1.2. Economic valuation of climatic warming

Nordhaus (1991; 1992) pioneered the economic valuation of warming by developing climatic-economic models, which were rapidly followed by others. In these approaches, the results of physical models are used to conduct cost-benefit analyses of the consequences of warming. The Stern Review Report (Stern *et al*., 2006) also relies on a climatic-economic model (Hope, 2006). Time is at the core of these studies, whether for very long-term climatic changes or for inter-temporal economic reasoning. The aim is to compare the damage and prevention costs so as to find an optimal policy pathway for reducing greenhouse-gas emissions.

The conclusions of these studies, which broadly converged until recently, can be summarized thus: emission-reducing policies are required and the optimal pace is to implement them slowly today and then intensify them progressively over time. The Stern Review (Stern *et al*., 2006) conclusions are the other way around: highly restrictive measures should be taken immediately, because any delay will increase the subsequent cost of reduction polices for future generations in unacceptable proportions. The crux of the divergence is the discount rate. We shall steer clear of this debate.

The divergence also relates to the economic agents' capacity to adapt. For example, Mendelsohn *et al*. (1994) analyze the effects on US farming of an increase of 5 °F in temperature and of 8% in rainfall. They use agronomic data and climatic data derived from the interpolation of readings from 5511 weather stations (their method is the closest to ours among economic studies). If producer adaptations are ignored, these changes lead to a loss of income; but if farmers can change their production systems, a slight gain occurs. This pioneering work was followed by a wave of comments and supplementary research.

1.3. Welfare

Climate, which is an attribute of the consumer utility function that is directly consumed, must be allowed for when calculating social welfare, regardless of the indirect market costs and benefits generally used in cost-benefit analysis of warming. In this way, the two strands of the literature just discussed can be unified.

Rosen (1979) and Roback (1982) provide foundations for the reasoning, which are summarized by Gyourko *et al*. (1999) in this way. Let the program of a consumer *j* at location *k* be: $\max U = U(Z_j, S_j, A_k, \alpha_j)$, under the constraint: $Z_j + R_k S_j = W_k$ where R is the land rent, S the area of a residential lot, A a climatic amenity, W income, and α_j are characteristics specific to consumer *j*. The indirect utility function V is $V_{jk} = V_j(W_k, R_k, A_k)$, and at the optimum: $V^* = V_{jk}$.

Let also a firm's profit be: $\pi_{jk} = pY_j(M_j, L_j, S_j, A_j, \beta_j) - p_M M_j - W_k L_j - R_k S_j$, where Y is output and p its price, M is capital input and p_M its price, L labor, S land, and β_j are characteristics of firm *j*. The indirect profit function is: $\Pi_{jk} = \Pi_j(W_k, R_k, p, p_M, A_k)$, and at the optimum $\Pi^* = \Pi_k$.

Wages and rents at equilibrium are determined from the utility and profit functions. From the first order conditions, it is easy to obtain the variations in wages and rents with amenities (indexes denote partial derivatives), which are:

$$\frac{\partial W}{\partial A} = \frac{\frac{1}{V_W}\left(-V_A + V_R \frac{\Pi_A}{\Pi_R}\right)}{1 - \frac{V_W}{V_R}\frac{\Pi_R}{\Pi_W}} \text{ (indeterminate sign) and } \qquad \frac{\partial R}{\partial A} = \frac{-\frac{V_A}{V_R} + \frac{V_W}{V_R}\frac{\Pi_A}{\Pi_W}}{1 - \frac{V_W}{V_R}\frac{\Pi_R}{\Pi_W}} > 0 \qquad (1)$$

Land values rise with amenities. The sign is indeterminate for wages: if the amenity does not affect firms' productivity (Π_A=0), the amenity is negatively capitalized in wages. If the amenity has positive productivity, the change in wages is indeterminate, and rents increase more than in the previous case.

If warming is an amenity in temperate countries, an increase in temperature *ceteris paribus* entails an increase in consumer's utility because consumers enjoy a greater quantity of this good. To maintain their utility at the same level (Hicksian approach) the government has to collect a tax, which swells the public purse. Otherwise (Slutsky approach), tenants pay more (cf. (1)); in this case, landowners receive more rent, which is imputed to the households item in the National Accounts. In both cases, the climatic amenity is reflected by a gain in GDP brought about by warming.

This effect depends on consumer preferences and firms' technology levels (substitutability or complementarity between goods or inputs) and on assumptions about international trade (mobility or immobility of goods, firms, and people). It also depends on the initial level of temperature: all things been equal, GDP will rise in a temperate country, which is sensitive to warming, and will decrease in a hot country, which is negatively affected. Quantification of these effects is beyond the bounds of this paper.

2. Methods and data

2.1. Econometric issues

In the absence of any theoretical guidance about the functional form relating housing prices or worker's wages to covariates, we use a logarithmic form (a Box Cox transformation made at a preliminary stage supports this hypothesis). Accordingly, we focus here on several issues that are usual with the hedonic method.

First, the identification problem is well-known: in general, the second step of Rosen's method (1974) is required to estimate the supply and demand functions (see especially Brown and Rosen, 1982). However, if supply is price-inelastic "households can be viewed as bidding for fixed quantities of models with desired bundles of characteristics. A regression of each household's marginal willingness to pay as measured by its implicit price against the quantity of the characteristics actually taken, incomes and other variables should identify an inverse demand function" (Freeman, 1979, p. 158). This is the case of climate attributes, which are price inelastic.

Second, some explanatory variables may be endogenous (Epple, 1987), particularly in a housing equation, when the purchaser simultaneously chooses the price (dependent variable) and the quantity of certain attributes (e.g. the living space). Thus, we use the instrumental method. As theory suggests, when consumers are heterogeneous in their tastes (Epple, 1987), we use personal characteristics of the households as instruments. Their exogeneity is tested by Sargan's method, and the endogeneity of the covariate(s) is tested by Hausman's method (increased regression). The main equation is then estimated by the 2SLS.

Thirdly, there are many and strong correlations among climatic variables (see Appendix 1). This may entail instability of the regression coefficients estimated by OLS/2SLS. Multicollinearity is detected by the *condition number* based on the principal components method (Greene, 2003, pp. 57–58). When multicollinearity occurs, we use a second estimation procedure, Partial Least Squares (PLS, Wold 1985), which may be thought of as an intermediate procedure between OLS and principal component regression (Stone and Brooks, 1990). It can markedly reduce the variance of estimators by projecting the explanatory variables over a small area that takes account of the dependent variable. PLS regression consists of looking for linear combinations of the initial variables, which are not correlated with each other, that will act as new synthetic variables in the regression model. The regression coefficients are estimated iteratively on the following principle: first we look for the linear combination of explanatory variables that is most closely correlated with the dependent variable so as to determine the first axis of PLS regression. From this, we obtain the estimated residuals and we then look for a second linear combination of explanatory variables that is not correlated with the first axis, with maximum correlation with the residuals from the first stage. The procedure is reiterated and the stop criterion is generally based on the number of PLS components in the model fixed beforehand.

We used a modified version of this algorithm presented in Bastien *et al*. (2005) in which PLS components were constructed solely using variables whose correlations with the dependent variable (the estimation residuals from the preceding stage) are significant at the 10% level. This approach allows us to select just the most influential variables when constructing the PLS axes and it provides an automatic stop criterion for the algorithm, which stops when there are no more variables significantly correlated with the dependent variable. The main shortcoming of the PLS regression is the absence of inferential statistical tools with which to test the significance of the parameters estimated. We therefore used an approach based on bootstrap (Horowitz, 2001) to determine the distribution of the PLS estimators of regression coefficients, by making 2000 iterations. The empirical quantiles mean confidence intervals can be calculated and coefficient significance tested.

Finally, the spatial autocorrelation between the residuals cannot be tested because the data are anonymous: their spatial distribution is unknown.

In sum, we estimate hedonic price equations both by the instrumental method to allow for endogeneity, and by PLS, to allow for multicollinearity (if a covariate is endogenous, it is projected on instruments and this projection is used in the PLS estimation).

2.2. The economic data

The economic data are mainly from housing surveys conducted by the INSEE in 1988, 1992, 1996, and 2002. The climatic variables and the spatial variables (see below) were matched with these surveys by the INSEE.[2]

The Mincer-type wage equation (Mincer, 1962) was obtained from individual income data of people in dwellings surveyed in 2002. After excluding state employees (whose wages are not location-dependent) and extreme wages (less than €1000 and more than €150,000 per year), the sample comprised 19,063 people. The endogenous variable is the logarithm of the annual wage earned in the 12 months preceding the survey. The explanatory variables characterizing the employee are (cf. the descriptive statistics in Appendix 2): age, sex, socio-occupational category, employment rate, employment contract type, highest diploma, nationality, and country of birth.

For housing, we selected households that had moved in recently (within the last four years). Four equations were estimated for buyers and tenants crossed with detached houses and apartments. By stacking the 1988, 1992, 1996, and 2002 surveys we had a total of 9,640 buyers of single-detached houses, 2,658 buyers of apartments, 3,447 tenants of single-detached houses and 8,615 tenants of apartments (after eliminating the extreme centiles and observations with incomplete data). The data were deflated into €2002, using the GDP price index as deflator.

The explanatory variables characterizing housing are (cf. descriptive statistics in Appendix 2): detached housing or housing in apartment blocks, survey year, floor space, garden area for detached houses (quadratic form), sanitation facilities (bathrooms and toilets), main room size (quadratic form), heating type, garage, parking space, cellar, veranda, fireplace(s), date of construction of the structure (quadratic form), and the date the household moved in.

Spatial variables were introduced into the equations (dummies or continuous variables): INSEE typology of urban areas,[3] population of the core commune of the area, and, for the commune where the housing is located (the commune is the lowest administrative tier in France): population density, mean taxable income of households, coastal commune, and unemployment rate. For the wage equation we also used a market-size variable defined as the product of the taxable income of the urban area by the number of households there (other spatial variables were tested but were not selected as their parameters were not significant).

Lastly, variables characterizing the climate were introduced into each of these equations.

2.3. Climatic data

Climatic variables come from Météo-France (monthly data for the period 1970–2000). They are (cf. descriptive statistics in Appendix 2): mean annual temperature, temperatures for January and July, number of days with temperatures of less than –5 °C in January and more than 30 °C in July, standard deviation of mean January and July temperatures, mean monthly rainfall, rainfall in January and July, number of days' precipitation in January and July, standard deviation of precipitation in January and July.

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[2] We thank Alain Jacquot and Anne Laferrère for authorizing this operation when they were heads of the Housing Division.

[3] Urban areas comprise an urban center (urban units with 5000 jobs or more) and a periurban belt (communes where 40% of active residents commute to work outside the commune but within the urban area). The delimitation method is similar to that for *Statistical Metropolitan Areas* in the US but the thresholds are lower.

These data are recorded by a network of scattered weather stations (rainfall is collected by 2031 stations and temperature by 651). Interpolation is used to reconstruct a spatial continuum based on this information (Joly et al., 2008). First we use regressions between temperature/rainfall and explanatory variables suggested by climatology[4], and then kriging of residuals from the regressions. As the models and parameters estimated are not identical over an area of the size of France, interpolation is done for small polygons including the 30 closest stations. The predicted values are computed for each French commune, and then merged with the housing survey data.

3. Results

We do not comment here on the results of the non-climatic characteristics as they are not the relevant variables in this paper (see complete results in Appendix 3).

Some climatic variables were not used in the regressions. The differences between the mean annual monthly rainfall and the rainfall in January and July were not kept because they are less significant than the number of days with rain (in the same months). This is probably because people are more sensitive to whether it rains or not than to the amount of rainfall. The inter-yearly standard deviations of precipitation and temperature in January and July, computed for the thirty-year period 1970–2000, were also omitted, because these variables are difficult to interpret in terms of human behavior, even if some of them may be statistically significant.

Table 1 shows the results of climatic variables.

[Insert here Table 1]

For the housing equations, we tested whether the living space was endogenous (this is often the case because of a simultaneous choice between the size of the housing and its price). We selected two instruments: the number of consumer units of the household and the gender of the head of the household. Depending on the equations, the partial R^2s were comprised between 0.09 and 0.25 and the Sargan statistics were higher than 0.3, showing that these instruments were exogenous. The living space was endogenous in three out of four housing equations (it was exogenous for owner-occupied, single-detached houses); in this case its projection was used in the main equations, estimated by 2SLS or by PLS.

The *condition number* diagnostic shows that multicollinearity occurs between climatic variables anyway; it is average-sized despite the high Pearson's correlation coefficients. Therefore, the PLS estimation was made in any case. In most of the equations, the results are similar to those of the OLS/2SLS, confirming that multicollinearity does not affect the estimates too much (probably because of the high number of observations).

From the equation and the estimation method, the R^2 varies between 0.54 and 0.61.

[4] A GIS was made up of climatic data, geographical coordinates of the weather stations and a set of explanatory variables used in regression, made up from two information sources: a land-use image from the Corine Land Cover (CLC) European database and a digital elevation model (DEM) produced by France's *Institut géographique national* (IGN). Eleven explanatory variables are produced: latitude and longitude, a vegetation index, the distance to the nearest forest, to the nearest sea or ocean, slope angle, slope orientation, topographic ruggedness, prominence index, and aggregate theoretical radiation for the summer solstice. Temperature and rainfall are explained by the best covariates.

3.1. Hedonic price of temperature and rainfall

The first finding shown by Table 1 is the lack of significance of the estimates in the wage equation (the number of January days with rainfall is an exception, with an unexpected negative sign). In France, climatic amenities are not capitalized in wages. This is probably because wages are often independent of location (and so insensitive to climatic amenities), due to labor-market regulations at the national level. Afterwards, we focus on the real-estate findings.

The mean annual temperature has a positive significant effect on the housing price for owner-occupiers: a rise of 1 °C entails an increase in housing prices of 5.9–6.2% (according to the equation and estimation method). Housing in the ninth decile of the dwelling distribution by mean annual temperature (11.8 °C) is worth almost one sixth more than housing in the median of the distribution. The sign is also positive for tenants, with values between 2.5 and 3.9% (according to the equation and estimation method), which are roughly half as much as for owner-occupiers.

The effect of warmer summers (mean July temperature minus mean annual temperature) is compounded with the preceding one for single-detached houses: an extra 1 °C entails a price increase of 3.7 to 8.4% (depending on the model). This effect is insignificant for apartments. Hot summer days (more than 30 °C) have a significant effect on real-estate values for owner-occupiers of single-detached houses and renters of apartments. At the median point, an extra day of heat lowers the value of housing by 4.3% (owner-occupiers) or by 1% (tenants). This effect offsets that of mean annual temperature (the correlation between the two variables is 0.63). It is quadratic, probably due to seaside sites where hot summers are appreciated. French households are insensitive to cold winters, either the January temperature minus the mean annual temperature or the number of coldest days (less than – 5 °C). These influences may be unimportant because it is easy to protect oneself both by heating and by winter clothes.

The number of days' rain in January and July has a significant effect on real-estate values. The January sign is the expected one and the parameter is significant at the 5% level (10% level for owner-occupiers of apartments): prices or rents fall by almost 1.2–2.3% for an extra day's rain; the drop is –3.2 to –5.2% for a standard deviation (2.3 days). The number of days of rainfall in July also exerts a positive effect on the price of apartments (but not on the price of single-detached houses), indicating that households pay more for their housing (1.4 to 4.4% depending on estimations) for an extra summer day's rain.

3.2. Does France benefit from warming?

It would be beyond the scope of this paper to propose a scenario of climate change and to assess its effects on French GDP. We propose something less ambitious here: to show that direct consumption of climate and its capitalisation in rents and/or wages have a significant macroeconomic effect.

Let us set out some simplifying assumptions: (i) in France, the capitalization of the price of climate into wages can be ignored; (ii) the land and structure combination in the housing production function is assumed to be constant, which is an acceptable hypothesis, since the housing stock in France is renewed slowly (mean construction date in our sample is 34 years); (iii) land consumption by firms is ignored; (iv) housing and workers are internationally immobile. It follows that warming does not impact on the production sectors, and that the price of warming is capitalized in the land rent. French consumers' utility increases, owing to the greater quantity of temperature, which is a valued good. The price of this good corresponds to a real increase in wealth. GDP therefore rises in real terms. We also assume there is neither redistribution nor indirect effects, and we ignore the regional effects within France (migrations, etc.).

By way of illustration, we study the effects of a rise of the mean temperature by 1 °C from 11.8 °C to 12.8 °C. We assume the rise in temperature is uniform nationwide. July temperatures, and July days of more than 30 °C (if significant) are changed when mean annual temperature rises, in accordance with the elasticity between these variables. We ignore the effects of warming on rainfall, and the effects on temperature for months other than July. The results are set out in Table 2.

[Insert Table 2 here]

The effects on housing prices are sizeable for single-detached houses (9% or so), weaker for owner-occupiers of apartments (6%) and negligible for tenants of apartments (-0.1%). In the latter case, the rise in rent due to the increase of the mean yearly temperature is offset by the effect of the number of very hot days in July (more difficult to endure in apartments than in single-detached houses).

Housing represents 16% of GDP in France. Under our assumptions, GDP is affected only by the variation in the price of housing that appears in the Household Account. The effect on GDP of 1 °C warming is therefore equal to one-sixth of housing prices or rents, weighted by the proportion of the two occupier-statuses (56% for owners and 44% for tenants). By the OLS/2SLS method, GDP increases by 1.0%, and by the PSL it increases by 0.8% when temperature rises by 1°C. This effect is substantial, contrary to the result obtained by Rehdanz and Maddison (2008), who concluded that, in Germany, the selected emissions scenario has a negligible effect because, as the authors concede, climatic variables are not measured with sufficient precision.

4. Conclusions

Climate is a directly-consumed, non-market good that is therefore a direct component of welfare. Analyses of the consequences of warming by cost-benefit methods do not allow for this direct effect, leading to inaccurate evaluations. In this paper, we estimate the hedonic price of climatic attributes (temperature, rainfall) from individual data on housing and wages in France. Climatic variables are obtained by local interpolation (by regression and kriging) from weather stations. Econometric estimates are obtained by two methods (OLS/2SLS and PLS) for 12,298 owner-occupied houses (9,640 single-detached houses and 2,658 apartments) and 12,062 rented dwellings (3,447 single-detached houses and 8,615 apartments) and on the wage-earners occupying the housing (19,063 people).

The results show that climate is not capitalized in wages (as in France wages are often independent of location because of national labor regulations) and that capitalization is quite high in the value of housing, especially for owner-occupiers. So, housing is worth almost 6% more when the mean annual temperature increases by 1 °C. At the median point, an extra day of excessive July heat lowers housing values by 4.3% (owners) or by 1% (tenants). The effects on housing prices and rents of mean January temperatures and of the number of days of extreme cold in winter are insignificant. Rainfall affects housing prices or rents less than temperature. The estimated average effects vary according to the type of housing (single-detached houses or apartments in collective buildings).

These results are used to calculate the variation in welfare due to warming, which is capitalized in housing values, leading to an increase in GDP. At the cost of simplifying assumptions, we obtain an increase in French GDP of 1.0% or so for a uniform 1 °C rise in mean annual temperature. Stern (2006)-type models therefore fail in estimating welfare because they ignore the direct consumption of climate. This error is not negligible.

Other studies need to be developed to analyze the economic effects of warming on other countries. In particular, these effects are probably different in temperate or cold countries and in hot ones, leading to non-egalitarian effects of global warming. Moreover, international trade is affected whenever there is an effect on production. Macroeconomic models are required to extend this analysis, but they lie outside the scope of this paper.

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Appendix 1.

Pearson correlation coefficients between climatic variables

(Example of owner-occupier single-detached houses)

	Mean annual tempera-ture (°C)	Difference (July-mean annual temperature) (°C)	Difference (January-mean annual temperature) (°C)	July warm days (> 30° C)	Janua-ry cold days (< - 5° C)	July days with rainfall
Mean annual temperature (°C)	1.000					
Difference (July-mean annual temperature) (°C)	0.115	1.000				
Difference (January-mean annual temperature) (°C)	0.026	-0.951	1.000			
July warm days (> 30° C)	0.746	0.632	-0.470	1.000		
January cold days (< - 5° C)	-0.650	0.512	-0.606	-0.128	1.000	
July days with rainfall	-0.847	-0.242	0.030	-0.794	0.464	1.000
January days with rainfall	-0.605	-0.652	0.499	-0.802	0.064	0.735

Appendix 2: descriptive statistics

Climatic variables

	mean	std	min	max
Mean annual temperature (°C)	11.6585	1.4248	7	15.8
Difference (July-mean annual temperature) (°C)	7.9623	0.8668	5	9.8
Difference (January-mean annual temperature) (°C)	-7.2442	0.8909	-10	-4.3
July warm days (> 30° C)	5.7722	4.0067	0	23.4
January cold days (< - 5° C)	2.9790	1.9270	0	14.3
mean monthly rainfall (mm)	66.3353	15.3687	33.9917	178.025
Difference (July-mean monthly rainfall) (mm)	-12.2074	15.7812	-116.925	24.7083
Difference (January-mean monthly rainfall) (mm)	3.1912	12.0487	-38.1917	55.0833
July days with rainfall	7.0474	2.0660	1	12.1
January days with rainfall	10.7308	2.2790	4.8	17.1

Appendix 2: descriptive statistics (following)

Wage equation

	mean	std
senior managerial	0.1357801	0.3425640
intermediate managerial	0.2136579	0.4098990
office worker	0.0538539	0.2257353
personal service providers	0.0791030	0.2699066
skilled industrial worker	0.0925265	0.2897755
skilled self-employed worker	0.0797422	0.2709009
skilled workers (other)	0.0614180	0.2401018
industrial unskilled worker	0.0820860	0.2745030
unskilled self-employed worker	0.0286582	0.1668483
farmworker	0.0143291	0.1188466
full time employment	94.4587972	15.6109294
apprentice	0.0158739	0.1249909
interim worker	0.0294572	0.1690887
limited-tenure employment	0.0798487	0.2710661
age: <19 years	0.0192297	0.1373352
age: 20–24	0.0910350	0.2876665
age: 25–29	0.1381239	0.3450392
age:30–34	0.1565546	0.3633900
age: 40–44	0.1401481	0.3471499
age: 45–49	0.1252863	0.3310521
age:50–54	0.1115432	0.3148120
age:55–81	0.0620039	0.2411691
male	0.5760933	0.4941890
4 years higher education	0.1507484	0.3578130
2 years higher education	0.1002504	0.3003415
capbepc	0.4090449	0.4916707
no educational qualification	0.1881958	0.3908789
French by naturalisation	0.0346775	0.1829664
European nationality	0.0279124	0.1647263
African nationality	0.0218399	0.1461644
other nationality	0.0044745	0.0667437
born in Europe	0.0112395	0.1054221
born in Africa	0.0132637	0.1144050
born in other region	0.9430032	0.2318426
rural commune	0.1522399	0.3592629
disadvantaged region	0.0770255	0.2666390
market size	31.3590847	54.4587101
poor commune 1000-1500K	0.0698343	0.2548744
poor commune Paris	0.0581154	0.2339677
poor commune 500-1000Kinhabitants	0.0238108	0.1524634
unemployment rate	0.1204421	0.0492953

Appendix 2: descriptive statistics (following)

Housing equation

	owners		renters	
	mean	std	mean	std
detached house	0.7838673	0.4116226	0.2857735	0.4518008
housing in an apartment block	0.2161327	0.4116226	0.7142265	0.4518008
1988 survey (detached house)	0.2316637	0.4219124	0.0569557	0.2317676
1992 survey (detached house)	0.1774272	0.3820454	0.0789256	0.2696337
1996 survey (detached house)	0.136445	0.3432744	0.062842	0.2426886
2002 survey (detached house)	0.2383314	0.4260802	0.0870502	0.2819204
1988 survey (housing in an apartment block)	0.060335	0.2381162	0.1217045	0.3269578
1992 survey (housing in an apartment block)	0.0500081	0.2179706	0.1967335	0.3975457
1996 survey (housing in an apartment block)	0.0410636	0.1984454	0.1886918	0.3912798
2002 survey (housing in an apartment block)	0.064726	0.2460517	0.2070967	0.4052422
living space (detached house)	112.3328838	36.2140997	90.7719756	29.9605117
living space (housing in an apartment block)	74.7599699	24.0453159	54.9673825	23.5503152
garden size (detached house)	958.4891079	1146.53	470.3263708	762.0989275
number of bathrooms (detached house)	2.5316909	0.8900301	2.2489121	0.7332841
number of bathrooms (housing in an apartment block)	2.1403311	0.5805972	1.8904817	0.4514918
poor heating	0.1026183	0.303472	0.1370419	0.3439059
room size (detached house)	23.2651831	6.1306681	22.2538758	5.7007738
size of the roons (housing in an apartment block)	22.5275005	4.8642808	23.8414523	6.3841104
garage (detached house)	0.8655602	0.341142	0.7229475	0.4476076
garage (housing in an apartment block)	0.5921746	0.4915229	0.3890888	0.4875718
cellar (detached house)	0.4221992	0.4939356	0.3785901	0.4851061
cellar (housing in an apartment block)	0.7633559	0.4251019	0.5216483	0.4995601
veranda	0.0352903	0.1845201	0.0155861	0.1238728
date of arrival in the housing	2.448203	3.8836823	1.0501575	1.0973906
before 1948 (detached house)	0.1927386	0.39447	0.4078909	0.491514
1949–1974 (detached house)	0.1207469	0.3258498	0.2164201	0.4118636
1975–1984 (detached house)	0.1060166	0.3078748	0.1430229	0.350147
after 1985 (detached house)	0.5804979	0.4935031	0.2326661	0.4225925
before 1948 (housing in an apartment block)	0.1997743	0.3999058	0.3461405	0.3461405
1949-1974 (housing in an apartment block)	0.3720843	0.4834517	0.3012188	0.3012188
1975-1984 (housing in an apartment block)	0.1617758	0.3683143	0.10296	0.10296
after 1985 (housing in an apartment block)	0.2663657	0.4421409	0.2496808	0.2496808
fireplace (detached house)	0.4068465	0.4912713	0.2251233	0.4177241
fireplace (housing in an apartment block)	0.027088	0.1623705	0.0123041	0.1102458
number of storeys of the building	1.0822085	2.8006593	2.9461118	3.3325853
ground floor	0.0307367	0.1726105	0.1316531	0.3381273
urban area, center < 30 000 inhabitants	0.0727761	0.2597791	0.0737854	0.2614322
urban area, center 30 000 – 50 000 inhabitants	0.0535859	0.2252079	0.0423645	0.2014276
urban area, center 50 000 – 100 000 inhabitants	0.0909904	0.2876072	0.0882109	0.2836131
urban area, center 100 000 – 200 000 inhabitants	0.0952187	0.2935288	0.0997347	0.2996584
urban area, center 200 000 – 500 000 inhabitants	0.126606	0.3325445	0.1713646	0.3768429
urban area, center 500 000 – 1 million inhabitants	0.0799317	0.2711985	0.1060355	0.3078958
urban area, center 1 – 3 million inhabitants	0.0822085	0.2746933	0.092522	0.2897734
urban area, center Paris	0.2027972	0.402099	0.1994694	0.3996181
rural commune	0.1386404	0.345585	0.0984911	0.2979899
peri-urban commune	0.2803708	0.4491986	0.120461	0.3255133
urban commune	0.5809888	0.4934173	0.7810479	0.4135532
population of the commune < 500 inhabitants	0.0803383	0.2718272	0.0280219	0.1650422
population of the commune 500 – 2 500 inhabitants	0.2503659	0.4332414	0.1190516	0.3238626
population of the commune 2 500 – 10 000 inhabitants	0.2454871	0.4303931	0.16581	0.3719254
population of the commune 20 000 – 50 000 inhabitants	0.1429501	0.3500362	0.1769193	0.3816162
population of the commune 50 000 – 200 000 inhabitants	0.106928	0.3090342	0.2273255	0.4191219
population of the commune 200 000 – 500 000 inhabitants	0.0387868	0.1930943	0.1169789	0.3214085
Paris	0.0202472	0.1408505	0.0669043	0.2498666
richness of the commune (log) (detached house)	3.1395885	0.2465024	3.1136964	0.2197903
block)	3.2023353	0.2443167	3.1802341	0.2627972
density	1718.28	2324.55	3058.21	2677.59
unemployment rate	0.1172443	0.0481474	0.1357735	0.0477133
evolution of the population (1990-1999)	6.0803383	10.7442968	3.8191013	8.2522482
coastal commune	0.0950561	0.2933043	0.1096833	0.3125076
commune less than 15 min from the coast	0.033664	0.1803701	0.0232963	0.1508492
harbor	0.0826964	0.2754339	0.0808324	0.2725888

Appendix 3. Results

	owner-occupiers							
	single detached houses				apartments			
	OLS		**PLS**		**2SLS**		**PLS**	
	estimate	**Pr > |t|**	**estimate**	**p value**	**estimate**	**Pr > |t|**	**estimate**	**p value**
Intercept	9,87409	<,0001	/	/	8,892751	<,0001	/	/
1988 survey	-0,15075	<,0001	-0,04824	0,005	-0,3255	<,0001	-0,2287	<,0001
1992 survey	-0,13403	<,0001	-0,02829	0,031	-0,06711	0,0008	0,0282	0,06
1996 survey	-0,13182	<,0001	-0,02306	0,02	-0,05121	0,0156	0,04881	0,012
2002 survey	/	/	0,1059	0,001			0,09578	0,004
living space	0,00413	<,0001	0,004121	<,0001	0,007962	<,0001	0,008599	<,0001
garden size (detached house)	8,105E-05	<,0001	8,006E-05	<,0001	/	/	/	/
garden size (detached house) (square term)	-7,7E-06	<,0001	-7,58E-06	<,0001	/	/	/	/
number of bathrooms	0,08094	<,0001	0,08175	<,0001	0,085326	<,0001	0,07643	0,01
poor heating	-0,14581	<,0001	-0,1461	<,0001	-0,03264	0,2677	-0,01739	0,238
room size	-0,00339	0,1125	-0,001467	0,499	0,015499	0,0151	0,01751	0,052
(room size)²	-4,13E-05	0,2298	-7,57E-05	0,195	-0,00025	0,0242	-0,000302	0,125
garage	0,10454	<,0001	0,1072	<,0001	0,069522	0,0002	0,05512	0,006
cellar	0,06036	<,0001	0,06233	<,0001	0,073781	<,0001	0,06694	0,001
date of arrival in the housing	-0,03579	<,0001	-0,03622	<,0001	-0,02649	<,0001	-0,0269	<,0001
age of the structure	-0,00771	<,0001	-0,007371	<,0001	-0,01575	<,0001	-0,01583	<,0001
(age of the structure)²	3,896E-05	<,0001	3,626E-05	<,0001	0,00011	<,0001	0,0001106	<,0001
fireplace	0,05736	<,0001	0,05688	<,0001	0,179896	<,0001	0,1222	0,034
urban area, center < 30,000 inhabitants	-0,07608	<,0001	-0,09164	<,0001	-0,05553	0,6089	-0,02833	0,075
urban area, center 30,000 à 50,000 inhabitants	-0,05497	0,0075	-0,06209	<,0001	-0,08103	0,4575	-0,02036	0,188
urban area, center 50,000 à 100,000 inhabitants	-0,03133	0,0853	-0,04651	0,003	-0,03667	0,7292	-0,02596	0,045
urban area, center 100,000 à 200,000 inhabitants	0,02523	0,1655	0,002651	0,382	-0,06716	0,5151	-0,05251	0,01
urban area, center 200,000 à 500,000 inhabitants	0,02068	0,2464	0,006955	0,217	-0,07155	0,4852	-0,04912	0,037
urban area, center 500,000 à 1 million inhabitants	0,00512	0,8114	-0,0132	0,167	-0,04401	0,6789	-0,001648	0,465
urban area, center 1 à 3 millions inhabitants	0,0727	0,0004	0,05852	<,0001	-0,00629	0,9516	0,00802	0,382
urban area, center Paris	0,30677	<,0001	0,2921	<,0001	0,199977	0,0523	0,2212	<,0001
rural commune	-0,05166	0,0014	-0,06905	<,0001	0,007775	0,9473	-0,0147	0,295
city and suburbs commune	0,09756	<,0001	0,101	<,0001	0,113623	0,0143	0,1049	0,015
population of the commune < 500 inhabitants	-0,14947	<,0001	-0,1313	<,0001	0,144308	0,6913	/	/
population of the commune 500 à 2,500 inhabitants	-0,10587	<,0001	-0,08941	<,0001	-0,1079	0,0895	-0,04958	0,339
population of the commune 2,500 à 10,000 inhabitants	-0,04746	0,0006	-0,03367	0,065	-0,02443	0,4655	-0,01924	0,494
population of the commune 20,000 à 50,000 inhabitants	0,02858	0,0787	0,03163	0,065	0,052164	0,0401	0,03206	0,158
population of the commune 50,000 à 200,000 inhabitants	0,07578	0,0001	0,07727	0,016	0,127807	<,0001	0,104	0,026
population of the commune 200,000 à 500,000 inhabitants	0,24651	<,0001	0,2484	<,0001	0,134574	0,0005	0,09113	0,091
Paris	0,21586	0,2788	/	/	0,523102	<,0001	0,4753	<,0001
richness of the commune (log)	0,13775	<,0001	0,1513	<,0001	0,266095	<,0001	0,305	<,0001
density	1,647E-05	<,0001	0,0000175	<,0001	0,000029	<,0001	3,084E-05	<,0001
unemployment rate	-1,51771	<,0001	-1,404	<,0001	-2,47922	<,0001	-2,253	<,0001
evolution of the population (1990-1999)	0,00116	0,0012	0,001096	0,002	0,00022	0,8596	-6,47E-05	0,46
coastal commune	0,09357	<,0001	0,0897	<,0001	0,114716	0,0028	0,09776	0,031
commune less than 15 mn from the coast	0,07437	0,0002	0,0687	0,03	0,04371	0,5505	-0,009506	0,361
harbor	0,05125	0,0001	0,04428	0,001	0,057143	0,0898	0,02094	0,428
Mean annual temperature (°C)	0,0599	<,0001	0,05726	<,0001	0,057262	0,0074	0,05812	0,009
Difference (July-mean annual temperature) (°C)	0,08037	0,0004	0,06848	0,001	0,063547	0,2275	0,04482	0,135
Difference (January-mean annual temperature) (°C)	0,02591	0,1814	0,01459	0,37	0,046843	0,2858	0,01777	0,359
July warm days (> 30° C)	-0,04199	<,0001	-0,0405	<,0001	-0,01963	0,2092	-0,02498	0,109
(July warm days)² (> 30° C)	0,00149	<,0001	0,001424	<,0001	0,001413	0,0481	0,001596	0,031
January cold days (< - 5° C)	0,00669	0,4935	0,0009078	0,476	-0,01368	0,5215	-0,01974	0,229
(January cold days)² (< - 5° C)	0,0014	0,0504	0,001858	0,011	0,00268	0,1034	0,002955	0,054
July days with rainfall	0,00948	0,0723	0,007804	0,088	0,042811	0,0001	0,03886	<,0001
January days with rainfall	-0,02237	<,0001	-0,02203	<,0001	-0,01444	0,076	-0,01427	0,057

Appendix 3. Results (following)

	Tenants							
	single detached houses				apartments			
	2SLS		PLS		2SLS		PLS	
	estimate	Pr > |t|	estimate	p value	estimate	Pr > |t|	estimate	p value
Intercept	5,366151	<,0001	/	/	5,025905	<,0001	/	/
1988 survey	-0,29258	<,0001	-0,1681	<,0001	-0,23613	<,0001	-0,1402	0,009
1992 survey	-0,16786	<,0001	-0,05179	0,001	-0,09425	<,0001	-7,4E-05	0,421
1996 survey	-0,06137	0,0001	0,06076	<,0001	-0,04786	<,0001	0,04649	0,033
2002 survey	/	/	0,1143	<,0001	/	/	0,09258	0,009
living space	0,010031	<,0001	0,009231	<,0001	0,009911	<,0001	0,009648	<,0001
garden size (detached house)	0,000028	0,1141	3,36E-05	0,026	/	/	/	/
garden size (detached house) (square term)	-5,11E-06	0,123	-6,2E-06	0,007	/	/	/	/
number of bathrooms	-0,00744	0,5762	0,008011	0,318	0,010825	0,1886	0,0174	0,267
poor heating	-0,15368	<,0001	-0,1681	<,0001	-0,04298	<,0001	-0,04495	<,0001
room size	-0,0382	<,0001	-0,03459	<,0001	-0,00207	0,141	0,000691	0,441
(room size)²	0,000397	<,0001	0,000356	<,0001	-0,00004	0,0543	-9,3E-05	0,037
garage	0,024669	0,0869	0,03182	0,019	0,018138	0,0077	0,02286	<,0001
cellar	-0,01766	0,1876	-0,0085	0,242	0,001938	0,7562	0,007144	0,303
date of arrival in the housing	-0,04987	<,0001	-0,04963	<,0001	-0,03738	<,0001	-0,03736	<,0001
age of the structure	-0,00539	<,0001	-0,00525	<,0001	-0,0057	<,0001	-0,00564	<,0001
(age of the structure)²	0,000028	<,0001	2,66E-05	<,0001	0,000038	<,0001	3,79E-05	<,0001
fireplace	0,008148	0,5774	0,01821	0,168	0,026604	0,2931	0,01049	0,082
urban area, center < 30,000 inhabitants	-0,02982	0,3325	-0,08122	0,001	-0,04999	0,0999	-0,06958	0,001
urban area, center 30,000 à 50,000 inhabitants	0,004471	0,893	-0,03718	0,155	-0,00873	0,7845	-0,01339	0,022
urban area, center 50,000 à 100,000 inhabitants	0,049531	0,0949	-0,0059	0,563	-0,01514	0,6069	-0,03375	0,012
urban area, center 100,000 à 200,000 inhabitants	0,09808	0,001	0,02375	0,003	0,024884	0,3886	0,004085	0,393
urban area, center 200,000 à 500,000 inhabitants	0,085517	0,0033	0,006764	0,198	-0,01764	0,5334	-0,02987	0,02
urban area, center 500,000 à 1 million inhabitants	0,09625	0,0048	0,008058	0,186	0,041756	0,1656	0,03093	0,014
urban area, center 1 à 3 millions inhabitants	0,111507	0,0022	0,02096	0,104	0,026326	0,3676	0,008716	0,316
urban area, center Paris	0,410022	<,0001	0,3225	<,0001	0,31061	<,0001	0,293	<,0001
rural commune	-0,01755	0,4869	-0,08567	0,001	-0,09504	0,0006	-0,1041	<,0001
city and suburbs commune	0,067806	0,0006	0,08158	<,0001	-0,00359	0,8362	0,00696	0,383
population of the commune < 500 inhabitants	-0,1121	0,0006	-0,06681	<,0001	-0,27561	<,0001	-0,2754	0,001
population of the commune 500 à 2,500 inhabitants	-0,06823	0,0091	-0,0353	0,016	-0,13712	<,0001	-0,1315	<,0001
population of the commune 2,500 à 10,000 inhabitants	-0,00071	0,9749	0,03168	0,016	-0,04449	0,0007	-0,05039	0,009
population of the commune 20,000 à 50,000 inhabitants	0,015431	0,5593	0,02043	0,041	0,027943	0,0146	0,006517	0,481
population of the commune 50,000 à 200,000 inhabitants	0,034723	0,2597	0,01205	0,03	0,04156	0,0006	0,01647	0,382
population of the commune 200,000 à 500,000 inhabitants	0,046914	0,3967	0,001433	0,184	0,037881	0,0171	0,003411	0,475
Paris	/	/	/	/	0,245218	<,0001	0,2126	<,0001
richness of the commune (log)	0,045296	0,0979	0,07457	0,015	0,143893	<,0001	0,1523	<,0001
density	0,000021	0,0003	2,74E-05	<,0001	0,000018	<,0001	1,91E-05	<,0001
unemployment rate	-0,37285	0,018	-0,1117	<,0001	-0,8475	<,0001	-0,7219	<,0001
evolution of the population (1990-1999)	0,003154	<,0001	0,003377	<,0001	0,004107	<,0001	0,004039	<,0001
coastal commune	0,074546	0,0025	0,03784	0,01	0,051313	<,0001	0,05941	<,0001
commune less than 15 mn from the coast	0,074344	0,0116	0,01804	0,412	-0,0052	0,835	-0,01389	0,044
harbor	0,056488	0,0041	0,03074	0,076	0,019369	0,0891	0,003792	0,374
Mean annual temperature (°C)	0,037957	0,0162	0,03737	0,005	0,027625	0,0005	0,02504	0,004
Difference (July-mean annual temperature) (°C)	0,062578	0,0678	0,03617	0,022	-0,00171	0,9285	-0,00223	0,453
Difference (January-mean annual temperature) (°C)	0,033658	0,2703	0,005734	0,411	-0,0109	0,5144	-0,015	0,081
July warm days (> 30° C)	-0,00714	0,4654	-0,01138	0,115	-0,02554	<,0001	-0,02361	0,001
(July warm days)² (> 30° C)	0,000237	0,4755	0,000293	0,184	0,001056	<,0001	0,000964	0,001
January cold days (< - 5° C)	-0,02078	0,1754	-0,02962	0,045	-0,00454	0,6019	-0,00886	0,218
(January cold days)² (< - 5° C)	0,003287	0,006	0,004102	0,001	0,000299	0,6781	0,000511	0,308
July days with rainfall	0,008452	0,3083	-0,0011	0,443	0,013582	0,0011	0,01394	0,002
January days with rainfall	-0,01335	0,0205	-0,01225	0,022	-0,02014	<,0001	-0,01987	<,0001

Appendix 3. Results (following)

	wages			
	OLS		PLS	
	estimate	Pr > |t|	estimate	p value
intercept	8,48484	<,0001	/	/
senior managerial	0,56473	<,0001	0,5804	<,0001
intermediate managerial	0,17879	<,0001	0,1908	<,0001
office worker	-0,13727	<,0001	-0,1255	<,0001
personal service providers	-0,31372	<,0001	-0,3122	<,0001
skilled industrial worker	0,05538	0,0001	0,0661	<,0001
skilled self-employed worker	-0,05691	0,0002	-0,03917	0,003
skilled workers (other)	-0,01387	0,4061	0,00008014	0,421
industrial unskilled worker	-0,07718	<,0001	-0,06173	0,001
unskilled self-employed worker	-0,1582	<,0001	-0,1618	<,0001
farmworker	-0,28111	<,0001	-0,2453	<,0001
full time employment	0,01155	<,0001	0,01154	<,0001
apprentice	-0,5666	<,0001	-0,5403	<,0001
interim worker	-0,34414	<,0001	-0,3455	<,0001
limited-tenure employment	-0,34379	<,0001	-0,3403	<,0001
age: <19	-0,57992	<,0001	-0,5797	<,0001
age: 20–24	-0,34235	<,0001	-0,3255	<,0001
age: 25–29	-0,17752	<,0001	-0,1621	<,0001
age:30–34	-0,06613	<,0001	-0,05018	0,001
age: 40–44	0,03424	0,0039	0,04886	<,0001
age: 45–49	0,0494	<,0001	0,0657	<,0001
age:50–54	0,1007	<,0001	0,1204	<,0001
age:55–81	0,09387	<,0001	0,1116	<,0001
male	0,18547	<,0001	0,1774	<,0001
4 years higher education	0,09197	<,0001	0,08953	<,0001
2 years higher education	0,03469	0,0092	0,03026	0,028
capbepc	-0,05641	<,0001	-0,05637	<,0001
no educational qualification	-0,17576	<,0001	-0,1787	<,0001
French by naturalisation	-0,07915	<,0001	-0,064	0,006
European nationality	-0,039	0,2221	0,02423	0,12
African nationality	-0,09393	<,0001	-0,08251	<,0001
other nationality	-0,15937	0,001	-0,1198	0,001
born in Europe	-0,00507	0,8872	0,01504	0,019
born in Africa	-0,1259	0,0017	-0,05516	<,0001
born in other region	-0,05125	0,0765	0,003248	0,433
rural commune	-0,05078	0,0012	-0,05159	0,002
disadvantaged region	-0,02996	0,0389	-0,03389	0,021
market size	-0,03693	0,0155	-0,03331	0,026
poor commune 1000-1500K inhabitants	-0,03359	0,0096	-0,02752	0,062
poor commune Paris	0,0009621	<,0001	0,0009854	<,0001
poor commune 500-1000Kinhabitants	-0,02547	0,0574	-0,03691	0,015
unemployment rate	-0,06509	<,0001	-0,08159	<,0001
poor commune 500-1000Kinhabitants	-0,04269	0,0509	-0,03148	0,053
unemployment rate	-0,4206	<,0001	-0,3544	<,0001
Mean annual temperature (°C)	0,00245	0,7347	0,001933	0,395
Difference (July-mean annual temperature) (°C)	-0,01279	0,5443	-0,002569	0,461
Difference (January-mean annual temperature) (°C)	-0,02325	0,2086	-0,01892	0,136
July warm days (> 30° C)	-0,00185	0,4407	-0,002552	0,176
January cold days (< - 5° C)	-0,000531	0,8947	-0,00178	0,349
July days with rainfall	0,00531	0,2469	0,005169	0,127
January days with rainfall	-0,00819	0,0112	-0,007652	0,011

	owner-occupiers							
	single detached houses				apartments			
	OLS		PLS		2SLS		PLS	
	estimate	Pr > |t|	estimate	p value	estimate	Pr > |t|	estimate	p value
Mean annual temperature (°C)	0.0599	<.0001	0.05726	<.0001	0.057262	0.0074	0.05812	0.009
Difference (July-mean annual temperature) (°C)	0.08037	0.0004	0.06848	0.001	0.063547	0.2275	0.04482	0.135
Difference (January-mean annual temperature) (°C)	0.02591	0.1814	0.01459	0.37	0.046843	0.2858	0.01777	0.359
July warm days (> 30° C)	-0.04199	<.0001	-0.0405	<.0001	-0.01963	0.2092	-0.02498	0.109
(July warm days)^2 (> 30° C)	0.00149	<.0001	0.001424	<.0001	0.001413	0.0481	0.001596	0.031
January cold days (< - 5° C)	0.00669	0.4935	0.0009078	0.476	-0.01368	0.5215	-0.01974	0.229
(January cold days)^2 (< - 5° C)	0.0014	0.0504	0.001858	0.011	0.00268	0.1034	0.002955	0.054
July days with rainfall	0.00948	0.0723	0.007804	0.088	0.042811	0.0001	0.03886	<.0001
January days with rainfall	-0.02237	<.0001	-0.02203	<.0001	-0.01444	0.076	-0.01427	0.057

	Tenants							
	single detached houses				apartments			
	2SLS		PLS		2SLS		PLS	
	estimate	Pr > |t|	estimate	p value	estimate	Pr > |t|	estimate	p value
Mean annual temperature (°C)	0.037957	0.0162	0.03737	0.005	0.027625	0.0005	0.02504	0.004
Difference (July-mean annual temperature) (°C)	0.062578	0.0678	0.03617	0.022	-0.00171	0.9285	-0.002226	0.453
Difference (January-mean annual temperature) (°C)	0.033658	0.2703	0.005734	0.411	-0.0109	0.5144	-0.015	0.081
July warm days (> 30° C)	-0.00714	0.4654	-0.01138	0.115	-0.02554	<.0001	-0.02361	0.001
(July warm days)^2 (> 30° C)	0.000237	0.4755	0.0002927	0.184	0.001056	<.0001	0.0009637	0.001
January cold days (< - 5° C)	-0.02078	0.1754	-0.02962	0.045	-0.00454	0.6019	-0.008856	0.218
(January cold days)^2 (< - 5° C)	0.003287	0.006	0.004102	0.001	0.000299	0.6781	0.0005114	0.308
July days with rainfall	0.008452	0.3083	-0.001103	0.443	0.013582	0.0011	0.01394	0.002
January days with rainfall	-0.01335	0.0205	-0.01225	0.022	-0.02014	<.0001	-0.01987	<.0001

	wages			
	OLS		PLS	
	estimate	Pr > |t|	estimate	p value
Mean annual temperature (°C)	0.00245	0.7347	0.001933	0.395
Difference (July-mean annual temperature) (°C)	-0.01279	0.5443	-0.002569	0.461
Difference (January-mean annual temperature) (°C)	-0.02325	0.2086	-0.01892	0.136
July warm days (> 30° C)	-0.00185	0.4407	-0.002552	0.176
(July warm days)^2 (> 30° C)				
January cold days (< - 5° C)	-0.00053069	0.8947	-0.00178	0.349
(January cold days)^2 (< - 5° C)				
July days with rainfall	0.00531	0.2469	0.005169	0.127
January days with rainfall	-0.00819	0.0112	-0.007652	0.011

Table 1. Results (climatic variables)

	owner-occupiers				tenants			
	single detached houses		apartments		single detached houses		apartments	
	OLS	**PLS**	**2SLS**	**PLS**	**2SLS**	**PLS**	**2SLS**	**PLS**
Mean annual temperature (°C) (€)	1008.8	963.0	920.3	934.5	2.67	2.63	1.79	1.62
Difference (July-mean annual temperature) (°C) (€)	1367.6	1158.3	NS	NS	4.47	2.55	NS	NS
July warm days (> 30° C) (€)	-763.0	-738.9	NS	NS	NS	NS	-1.85	-1.71
TOTAL (€)	1613.3	1382.4	920.3	934.5	7.14	5.18	-0.07	-0.09
TOTAL (%)	9.9%	8.5%	5.9%	6.0%	10.3%	7.5%	-0.1	-0.14

NS: unsignificant

global effect on GDP	**1,0%**	**0,8%**

Table 2. Effect of a 1 °C mean annual temperature rise on housing prices and GDP