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Valuing Energy Performance Certificates in the Portuguese Residential Sector

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Abstract

Informational instruments such as energy performance certificates have been widely adopted by many governments during the last decade to promote energy efficiency in the residential sector. The objective of these instruments is to reduce the informational and behavioural failures that avoid consumers from taking efficient decisions regarding dwelling energy efficiency. The European Commission approved in 2012 the Energy Performance of Buildings Directive, which states that a certificate must be made available to buyers or tenants in the moment the dwelling is sold or rented out. Despite the rapid diffusion and interest this type of instruments have raised, little is known about its effectiveness. We provide the first analysis on consumers' willingness to pay for energy performance certificates in a Southern European Country: Portugal. Portugal is an interesting case study because this Directive is fully and properly implemented, and the level of consumer's awareness is high. We construct a database that contains a large number of dwelling attributes, including energy efficiency characteristics, such as heating or air conditioning systems, gas or solar energy sources. These characteristics allow us to isolate the effect of the certificate on the price. We use the two-step Heckman procedure to estimate a hedonic price function for dwellings. Our results show that Portuguese consumers have a high valuation for high rated dwellings.

Keywords: Energy Efficiency; Incomplete Information; Energy Performance Certificate; Residential Sector; Hedonic Price Model; Portugal.

JEL Classification: Q41; Q58; R21; C25

1. Introduction

Climate change and energy dependence have raised increasing attention towards the need to decrease energy consumption and its associated CO_2 emissions. The building sector represents a great opportunity to reduce energy demand since an important part of the current energy consumption comes from buildings; in industrialized countries, residential and commercial sectors account for approximately 40% of the final energy consumption (European Commission 2011). More importantly, technical studies have identified a large potential for cost-efficient energy savings in buildings through the adoption of energy efficiency (EE) measures (IPCC 2007).

Despite the fact that EE could provide many benefits to the society, the rate at which agents adopt EE is slower than the expected by economic models. This situation is well known as the *Energy Efficiency Paradox* (Jaffe and Stavins 1994) and it is generally explained as the result of the multitude of market barriers that exist in this market. During several decades governments have made a great effort to change this situation by approving numerous policies to promote EE. However, the results were not as expected and the potential for energy savings in the residential sector remains unexploited (European Parliament 2014).

Researchers have pointed out that the assumptions of perfect information and consumer rationality that conventional policies assume could partially explain this situation. In the last years, the theories proposed by behavioral economists (e.g., Kahneman and Tversky 1979) about consumers' systematic deviations from the rationality have gained much attention in the field of EE. The fact that energy consumption is an intangible attribute of energy services and products is the origin of several informational problems, such as incomplete and asymmetric information, that lead agents to not include EE among their preferences. In addition, agents are subjected to cognitive limitations and other behavioral failures that might induce them to take inefficient decisions regarding EE. For instance, agents do not have the ability to correctly predict the future energy consumption of a dwelling, and to solve this complex task they could use heuristic rules in their decision-making process such as valuing only the most salient characteristics of the products (DellaVigna 2009).

As a consequence, many governments have rapidly adopted informational instruments to target informational and behavioral failures in the residential sector. Informational instruments represent both a low cost alternative and a complement to conventional policies (Allcott and Mullainathan 2010). Their goal is to help consumers to take efficient decisions regarding EE by providing them with clear and direct information about the energy performance of the products. At the same time, it is expected that buildings with a higher level of EE are transacted at a higher price. Besides environmental concerns, the reduction of energy consumption leads to lower energy bills, so one would expect that effect to be reflected into the market price. This hypothesis represents an incentive for agents to increase the level of EE of their properties. Hence, labels would also create indirect incentives for owners to invest in EE.

Labeling systems have been previously used for other energy products such as appliances or vehicles, and nowadays are present in the building sector of many countries[1]. The European Union introduced in 2002 the *Energy Performance of Buildings Directive*, EPBD (Directive 2002/91/CE, then recasted into the Directive 2010/31/EU). The EPBD requires Member States to develop a national Energy Performance Certificates (EPCs) system for buildings, which must be made available to buyers or tenants in the moment the building (or building unit) is sold or rented out. Based on structural characteristics, buildings or building units must be classified according to an index from A (the higher level) to G (the lowest). With this information, agents have not only fast, reliable and costless information, but they can also compare different buildings in terms of EE.

Despite the widespread diffusion of this measure, little is known about its effectiveness, in particular in the residential sector. Although there is not yet available data to estimate the effects of labeling on energy consumption or on the probability to purchase buildings with a higher level of EE, we can evaluate how this information affects consumers' preferences for EPCs. Many of studies have been conducted in the last decade to estimate the market value of EPC or other labeling systems, mostly in the commercial sector in the U.S. Almost all of them point out that certified office buildings are sold or rented out at a higher price. However, we focus on consumers' valuation for EPC in the residential sector since more policy intervention is required in this sector. First, households do not always follow the minimization cost principle when making decisions, and hence they are more likely to make inefficient ones. Second, they have fewer

[1] In the U.S. there are two voluntary labeling systems for buildings and other energy products: the Energy Star program, which belongs to the U.S. Environmental Protection Agency (EPA), and the LEED (Leadership in Energy and Environmental Design) rating system. Similar systems are in place in many other countries, such as Canada, Australia or China.

incentives for EE adoption given that their individual energy savings are smaller. The evidence for the European residential sector is rather scarce, although the results go in the same direction of the commercial sector.

All these studies use the hedonic price model to estimate the implicit price of the attributes of the building. However, the number of attributes they include is rather small because detailed information on dwelling attributes is generally not available. This fact could make the model suffer from omitted variables bias, and if this is the case, the estimates for the EPC might be overestimated. In particular, given that most of these models do not include information on energy attributes, they cannot identify whether that estimated "price premium" is associated with the EPC itself or with other EE building attributes not included in the model[2].

We use as data source the website of one of the largest real estate companies in Portugal with more than 21.000 dwellings advertised for sale on it. After gathering data we have constructed a database that includes a complete set of dwelling characteristics, such as the asking price, dwelling size, structural characteristics, an extended number of geographic location measures, and the EPC score. Following the previous methodology we define a hedonic price function to estimate the price of each dwelling attribute. However, our price function additionally includes information on EE attributes which, if omitted, could lead to an overestimation of the EPC effect. In particular, we include information on certain EE measures installed in the dwelling, such as availability of heating or air conditioning systems, gas or solar energy sources.

Thus, we contribute to previous literature by providing the first evidence on consumers' valuation for EPC in a Southern European country: Portugal. The group of Southern European Countries has important economic, climatic and cultural particularities, which could potentially lead to different policy implementation results when compared to Northern countries. As well as in other Southern European countries, per capita final energy consumption in the Portuguese residential sector is lower than the European average. This situation, which could be partially explained by warmer temperatures, is likely to affect consumer's willingness to pay for building's EE attributes and EPCs. Besides, Portugal is an interesting case study because it was one of the early

[2] In their pioneer paper, Eichholtz et al. (2010), stated that "the rent premium associated with the label on any building represents the joint effects of the energy efficiency of the building together with other unmeasured, but presumably important attributes of the building".

adopters of the EPBD, and hence, the implementation of this legislation has been fully completed and the level of consumers' awareness is high.

The paper is organized in six sections and 4 annexes that contain additional information about variables' description, representativeness of the sample, and results of alternative model specifications. **Section 2** reviews the related literature in the field, **Section 3** describes our sample and tests whether it is representative of the Portuguese real estate market. **Section 4** presents the methodology followed in this analysis and **Section 5** shows the results. Finally, **Section 6** discusses the main conclusions.

2. Related literature

Given the recent introduction of EPCs systems in the building sector, the research in this field is constrained by an important lack of detailed data. The current inability of national databases to combine information about the number of EPC available in the country with relevant household and dwelling characteristics does not allow us to infer the effects on final energy consumption. However, it is possible to study the direct effect that the EPC has on consumer's decisions by analyzing how they respond to the information provided in the certificates.

During the last decade, some studies have carried out estimations to determine the capitalization of building labeling systems, particularly in the U.S. office market. The preferred technique to conduct this analysis has been the hedonic pricing method (Rosen 1974). This is the case of the pioneer study by Eichholtz et al. (2010), who used information from CoStar (a large database for the U.S.) and found that office buildings certified with Energy Star or LEED label were rented at a 3% higher price per square foot than non-certified buildings, and were sold out at a 16% higher price. Under the same umbrella of hedonic pricing, similar results are obtained by Fuerst and McAllister (2011a) (4-5% increase in certified rented buildings and 25% in sold buildings) and Wiley et al. (2010) (7-9% associated with Energy Star labels and 15-18% for LEED). For European countries, on the one hand, Kok and Jennen (2012) confirmed these results for the office market of the Netherlands. They found that inefficient offices (those labeled with D or lower) had realized rents approximately 6% lower than the rest of offices. On the other hand, Fuerst and

McAllister (2011b) have not found any connection between EPC and the asset value for commercial buildings in the U.K.[3]

Only a few of the above mentioned studies include detailed information on building's characteristics and attributes related with EE. Eichholtz et al. (2010) (updated in Eichholtz et al. 2013) is one of them. These authors used a reduced sample to determine which part of the estimated price premium corresponds to the building's level of EE. In particular, they use energy consumption as a control variable in a second regression to determine which part of the price premium is generated by EE attributes *per se*. Their aim is to distinguish the intangible effects of the label itself from the effects of EE attributes. Although they found that an important part of the price premium is due to other intangible effects such as reputation, they did not reach a general conclusion.

We next summarize the results of the most relevant studies on the European residential sector. First, Brounen and Kok (2011) performed the first analysis regarding the European residential sector. They study the determinants of the adoption of EPCs and their economic implications in the Netherlands. Based on postal address, they match information from several sources, including transaction data from the Dutch Association of Realtors. They have information on building type, year of construction, and certain thermal and quality characteristics such as central heating or insulation quality. They also have information on neighborhood characteristics at the zip level (housing density, average time a house is in the market, average monthly household income and the share of green voters). At the time the research was performed the EPBD was voluntary. Hence, their sample potentially suffered from sample selection bias. Using the Heckman two-step method and a "news index"[4] variable as the exclusion variable that determines EPC adoption, they showed that there is a positive relation between the EPC of a dwelling and its market price. Concretely, a "green" certified dwelling (those rated as A, B or C) had a 3.7% price premium over a "non-green" one.

Second, Höberg (2013) uses information on standard energy consumption disclosed in the EPC to determine whether the energy performance of a dwelling is capitalized into the transaction

[3] Some other authors found similar results (Das et al. 2011; Bloom et al. 2011; Reichardt et al. 2012 or Chegut et al. 2013).

[4] The "news index" is a quantitative measure constructed by the authors based on counts of negative or positive reporting on the energy label in the popular press. "Positive news receives a score of 1, whereas negative news receives a score of –1. Front page news presumably has more impact and receives a score of 2 or –2, respectively."

selling price for single-family dwellings in a municipality of Stockholm. She classifies a detailed set of attributes into two categories: property specific attributes and neighborhood specific attributes. The first category includes a “quality index” used in Sweden. This index is the result of a large number of quite standard dwelling items, and although some of the scores are associated with high EE, the correlation between this variable and the EPC is weak. The second category includes dummy variables (87) for each “value area” as categorized by the Swedish Tax Agency. These values take into account views, noises or distance from the city center. Additionally, she introduces the EE potential of each dwelling, which is given by the energy-saving recommendations that a specialized technician reports in the EPC. Based on a sample of more than 1000 transactions and using OLS regressions, her results show that the estimated energy consumption reported in the EPC[5] has positive effects on house selling prices.

Hyland et al. (2013) gathered the advertisements on the web page of one of the largest real estate companies in Ireland during 2008-2012 to build a panel with 15.000 dwellings for sale and 21.000 for rent. The authors used asking prices given the lack of transaction data for Ireland. There are two main limitations in this study: the only information about dwellings’ location is at county level, and the set of attributes included in the sale sample is considerably small (they only include dwelling type, number of bedrooms and bathrooms and whether it is a new development). Sample selection bias comes from those advertisements with no EPC information. They create a dummy variable that takes value 0 before the recast of the EPBD, and 1 afterwards, as the exclusion variable that determines the probability of advertising the EPC. Results from the Heckman two-step model show that dwellings for sale with an EPC of A receive a price premium of 9.3% with respect to dwellings with an EPC of D; and this percentage decreases to 1.8% for the rent sample. They find that sample selection bias is not present in their data.

Finally, Cajias and Piazolo (2013) analyze the German residential sector during the period 2008-2010. Their results are considerably higher if compared with previous findings for other countries. They obtain that the market value is above 60% for dwellings with the highest EPC (B, C and D), ceteris paribus; and the corresponding rents are approximately 13% higher for these dwellings than for energy inefficient ones.

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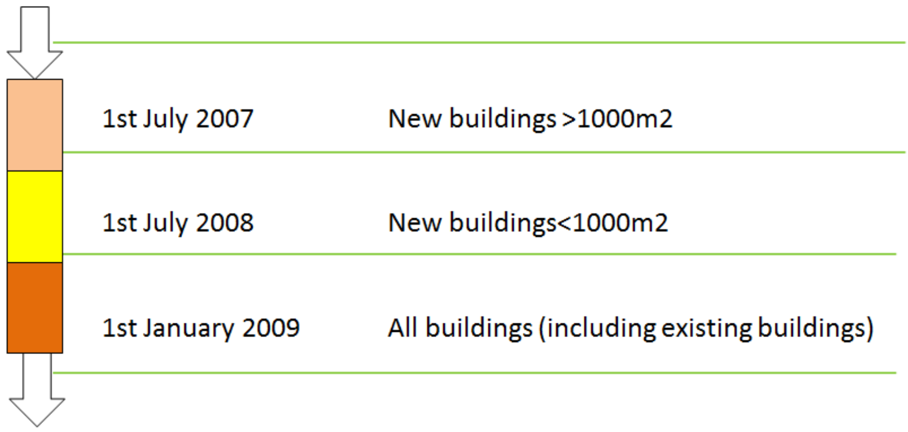
[5] The authors had information on the estimated energy consumption displayed in the EPC and they used this information as the measure for EE, contrary to the EE levels used by Brounen and Kok (2011).

We conclude this section analyzing the main contributions on the Asian residential market. With a two-stage estimation that carefully controlled for locational effects, Deng et al. (2012) found that condominiums and apartments certified with the Green Mark (the energy efficient labeling system used in Singapore) were sold with a 4% premium. Zheng et al. (2012) studied the case of Beijing where energy rating standards had not formally been adopted at that time. Hence, the authors created an artificial "green" index using a Google search to identify the houses advertised as "green". They found that "green" houses were initially sold with a price premium, at the presale stage, but were subsequently resold or rented with a price discount. This could be due to the fact that sellers would lie about the true energy performance of the house in the presale stage. For Japan, Yoshida and Sugiura (2011) suggested that the willingness to pay for buildings labeled with the *Tokyo Green Labeling System for Condominiums* was due to building´s age and quality, since once they controlled for these two variables, labels became not statistically significant. However, the Tokyo labeling system consists of eight itemized green scores, which may not be as easy to understand by consumers as the EPC.

3. Data

The residential sector is responsible for 17.7% of the Portuguese energy consumption. This percentage rises to 30% when it comes to electricity consumption (ADENE, 2012a). In 2006, the Portuguese government partially transposed the EPBD into the national legislation by the *Decreto de Lei 78/2006*, which creates the national energy certification system _*Sistema Nacional de Certificação Energética e da Qualidade do Ar Interior nos Edifícios* (SCE), and the *Decreto de Lei 79/2006* and *80/2006*. **Annex 1** shows an example of the first page of the EPC used in Portugal. Although the official start of the EPC scheme in Portugal took place in 2006, it was not until July 2007 that the practical implementation started (see **Figure 1**). The transposition of the EPBD recast gave origin to a new regulation (*Decreto de Lei 118/2013*), which imposed more restrictive rules for the classification of the buildings since the 1st of December of 2013. Besides extending the number of EPC categories into 9, ranging from "A+" to "G"; article 14 of the aforementioned decree also states that the corresponding EPC classification has to be displayed in any sale/rent advertisement.

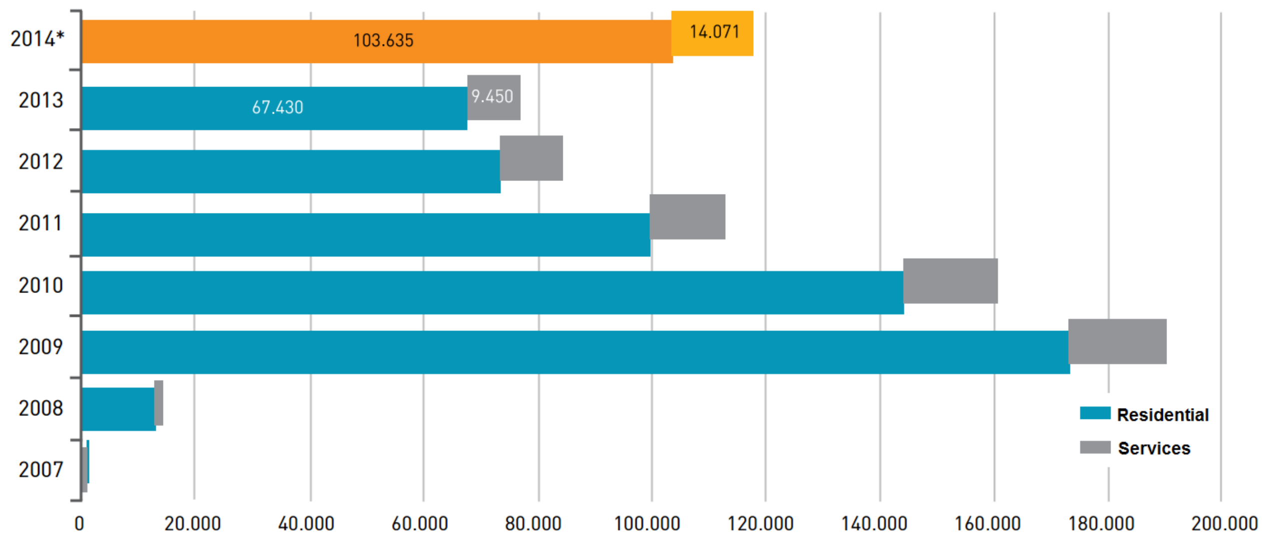
Figure 1: EPC implementation in Portugal



Source: www2.adene.pt

Whereas the degree of implementation of the EPBD is still low in some member states, Portugal represents a good case study because it has made great efforts to implement it. In fact, ADENE (Portuguese Agency for Energy) has supported several promotional activities towards municipalities, stakeholders and key market players to promote EPC dissemination. According to this Agency, an EPC is issued in around 90% of the buildings transacted (ADENE, 2012b). Since the implementation of the legislation until August 2014, a total of 755.000 certificates have been issued. **Figure 2** shows the evolution of EPCs registered in Portugal. After a strong boom, the number of new certificates has decreased considerably during the economic crisis, although it has come back to the initial trend in 2014.

Figure 2: Annual evolution of EPC registered in Portugal.

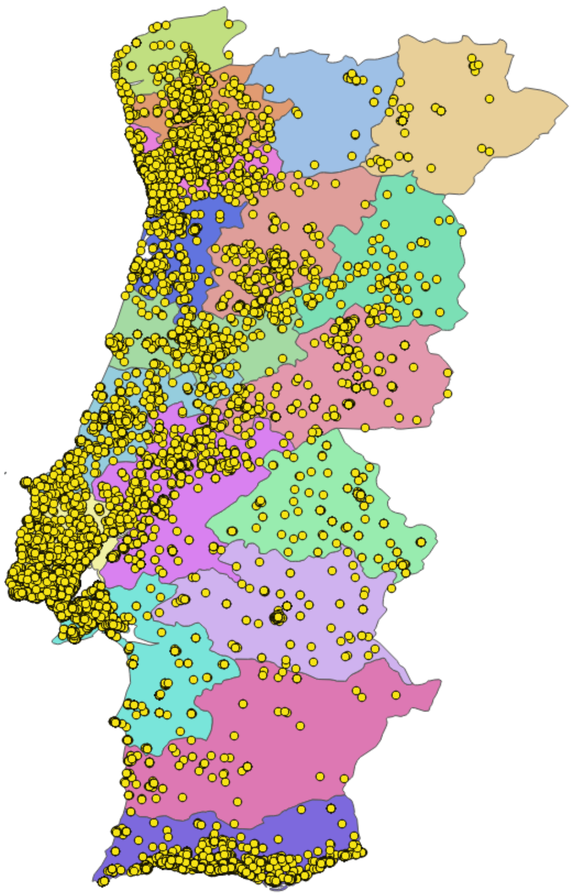


Source: ADENE/APEMIP. *August 2014

Our database contains information on all dwellings advertised for sale at the website of one of the largest real estate companies in Portugal[6]. For each dwelling we have detailed information on a number of structural characteristics, its exact geographic location, asking price and the EPC. There is also a brief description containing additional details about the dwelling that we have used to complete missing data (**Annex 2** shows the description of all variables in the database). All this information is filled by a real estate agent from the company, who ultimately decides which information is displayed in the online advertisement.

Unfinished dwellings, ruins, farms, rural-tourism and any other type of dwellings working as a business were deleted from the sample. Additionally, in order to avoid differences in how prices are set, we have only considered houses in Continental Portugal. The final sample consists of 21.230 dwellings. **Figure 3** shows their geographic distribution.

Figure 3: Geographic distribution of our sample.



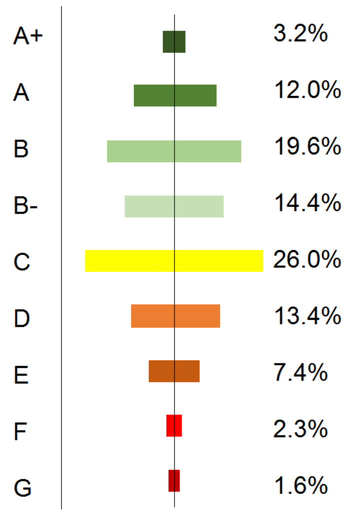
Source: The authors.

[6] The data was extracted from www.remax.pt. The download was in March 2015 using the *Python* software. Neither *Remax* nor any other agency provided the data directly to us despite our efforts in that sense.

According to Census 2011 (INE, 2012), the total number of existing houses in 2011 was 5.878.756 (around 5.600.000 in the Continental part of the country)[7]. In order to determine the representativeness of our sample in relation to the residential real estate market of Portugal, we have compared it with all the relevant indicators available at official statistics.

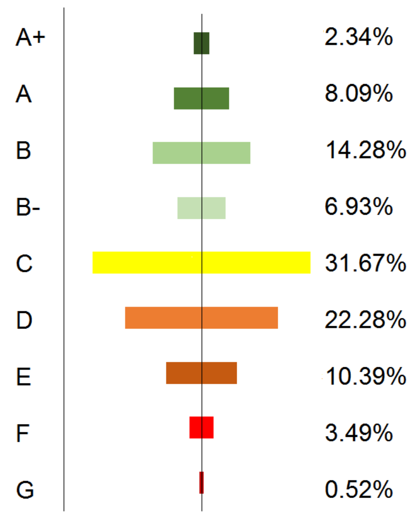
If we focus on EPCs, according to ADENE, "C" and "B" energy classes are predominant in the Portuguese stock of certified buildings[8] (see **Figure 4a**) from June 2007 until August 2014. **Figure 4b** shows how EPC categories are represented in our sample. We observe that center labels and lower tail categories, despite of G, are overrepresented, whereas upper tail categories are underrepresented. However, these differences were expected since we are comparing the total amount of certificates issued in Portugal during 7 years with a sample of residential dwellings on sale in March 2015. We emphasize that 26% of the dwellings in our sample did not display the EPC in the advertisement despite being compulsory by *Decreto de Lei 118/2013*.

FIGURE 4a: Energy structure of the Portuguese stock of certified buildings (cumulative data).



Source: ADENE/APEMIP

FIGURE 4b: Energy structure of certified dwellings in our sample.



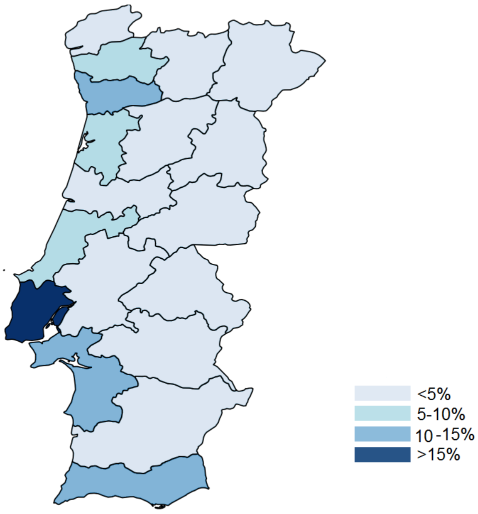
Source: the authors.

[7] The size of our sample represents the 0.38% of this amount. There is no official data available about the percentage of houses on sale.

[8] Stock refers to comercial and residentail buildinga unless specieified otherwise.

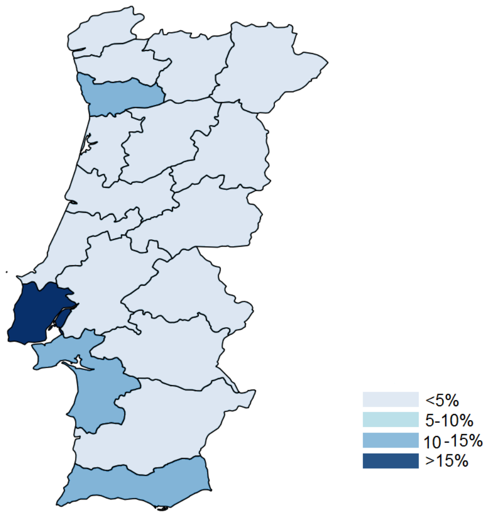
Attending to the geographic distribution of these EPCs, Lisboa, Porto, Faro and Setúbal are the districts with the largest number of registered certificates (see **Figure 5a**). The largest shares of certified dwellings in our sample also correspond to these districts (see Figure 5b). However, Braga, Aveiro and Leiria are slightly underrepresented (<5%) compared to the national stock of certified building (5-10%). **Annex 3** shows in more detail the energy structure of the certificates by districts for Portugal (**Table 1**) and for our sample (**Table 2**).

FIGURE 5a: Geographic distribution of the Portuguese stock of certified buildings (cumulative data).



Source: ADENE/APEMIP

FIGURE 5b: Geographic distribution of certified dwellings in our sample.



Source: the authors.

Finally, we analyze if our sample is representative in terms of price and structural characteristics of dwellings. **Table 1** summarizes the results for the Portuguese stock of residential buildings and for our sample. The third column restricts the sample to certified dwellings. We observe that the average price per square meter is higher in our sample than in the Portuguese real estate sector according to average bank evaluation for the first three months of 2015. *A priori*, we would expect the opposite given the tendency to give high mortgage valuations. It could be the case that these valuations are more accurate after the crisis. Also, we are comparing asking prices with average bank evaluations. Additionally, the percentages of old houses are smaller in our sample in general. Two reasons could justify this. First, our sample includes houses constructed until 2015 while the housing stock only includes houses constructed until 2010 (from Census 2010). Second, houses for sale tend to be recent/new while the housing stock includes older houses were the families have lived for a long time. Furthermore, it is noticeable that houses are bigger in our sample compared to the housing stock. The type of dwellings is similar among the samples and the state of the dwellings is better (do not need work) in our sample, as it is expected.

Table 1: Characteristics of the Portuguese housing stock versus our sample

		Housing stock	**Complete sample**	**Sample of certified dwellings**
Price	Price per square meter	1011€/m^2 *	1366.29€/m^2	1455.48€/m^2
Construction year	Until 1945	10.6%	3.6%	2.7%
	1946-1960	9.2%	5.0%	4.9%
	1961-1970	11.2%	3.51%	3.5%
	1971-1980	17%	6.9%	7.2%
	1981-1990	17.3%	13.1%	13.1%
	1991-2000	18.7%	18.6%	17.9%
	2001-2005	9.8%	14.9%	14.3%
	From 2006**	6.2%	34.3%	36.4%
	Average age	33,95 years	22 years	21 years
Area (m^2)	Until 59	16.4%	1%	1.1%
	60-79	15%	10.9%	11.6%
	80-99	20%	25.2%	26.7%
	100-119	17.3%	4.4%	3.5%
	120-149	14.4%	23.2%	23.9%
	150-199	9.3%	18.4%	17.2%
	200 and more	7.6%	16.7%	16%
	Average area	109.9m^2	148.4 m^2	144.9m^2
Construction type	Apartments	66.2%	67.1%	70%
General condition	Needs work	27%	2.4%	2.3%

Source: INE (Portuguese National Institute of Statistics) and the authors. *Average bank evaluation for the first three months of 2015. **Note that the Census only includes houses constructed until 2010.

Overall, we can conclude that our sample is suitable for analyzing the Portuguese residential sector in terms of composition and geographic distribution of EPCs, and structural characteristics of dwellings.

We next analyze the rest of the large set of variables available in our database (see **Table 1** in **Annex 3**). Location is generally considered as the most important item when purchasing a dwelling. We have information about the exact geographic coordinates for most dwellings. For those observations for which geographic location was not available, an imputation process was followed to recover coordinates from two sources. The first source was the name of the building or building complex. Second, we used *QGis* geocoding and *Google* information to convert addresses into geographic coordinates.

Table 2: Descriptive statistics.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Price/m²	21230	1366.58	1209.96	40.1907	20802.21
Log(price/m²)	21230	6.9695	0.6843	3.6936	9.9428
Certificate	15656				
ABC		63.32%			
D		22.28%			
EFG		14.40%			
EPC	21230	.7374123	0.4400319	0	1
Apartment	21230	.6704192	0.470072	0	1
Log(size)²	21230	24.15239	4.487058	11.56814	53.09856
Bedrooms	21179				
0		0.90%			
1		10.88%			
2		29.79%			
3		35.89%			
4		15.69%			
5		4.57%			
6 or more		2.27%			
Construction year	21224				
1300-1970		12.09%			
1971-1985		12.23%			
1986-1993		11.87%			
1994-1999		11.68%			
2000-2003		12.78%			
2004-2007		11.84%			
2008-2011		12.55%			
2011-2015		14.96%			
New	21230	.1916627	0.3936184	0	1
Needs work	21230	.0244454	0.154431	0	1
Renovated	21230	.1016909	0.3022485	0	1
Garage	21230	.5419434	0.4982494	0	1
Pool	21230	.1634403	0.3697756	0	1
Garden	21230	.3873581	0.4871581	0	1
Terrace	21230	.1849183	0.3882404	0	1
Balcony	21230	.3387499	0.4732959	0	1
Elevator	21230	.3223269	.4673784	0	1
Security	21230	.1398964	.3468877	0	1
Heating	21230	.2713956	0.4446902	0	1
Air conditioning	21230	.1818096	0.3856966	0	1
Solar	21230	.0747492	0.2629924	0	1
Gas	21230	.2605624	0.4389518	0	1
Electric blinds	21230	.0891621	0.2849843	0	1
Double window	21230	.0792709	0.2701674	0	1
Rented	21230	.0287316	0.167055	0	1
Fireplace	21230	.2428053	0.4287885	0	1
District	21230	9.648109	3.381379	1	18
Coastal municipalities	21230	0.5851154	0.4927137	0	1
Distance to school	21230	.0052445	0.0085521	5.91e-06	.1237477
Distance to city hall	21230	.0508659	0.0349206	1.00e-06	.2916289
Distance to garden	21230	.0729564	0.0833646	.0008	.8147576
Distance to hospital	21230	.0378919	0.0456491	.0000801	.5969091
Distance to shopping center	21230	.0870929	0.0976062	.0002845	.7360709
Distance to metro station	21230	.5143609	0.6236164	.0000485	2.261772
Agency size	21230	197.5586	115.2879	2	520

The administrative division of Portugal consists of 18 districts, which are divided in 308 municipalities. We use dummy variables to control for district and coastal municipalities. Besides that, individuals also consider accessibility to close amenities, such as public services, schools, sport facilities, green areas, etc. With each dwelling coordinates we were able to compute distances to the closest amenities in the city (see **Table 2**). For this task we used again the *QGis* program, which computes the distance to the closest target point. Amenities' coordinates were found from different sources: hospitals, shopping centers and gardens locations were directly downloaded from *OpenStreetMaps* (OSM)[9]. The information about metro stations for the metropolitan areas of Lisbon and Porto was downloaded using *Overpass API*[10]. The location of schools, kindergarten, universities and city halls was downloaded from different web pages[11].

For each dwelling we also have information on some EE attributes such as the availability of heating system, gas, air conditioning system, double window, electric blinds, and whether the dwelling has thermal solar panels. Finally, we have information on which agent from the real estate company is in charge of each dwelling. In particular, we have information on the agent ID, address and the agency to which the agent belongs. **Table 2** shows the descriptive statistics of our sample.

4. Model

We use the hedonic approach to estimate the implicit price of each dwelling attribute described above. This method assumes that a product z can be decomposed into its attributes z_i $(i = 1, \dots, n)$ and, by extension, the price of the product is a function of the attributes' price (Rosen 1974). That is,

$$P(z) = p\ (z_1, z_2, \dots, z_n). \quad (1)$$

[9] OSM is a large and open access database containing information about points, paths and geometry areas for world maps. Exact information about shopping centers was not available and we used cinemas as a proxy instead.

[10] Overpass API (Application Programming Interface) serves up custom selected parts of OSM data. Overpass turbo is a web implemented application of Overpass API that provides a way to access to its functionalities. We used http://overpass-turbo.eu/ to send a query on metro stops to the API and got back the corresponding dataset.

[11] Schools, kindergarten and universities location were downloaded from https://www.portaldasescolas.pt/portal/server.pt/community/01_escolas/240. Information about city hall location was downloaded from http://www.anmp.pt/index.php/municipios.

In equilibrium, the price of producing each product's attribute must equal its cost. Thus, in a competitive equilibrium, as it is the case of the real estate market, we can estimate the implicit price or willingness to pay (WTP) of each dwelling attribute. This WTP is given by the partial derivative of the dwelling price function with respect to each attribute. That is, $\frac{\partial \, P(z)}{\partial \, z_i}$ gives consumers' WTP for an extra unit of the attribute z_i or, similarly, the manufacturer marginal cost of producing such additional unit.

This approach is based on real transaction prices. However, in Portugal, there is neither official nor private data available with such information that also combines information on dwelling attributes. Thus, we have used dwelling asking prices as an approximation to real market prices.

For our analysis, we differentiate three groups of dwelling characteristics (see **Table 3**). The first group gathers information on the main structural characteristics together with other minor attributes of the dwelling (*S*). The second group contains information on dwelling location (*L*). The third group puts together information on EE measures and renewable energy sources, i.e., solar panels (*EE*).

We try to isolate the effect of the EPC by including this third group of variables in our model. These variables could have an effect on the price through consumer´s valuation for EE, but we can further control for a potential "signaling" effect that such attributes, in particular solar panels, generate. That is, the own existence of solar panels in a dwelling could be signaling those dwellings as "green" or "energy efficient", and in those cases, the extra information provided by the EPC could be lower. In other words, the EPC might have a higher valuation in those cases where the EE attributes of a house are not clearly identified by consumers, while in those houses with easily identified EE attributes, such as solar panels or electric blinds, the informational effect of the EPC could decrease together with its valuation.

Table 3: Explanatory variables

Structural characteristics (*S*)	Location characteristics (*L*)	EE characteristics (*EE*)
Apartment Construction year Size Bedrooms New Needs work Renovated Pool Garage Terrace Balcony Rented	Coastal municipalities District Distance to the closest school, kindergarten or university Distance to the closest hospital Distance to the closest shopping center Distance to the closest city hall Distance to the closest garden Distance to the closest metro station (only for Porto and Lisbon sample)	Heating system Air conditioner Solar panels Gas Double windows Electric blinds Fireplace

Thus, the hedonic regression for **Equation (1)** takes de following form:

$$log(price/m^2)_i = \alpha + \gamma Certificate_i + \beta_1 S_i + \beta_2 L_i + \beta_3 EE_i + v_i \qquad (2)$$

The dependent variable is the logarithm of the asking price per square meter $log(price/m^2)_i$, for dwelling *i*. $Certificate_i$ is a categorical variable that takes value 1 if dwelling *i* has certificate A, B or C; 2 if it has certificate D; and 3 if it has certificate E, F or G. S_i, L_i and EE_i are the explanatory variables displayed in **Table 3**, and v_i is the error term. We are interested in parameter γ, which reports the WTP for each type of certificate.

As it was explained in **Section 3**, the Portuguese legislation states that the EPC must be included in the advertisement of the dwelling since 2013. Some advertisements do not fulfill it despite of being mandatory. The fact that some advertisements do include the EPC and some others do not indicates that our sample could suffer from some sort of selection bias due to unobservable confounders. That is, there is an unobserved confounder (e.g., quality) that can affect both the decision of displaying the certificate and the price of the dwelling. It is reasonable to think that owners of high quality dwellings are more likely to display their certificate and also more likely to ask for a higher price. Hence, any inference based on estimated parameter from **Equation (2)** would lead us to wrong conclusions. We have used the Heckman two-step selection model to handle this problem[12].

The Heckman procedure establishes a two equation model. In a first stage we estimate the probability that an advertisement includes the EPC using a probit model:

$$prob(EPC_i) = \theta + \mu Agency\ size_i + \delta_1 \bar{S}_i + \delta_2 \bar{L}_i + \delta_3 \overline{EE}_i + u_i \qquad (3)$$

The dependent variable, EPC_i, in **Equation (3)** is a discrete variable that takes value 1 if advertisement of dwelling *i* includes information on the EPC, and 0 otherwise. $\bar{S}_i$, $\bar{L}_i$ and $\overline{EE}_i$ are subsets of the corresponding groups of variables displayed in **Table 3,** and u_i is the error term. *Agency_size* measures the number of dwellings managed by each company's office, and it is our exclusion variable. This variable has to be relevant for the decision to advert the EPC, but not highly correlated with the price. We have reasons to believe that the size of the office can influence the decision of including the EPC in the advertisement, but it has certainly no influence on the dwelling's price[13].

In a second stage we construct a consistent estimate of the inverse Mills ratio, $\hat{\lambda}$, based on the probit estimation of the first step. We include this selection variable as an instrument in the price equation (**Equation 4**) which becomes:

$$log(price/m^2)_i = \alpha + \gamma Certificate_i + \beta_1 S_i + \beta_2 L_i + \beta_3 ER_i + \tau\hat{\lambda} + v_i \qquad (4)$$

To determine the existence of sample selection we either observe the statistical significance of the estimated parameter τ or the correlation or the error terms from Equations (3) and (10).

[12] For a detailed explanation of the Heckman procedure see Cameron and Trivedi (2005).
[13] The correlation is 0.1773.

5. Results

Table 4 shows the results of the selection equation for two model specifications; one without the EE attributes and the other with them. In general, coefficients are statistically significant and have the expected sign for both specifications. Apartments are more likely to display the EPC in the advertisement, as well as recently constructed dwellings. The size of the dwellings does not affect the probability of including the EPC, although dwellings with 1 or 2 bedrooms are less likely to have the EPC with respect to studies (dwellings with zero bedrooms). As it would be expected, being renovated has a positive effect on the probability of having EPC, and the same effect is found for dwellings that are already rented. The effect of the extra equipment is not unidirectional: while swimming pool, balcony and fireplace show a positive effect; terrace do not have any effect in the second model specification.

With respect to EE characteristics, dwellings with heating system, with solar panels or with gas are more likely to include the EPC in the advertisement. Unexpectedly, the coefficient for electric blinds shows the opposite sign, and air conditioning and double window are not significant. With respect to location, dwellings located in the coastal municipalities are more likely to include the EPC.

Lastly, the coefficient of the exclusion variable, a$gency\ size$, is negative and statistically significant. According to this, dwellings managed by larger agencies are less likely to include the EPC.

Table 5 shows the results of the price equation for the corresponding model specification[14]. For the model specification with EE variables, the coefficient for the category *ABC* of the variable *Certificate* is positive and statistically significant. In particular, the logarithm of the price of a dwelling with EPC A, B or C is 5.9% higher than the one of a dwelling with EPC equal to D, *ceteris paribus*. This means that agents are willing to pay more for dwellings with a high EPC. Also, the implicit price of dwellings certified as E, F or G is 4.0% lower. For the model specification without EE variables the results are slightly higher (6.6% for ABC, and -4.6% for EFG). These results go in line with previous findings. Despite the fact that we have controlled for EE variables in the second model specification, the magnitude of the effect is considerably higher than those found for north European countries

[14] Columns 2 and 3 in table 5 correspond with columns 2 and 3 in table 6, and the same with columns 4 and 5.

(Netherlands and Sweden). These results could be due to different issues. First, it can be that consumers in Portugal simply have a higher valuation for EE in dwellings than citizens from north Europe. The economic crisis and the increase of electricity prices (according to *Eurostat* Portugal is one of the European countries with higher electricity prices after including taxes and levies) could explain that fact. Second, it can also be the case that, despite our model includes a large number of dwelling attributes and controls for location, there are some other unobservable factors that overestimate the effects of EPC. On the one hand, it could be the case that high certified dwellings are also dwellings that include the latest advances in the construction market, which are not controlled in our model. On the other hand, as it was stated by Eichholtz et al. 2010, high EPCs can be associated with some intangible characteristics, such as reputation or high construction quality, which lead consumers to show a higher valuation. To check the robustness of our results, we also consider each certificate label as a category. The results are even stronger for high rated dwellings (see **Annex 4**).

Regarding the structural characteristics, once we control for most of the attributes, the logarithm of the price per square meter is not statistically different for apartments than for houses, and the coefficient of the squared logarithm of size shows a concave relation between the size and the price per square meter. This means that the price per square meter increases with the size of the dwellings until it reaches a point where increases of the size lead to decreases of the price per square meter. However, the price per square meter for studios (dwellings with zero bedrooms) is higher than for dwellings with one or two bedrooms, and lower for dwellings with 5 or more bedrooms. As it would be expected, recently constructed dwellings show higher prices, although dwellings building before 1300 and 1970 are more expensive than those built between 1971 and 1985. This effect could be explained because dwellings in the first group can be considered as antiques. Then, renovated dwellings are sold at a higher price contrary to those that need any reparation. The last structural attributes (swimming pool, garage, garden, terrace, elevator and security) show the expected sign. They all show a positive effect on the price of the dwelling, except for balcony and fireplace, whose effect did not resulted to be significant, similarly to dwellings that are currently rented.

Table 4: Selection equation with model specification (1) and (2).

	Model specification without EE variables		Model specification with EE variables	
	Prob(EPC)		Prob(EPC)	
VARIABLES	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**
Apartment	0.209***	(0.0511)	0.198***	(0.0513)
Log (size) [2]	-0.00893	(0.0125)	-0.0115	(0.0125)
Bedroom (reference: 0)				
1	-0.269**	(0.131)	-0.288**	(0.131)
2	-0.317**	(0.146)	-0.346**	(0.146)
3	-0.257	(0.172)	-0.287*	(0.172)
4	-0.136	(0.203)	-0.175	(0.203)
5	-0.103	(0.229)	-0.150	(0.229)
6 or more	-0.136	(0.252)	-0.176	(0.253)
Construction year (reference: 1300-1970)				
1971-1985	0.150***	(0.0404)	0.145***	(0.0405)
1986-1993	0.102**	(0.0410)	0.0854**	(0.0412)
1994-1999	0.129***	(0.0421)	0.0863**	(0.0427)
2000-2003	0.0900**	(0.0417)	0.0308	(0.0427)
2004-2007	0.170***	(0.0430)	0.118***	(0.0440)
2008-2011	0.396***	(0.0458)	0.364***	(0.0466)
2011-2015	0.240***	(0.0460)	0.146***	(0.0483)
New	0.102***	(0.0333)	0.0715**	(0.0336)
Renovated	0.165***	(0.0358)	0.146***	(0.0359)
Needs workd	-0.0156	(0.0644)	-0.00445	(0.0646)
Rented	0.141**	(0.0618)	0.134**	(0.0644)
Pool	0.0971***	(0.0306)	0.0622**	(0.0312)
Terrace	0.0504*	(0.0260)	0.0320	(0.0262)
Balcony	0.0861***	(0.0218)	0.0513**	(0.0223)
Heating system			0.0823**	(0.0264)
Air conditioning			0.0530	(0.0290)
Solar panels			0.175***	(0.0449)
Gas			0.170***	(0.0258)
Electric blinds			-0.0718*	(0.0407)
Double window			-0.0489	(0.0395)
Fireplace			0.0755***	(0.0253)
Dummies for district	Yes		Yes	
Coastal municipalities	0.123***	(0.0251)	0.110***	(0.0253)
Agency size	-0.000977***	(9.19e-05)	-0.000955***	(9.22e-05)
Constant	0.827***	(0.260)	0.869***	(0.260)
Observations	21,170		21,170	

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Output equation for model specification with and without EE variables.

	Model specification without EE variables		Model specification with EE variables	
Variables	Log(price/m2)		Log(price/m2)	
	Coeff.	S.E.	Coeff.	S.E.
Certificate (reference: D)				
ABC	0.0661***	(0.00956)	0.0594***	(0.00944)
EFG	-0.0461***	(0.0122)	-0.0403***	(0.0120)
Apartment	0.0231	(0.0249)	0.0354	(0.0245)
$Log(size)^2$	-0.0350***	(0.00560)	-0.0353***	(0.00552)
Bedrooms (reference: 0)				
1	-0.155***	(0.0473)	-0.152***	(0.0468)
2	-0.165***	(0.0564)	-0.164***	(0.0557)
3	-0.101	(0.0686)	-0.106	(0.0678)
4	0.0837	(0.0834)	0.0632	(0.0823)
5	0.213**	(0.0959)	0.187**	(0.0945)
6 or more	0.398***	(0.107)	0.376***	(0.105)
Construction year (reference:1300-1970)				
1971-1985	-0.0707***	(0.0182)	-0.0694***	(0.0178)
1986-1993	-0.0127	(0.0182)	-0.0182	(0.0179)
1994-1999	0.0932***	(0.0193)	0.0811***	(0.0187)
2000-2003	0.189***	(0.0191)	0.153***	(0.0187)
2004-2007	0.294***	(0.0202)	0.257***	(0.0196)
2008-2011	0.546***	(0.0235)	0.513***	(0.0226)
2011-2015	0.595***	(0.0218)	0.540***	(0.0212)
New	-0.0129	(0.0138)	-0.0145	(0.0134)
Renovated	0.144***	(0.0154)	0.136***	(0.0149)
Needs work	-0.192***	(0.0279)	-0.176***	(0.0274)
Rented	-0.0202	(0.0246)	-0.0263	(0.0242)
Garage	0.118***	(0.00889)	0.0947***	(0.00890)
Pool	0.317***	(0.0131)	0.286***	(0.0128)
Garden	0.0959***	(0.00864)	0.0922***	(0.00861)
Terrace	0.104***	(0.0110)	0.0941***	(0.0108)
Balcony	0.00729	(0.00958)	-0.00419	(0.00924)
Elevator	0.0607***	(0.00936)	0.0555***	(0.00954)
Security	0.216***	(0.0112)	0.174***	(0.0117)
Heating system			0.159***	(0.0113)
Air conditioning			0.147***	(0.0116)
Solar panels			0.0337*	(0.0179)
Gas			-0.0337	(0.0117)
Electric blinds			-0.0330**	(0.0162)
Double window			-0.0684***	(0.0157)
Fireplace			0.0164	(0.0110)
Dummies for district	Yes		Yes	
Coastal municipalities	0.206***	(0.0114)	0.199***	(0.0111)
Distance to school	4.229***	(0.495)	3.705***	(0.489)
Distance to city hall	0.254**	(0.122)	0.279**	(0.120)
Distance to garden	-1.236***	(0.0685)	-1.212***	(0.0675)
Distance to hospital	-0.588***	(0.109)	-0.576***	(0.107)
Distance to shopping center	-0.925***	(0.0590)	-0.880***	(0.0582)
Lambda	0.459***	(0.0808)	0.452***	(0.0793)
Constant	7.015***	(0.118)	7.023***	(0.116)
Observations	21,170		21,170	

Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

With respect to EE characteristics, dwellings with heating and air conditioning system have a higher price per square meter, as well as those with solar panels. According to our results, the effect of gas is not significant and the effect of double window and electric blinds is low and negative.

At the bottom of **Table 4** the effects of location are showed (given the large number of dummy variables used for the districts, these effects are displayed in **Annex 4** for the second model specification). As it is expected, dwellings located in coastal municipalities show a higher price, as well as those closer to shopping centers, hospitals and gardens. However, the direction of the effect of the distance to the closest school on the price is unexpected. This fact might be due to the fact that we are including all type of schools without controlling for their quality and age target.

Finally, the inverse Mills ratio is statistically significant suggesting that the errors from **Equations (3)** and **(4)** are correlated and hence, our sample suffers from sample selection bias.

Furthermore, we have regressed **Equations (3)** and **(4)** for the two major Portuguese municipalities, Lisboa and Porto, using the second model specification. For these cities we also include the distance to the metro station as location variable. In addition, we transform the exclusion variable, agency size, into a 6-category variable, to better capture its capabilities in this subsample. Results are displayed in **Table 6** and do not show major changes.

Table 6: Heckman two-steep regression for Lisboa and Porto.

Variables	Output equation Log(price/m2)		Selection equation EPC	
	Coeff.	S.E.	Coeff.	S.E.
Certificate (reference: D)				
ABC	0.106***	(0.0197)		
EFG	-0.00629	(0.0269)		
Apartment	0.0919	(0.0599)	0.0268	(0.123)
Log(size)²	-0.0379***	(0.0142)	-0.0738**	(0.0287)
Bedrooms (reference: 0)				
1	-0.295***	(0.102)	-0.187	(0.274)
2	-0.291**	(0.127)	-0.0566	(0.317)
3	-0.140	(0.158)	0.248	(0.372)
4	0.0749	(0.197)	0.563	(0.445)
5	0.147	(0.229)	0.610	(0.505)
6 or more	0.376	(0.254)	0.922	(0.572)
1971-1985	-0.310***	(0.0335)	-0.0618	(0.0704)
1986-1993	-0.241***	(0.0361)	-0.164**	(0.0722)
1994-1999	-0.128***	(0.0377)	-0.156**	(0.0761)
2000-2003	0.0537	(0.0390)	-0.0478	(0.0817)
2004-2007	0.227***	(0.0420)	-0.0469	(0.0882)
2008-2011	0.550***	(0.0426)	0.247***	(0.0947)
2011-2015	0.533***	(0.0420)	-0.0449	(0.0924)
New	-0.189***	(0.0315)	-0.210***	(0.0716)
Renovated	0.175***	(0.0268)	0.0415	(0.0580)
Needs work	-0.212***	(0.0517)	-0.122	(0.105)
Rented	-0.0886**	(0.0401)	0.172*	(0.0927)
Garage	0.0809***	(0.0193)		
Pool	0.328***	(0.0319)	0.171**	(0.0729)
Garden	0.103***	(0.0178)		
Terrace	0.121***	(0.0244)	-0.0181	(0.0541)
Balcony	-0.0256	(0.0197)	-0.000112	(0.0436)
Fireplace	-0.00760	(0.0263)	0.113**	(0.0567)
Elevator	0.0622***	(0.0189)		
Security	0.169***	(0.0227)		
Heating system	0.132***	(0.0240)	0.0615	(0.0522)
Air conditioning	0.256***	(0.0256)	0.0546	(0.0579)
Solar panels	0.167***	(0.0450)	0.545***	(0.109)
Gas	-0.0990***	(0.0214)	0.0876*	(0.0452)
Electric blinds	0.00219	(0.0359)	0.311***	(0.0864)
Double window	-0.0216	(0.0323)	-0.121*	(0.0728)
Coastal municipalities	0.390***	(0.0274)	0.0535	(0.0559)
Distance to school	3.300	(3.510)		
Distance to city hall	1.993***	(0.518)		
Distance to garden	-6.515***	(0.522)		
Distance to hospital	0.838	(0.670)		
Distance to shopping center	-5.712***	(0.494)		
Distance metro	1.571***	(0.421)		
Agency size_1			-0.401***	(0.0705)
Agency size_2			-0.0442	(0.0781)
Agency size_3			-0.322***	(0.0700)
Agency size_4			-0.0616	(0.0729)
Agency size_5			-0.267***	(0.0815)
Lambda	0.665***	(0.145)		
Constant	7.538***	(0.262)	2.596***	(0.577)
Observations	6,500		6,500	

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

6. Conclusions

Informational instruments have been rapidly introduced by many governments around the world as an alternative tool to promote energy efficiency (EE). By providing consumers with simply information about the level of EE of each product, they expect to lead consumers to take efficient decisions regarding EE, at a low implementation cost. Despite U.S. and Europe have approved legislation on this matter at the beginning of this century, little is known about its effectiveness, in particular in the European residential sector.

In 2002, the European Commission approved the *Energy Performance of Buildings Directive* (EPBD), which establishes that owners of a building or a building unit must show an energy performance certificate (EPC) that classifies the building according to its level of EE, every time the building or building unit is sold or rented out. Portugal was one of the first adopters of this legislation and nowadays the EPBD is fully implemented with more than 750.000 building being certified since 2007. This fact allows us to evaluate the effectiveness of this policy instrument. Besides that, Portugal belongs to the group of Southern European countries, which present important economic, cultural and geographic differences.

We have constructed a unique database with information on more than 21.000 dwellings advertised for sale at the website of one of the biggest real estate companies in Portugal. Our database contains an extended number of variables with information on the main structural characteristics of the dwelling (type, size, number of bedrooms, construction year, whether it is new, has been renovated or needs any reparation), extra structural characteristics (garage, swimming pool, garden etc.), EE characteristics (availability of heating, air conditioning systems, solar panels and gas), the EPC and the exact geographic location. With the geographic coordinates and using specialized software (*QGis*) we were able to compute the distance from each dwelling to the closest amenities (school, town hall, shopping center, metro station, hospitals, and gardens).

With all this information we defined a price function to model the price of each dwelling. However, for some dwellings the web page did not display the EPC, and hence our sample was likely to be affected by sample selection bias. In order to tackle this problem we followed the Heckman two-step method. We first defined a selection equation to model the probability that the EPC was displayed in the sale advertisement for a certain dwelling, and then, we estimated the price function including the lambda of Heckman.

Our results go in line with previous findings. Dwellings with EPC equal to A, B or C are sold at a 5.9% higher price per square meter than those with an EPC equal to D. Contrary, dwellings with EPC equal to E, F or G are sold at a 4% less. Despite our sample controls for an important number of dwelling attributes, our values are higher than the ones found in the Netherlands and Sweden. This can be due to several reasons. First, it can simply happen that Portuguese have a higher valuation for EE in dwellings. The increase of electricity prices and the economic crisis could have increased the awareness for EE. Also the divulgation campaigns carried out by the Portuguese energy agency (ADENE) could have increased the awareness for EPC. But it can also be that there are some unobservable factors associated with EPC that our model was not able to control. As Eichholtz et al. (2010) stated in their seminal paper, reputational effects could overestimate the effect of the EPC.

Overall, our results confirm that consumers value the information provided by the EPC and hence, this informational instrument has been effective in Portugal. This also implies that dwelling owners have incentives to improve the level of EE of their properties. The policy implications of this result are important for neighbor countries such as Spain, where the implementation of the EPBD is still low. However, more policy evaluation is needed in this field; welfare analysis to determine the effects on consumers' surplus and empirical analysis to test the effects on final energy consumption are essential. The biggest hurdle for these analyses is the lack of data.

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Annex 1

Figure 1: First page of the EPC used in Portugal

Certificação Energética
e Ar Interior
EDIFÍCIOS

Nº CER 1234567/2007

CERTIFICADO DE DESEMPENHO ENERGÉTICO E DA QUALIDADE DO AR INTERIOR

TIPO DE EDIFÍCIO: EDIFÍCIO DE SERVIÇOS / FRACÇÃO AUTÓNOMA DE EDIF. SERVIÇOS

Morada / Situação:

Localidade ____________________ Freguesia ____________________

Concelho ____________________ Região ____________________

Data de emissão do certificado ____________________ Validade do certificado ____________________

Nome do perito qualif. ____________________ Número do perito qualif. ____________________

Imóvel descrito na [ ] Conservatória do Registo Predial de ____________________

sob o nº [ ] Art. matricial nº ____________________ Fracção autón. ____________________

Este certificado resulta de uma verificação efectuada ao edifício ou fracção autónoma, por um perito devidamente qualificado para o efeito, em relação aos requisitos previstos no Regulamento das Regulamento dos Sistemas Energéticos de Climatização em Edifícios (RSECE, Decreto-Lei 79/2006 de 4 de Abril), classificando o imóvel em relação ao respectivo desempenho energético. Este certificado permite identificar possíveis medidas de melhoria de desempenho aplicáveis à fracção autónoma ou edifício, suas partes e respectivos sistemas energéticos e de ventilação, no que respeita ao desempenho energético e à qualidade do ar interior.

1. ETIQUETA DE DESEMPENHO ENERGÉTICO

INDICADORES DE DESEMPENHO

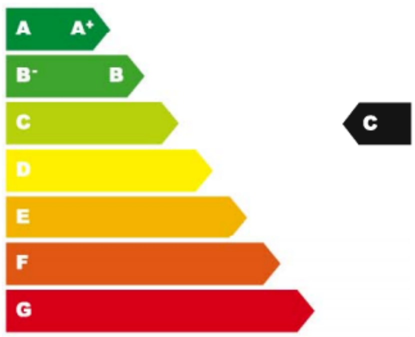
Valor do indicador de Eficiência Energética nominal (IEE_{nom}) calculado por simulação energética [ ] $kgep/m^2.ano$

Valor do Indicador de Eficiência Energética (IEE_{ref}) para edifícios novos, ao qual corresponde o limite inferior da classe B^- [ ] $kgep/m^2.ano$

Valor do Indicador de Eficiência Energética correspondente ao limite inferior da classe A^+ [ ] $kgep/m^2.ano$

Emissões anuais de gases de efeito de estufa associadas ao IEE nominal [ ] toneladas de CO_2 equivalentes por ano

CLASSE ENERGÉTICA



O indicador de eficiência energética, IEEnom, traduz o consumo nominal específico de um edifício, ou seja, a energia necessária para o funcionamento de um edifício durante um ano tipo, sob padrões nominais de funcionamento e por unidade de área, de forma a permitir comparações objectivas entre diferentes imóveis. Os consumos reais podem variar bastante dos indicados e dependem das atitudes e padrões de comportamento dos utilizadores. O valor de referência para este indicador (IEEref) está definido no D.L. 79/2006 de 4 de Abril para edifícios cuja licença ou autorização de construção é posterior a 4 de Julho de 2006, bem como para edifícios já existentes aquela data. Nos casos de edifício ou fracções autónomas com mais de uma tipologia de actividade, o IEEnom e IEEref correspondem a valores ponderados de acordo com as áreas afectas a cada tipologia.

Annex 2

Table 1: Variables description

Variables:	Name:	Description:
Dependent variable	Log(price/m2)	Asking price per square meter in logarithms (€/m^2).
EPC	EPC	Dummy variable that takes value 1 if the dwelling contains the EPC, 0 otherwise.
	Certificate	3-level categorical variable. Takes value 1 if dwelling has EPC equal to A, B or C; 2 if dwelling has EPC equal to D; 3 if dwelling has EPC equal to E, F or G.
Structural characteristics	Apartment	Dummy variable that takes value 1 for apartment, 0 for house.
	Log(size)	Square meters of the dwelling in logarithm.
	Bedrooms	Number of bedrooms. 7-level categorical variable.
	Construction year	Year of construction. 8-level categorical variable.
	Rented	Dummy variable that takes value 1 if the dwelling is rented, 0 otherwise.
	New	Dummy variable that takes value 1 if the dwelling is new, 0 otherwise.
	Renovated	Dummy variable that takes value 1 if the dwelling has been renovated, 0 otherwise (only applicable to non-new houses).
	Needs_work	Dummy variable that takes value 1 if the dwelling needs work, 0 otherwise (only applicable to non-new houses).
	Garage	Dummy variable that takes value 1 if the dwelling has garage, 0 otherwise.
	Swimming pool	Dummy variable that takes value 1 if the dwelling has swimming pool, 0 otherwise.
	Terrace	Dummy variable that takes value 1 if the dwelling has terrace, 0 otherwise.
	Balcony	Dummy variable that takes value 1 if the dwelling has balcony, 0 otherwise.
	Elevator	Dummy variable that takes value 1 if the dwelling has elevator, 0 otherwise.
	Security	Dummy variable that takes value 1 if the dwelling has security, 0 otherwise.
	Heating system	Dummy variable that takes value 1 if the house has heating system and 0 otherwise.
	Fireplace	Dummy variable that takes value 1 if the dwelling has fireplace, 0 otherwise.
	Heating system	Dummy variable that takes value 1 if the dwelling has heating system, 0 otherwise.
	Air conditioning system	Dummy variable which takes value 1 if the dwelling has air conditioning system, 0 otherwise.
	Solar panels	Dummy variable that takes value 1 if the dwelling has solar panels, 0 otherwise.
	Gas	Dummy variable that takes value 1 if the dwelling has gas, 0 otherwise.

	Electric blinds	Dummy variable that takes value 1 if the dwelling has electric blinds, 0 otherwise.
	Double glazing	Dummy variable that takes value 1 if the dwelling has double glazing, 0 otherwise.
Location	District	Dummy variables for each of the 18 districts of Portugal
	Coastal municipality	Dummy variable that takes value 1 if the dwelling is located in a municipality with coast, 0 otherwise.
	Distance to school	Distance between the dwelling and the closest school (in degrees).
	Distance to city hall	Distance between the dwelling and the closest city hall (in degrees).
	Distance to hospital	Distance between the dwelling and the closest hospital (in degrees).
	Distance to shopping center	Distance between the dwelling and the closest shopping center (in degrees).
	Distance to garden	Distance between the dwelling and the closest garden (in degrees).
	Distance to metro	Distance between the dwelling and the closest metro station (only for municipalities with metro) (in degrees).

Annex 3

Table 1: Energy Structure by district: All certified buildings in Portugal

Districts	A+	A	B	B-	C	D	E	F	G
Aveiro	3.8%	15.6%	20.5%	16.2%	20.3%	13.1%	6.7%	2.4%	1.4%
Beja	1.6%	9.8%	18.3%	15.5%	20.9%	18.3%	8.3%	4.1%	3.2%
Braga	2.9%	17.5%	23.5%	17.1%	18.0%	12.2%	5.5%	2.2%	1.0%
Bragança	3.8%	25.6%	21.2%	24.4%	7.4%	7.0%	5.1%	3.7%	1.7%
Castelo Branco	2.0%	6.6%	21.8%	19.3%	18.4%	15.1%	8.6%	4.8%	3.3%
Coimbra	3.4%	11.5%	23.8%	16.9%	19.6%	12.7%	7.8%	2.6%	1.7%
Évora	0.8%	8.6%	15.7%	14.9%	22.5%	19.5%	10.3%	4.5%	3.2%
Faro	3.1%	9.7%	15.1%	13.5%	28.3%	17.0%	9.7%	2.0%	1.5%
Guarda	3.6%	12.9%	17.8%	27.6%	9.0%	9.8%	8.6%	7.5%	3.2%
Leiria	2.8%	10.0%	20.9%	16.6%	22.7%	16.9%	6.0%	2.1%	1.9%
Lisboa	3.5%	9.3%	18.8%	12.3%	35.4%	13.7%	4.7%	1.0%	1.1%
Portalegre	0.6%	5.4%	16.2%	15.7%	19.0%	17.5%	11.8%	6.8%	6.8%
Porto	3.5%	14.4%	23.9%	11.5%	15.9%	10.6%	13.7%	4.2%	2.3%
Santarém	1.7%	7.7%	17.4%	16.9%	24.4%	18.2%	7.9%	3.1%	2.7%
Setúbal	3.2%	11.9%	14.6%	12.3%	39.5%	12.3%	4.3%	0.8%	1.0%
Viana do Castelo	4.4%	20.3%	21.0%	18.1%	12.8%	11.8%	6.5%	3.5%	1.6%
Vila Real	2.8%	24.3%	21.5%	21.3%	8.6%	8.0%	6.6%	4.3%	2.7%
Viseu	3.7%	15.0%	23.1%	28.1%	10.2%	9.1%	5.8%	3.3%	1.7%

Source: ADENE/APEMIP

Table 2: Energy Structure by district: certified dwellings in the sample

Districts	A+	A	B	B-	C	D	E	F	G
Aveiro	1.6%	9.4%	12.7%	7.5%	28.0%	26.3%	10%	3.5%	0.3%
Beja	0%	2.6%	6.6%	4%	18.4%	39.4%	14.5%	14.5%	0%
Braga	3.8%	6.3%	19.7%	4.7%	30.5%	18.2%	10.8%	6.0%	0%
Bragança	0%	2.1%	0%	2.1%	25%	35.4%	14.6%	18.7%	2.1%
Castelo Branco	0%	4.7%	7.0%	2.3%	9.4%	26.6%	26.6%	26.7%	0.8%
Coimbra	3.4%	16.1%	17.3%	11.3%	24.6%	13.5%	9.3%	4%	0.4%
Faro	1.4%	3.7%	14.8%	7.4%	37.6%	23.4%	9.5%	1.9%	0.3%
Guarda	0%	9.5%	2.4%	4.8%	14.3%	28.6%	21.4%	19%	0%
Leiria	0.3%	1.9%	15.6%	7.3%	25.8%	27.1%	15.1%	6.6%	0.3%
Lisboa	2.4%	9.0%	14.6%	7.3%	35.4%	21.0%	7.8%	2.1%	0.3%
Portalegre	0%	1.40%	0%	1.4%	10.5%	35.0%	23.1%	25.2%	3.5%
Porto	4.4%	14.2%	18. 9%	7.5%	22. 7%	18.7%	9.7%	3.1%	0.7%
Santarém	0%	1.0%	11.1%	4.0%	25.7%	27.1%	22.6%	6.7%	1.8%

Setúbal	1.7%	6.4%	9.6%	5.0%	36.3%	25.7%	12.9%	1.8%	0.4%
Viana do Castelo	5.4%	5.4%	6.8%	2.7%	20.3%	25.7%	18.9%	14.9%	0%
Vila Real	5%	0%	10%	15%	15%	20%	20%	15%	0%
Viseu	3.8%	7.8%	9.7%	10.3%	21.3%	23.8%	12.5%	8.1%	2.5%
Évora	2.3%	0%	5.4%	2.3%	26.9%	33.8%	17.7%	10%	1.5%

Annex 4

Table 1: Coefficient estimates for the districts in the model specification with EE variables.

	Log(price/m2)		EPC	
District	Coeff.	S.E.	Coeff.	S.E.
Aveiro (reference)				
Beja	0.284***	(0.0639)	-0.0237	(0.140)
Braga	-0.351***	(0.0568)	-0.881***	(0.0745)
Bragança	0.480***	(0.0871)	1.065***	(0.294)
Castelo Branco	-0.191***	(0.0665)	-0.835***	(0.0930)
Coimbra	0.0805**	(0.0351)	-0.143*	(0.0793)
Faro	0.265***	(0.0295)	0.128*	(0.0708)
Guarda	-0.0873	(0.0861)	-0.786***	(0.138)
Leiria	-0.168***	(0.0364)	-0.320***	(0.0754)
Lisboa	0.458***	(0.0292)	0.366***	(0.0657)
Portalegre	0.206***	(0.0548)	0.494***	(0.126)
Porto	0.0999***	(0.0284)	0.00366	(0.0672)
Santarém	0.128***	(0.0418)	-0.378***	(0.0761)
Setúbal	0.139***	(0.0303)	0.247***	(0.0701)
Viana do Castelo	0.133**	(0.0630)	-0.0317	(0.143)
Vila Real	0.359***	(0.117)	0.0431	(0.264)
Viseu	0.158***	(0.0428)	0.552***	(0.104)
Évora	1.082***	(0.0664)	0.690***	(0.145)

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 2: Disaggregated EPC.

	Output equation		**Selection equation**	
Variables	**Log(price/m2)**		**EPC**	
	Coef.	**s.e.**	**Coef.**	**s.e.**
Certificate (reference: D)				
A	0.404***	(0.0170)		
B	0.141***	(0.0120)		
C	0.00814	(0.00978)		
F	-0.0215	(0.0130)		
E	-0.131***	(0.0203)		
G	-0.0911**	(0.0481)		
Apartment	0.0256	(0.0229)	0.198***	(0.0513)
Log (size) [2]	-0.0308***	(0.00513)	-0.0115	(0.0125)
Bedrooms (reference: 0)				
1	-0.135***	(0.0428)	-0.288**	(0.131)
2	-0.169***	(0.0513)	-0.346**	(0.146)

3	-0.124**	(0.0625)	-0.287*	(0.172)
4	0.0222	(0.0760)	-0.175	(0.203)
5	0.139	(0.0875)	-0.150	(0.229)
6 or more	0.326***	(0.0972)	-0.176	(0.253)
Construction year (reference: 1300-1970)				
1971-1985	-0.0791***	(0.0165)	0.145***	(0.0405)
1986-1993	-0.0283*	(0.0166)	0.0854**	(0.0412)
1994-1999	0.0699***	(0.0174)	0.0863**	(0.0427)
2000-2003	0.143***	(0.0174)	0.0308	(0.0427)
2004-2007	0.228***	(0.0183)	0.118***	(0.0440)
2008-2011	0.415***	(0.0214)	0.364***	(0.0466)
2011-2015	0.383***	(0.0206)	0.146***	(0.0483)
New	-0.0262**	(0.0124)	0.0715**	(0.0336)
Renovated	0.134***	(0.0137)	0.146***	(0.0359)
Needs workd	-0.169***	(0.0254)	0.000445	(0.0644)
Rented	-0.0303	(0.0222)	0.141**	(0.0621)
Garage	0.0950***	(0.00872)		
Pool	0.273***	(0.0119)	0.0622**	(0.0312)
Garden	0.0818***	(0.00842)		
Terrace	0.0917***	(0.00993)	0.0320	(0.0262)
Balcony	-0.00696	(0.00853)	0.0513**	(0.0223)
Fireplace	0.0198*	(0.0102)	0.0755***	(0.0253)
Elevator	0.0566***	(0.00930)		
Security	0.155***	(0.0113)		
Heating system	0.135***	(0.0105)	0.0823***	(0.0264)
Air conditioning	0.136***	(0.0107)	0.0530*	(0.0290)
Solar panels	-0.0581***	(0.0168)	0.175***	(0.0449)
Gas	-0.0348***	(0.0108)	0.170***	(0.0258)
Electric blinds	-0.0310**	(0.0150)	-0.0718*	(0.0407)
Double window	-0.0471***	(0.0145)	-0.0491	(0.0395)
District (reference: Aveiro)				
Beja	0.299***	(0.0616)	-0.0237	(0.140)
Braga	-0.260***	(0.0532)	-0.881***	(0.0745)
Bragança	0.450***	(0.0838)	1.065***	(0.294)
Castelo Branco	-0.135**	(0.0699)	-0.835***	(0.0930)
Coimbra	0.0.0910***	(0.0364)	-0.143*	(0.0793)
Faro	0.309***	(0.0464)	0.128*	(0.0708)
Guarda	-0.0288	(0.0862)	-0.786***	(0.138)
Leiria	-0120***	(0.0370)	-0.320***	(0.0754)
Lisboa	0.450***	(0.0277)	0.366***	(0.0657)
Portalegre	0.181***	(0.0600)	0.494***	(0.126)
Porto	0.0927***	(0.0271)	0.00366	(0.0672)
Santarém	0.169***	(0.0403)	-0.378***	(0.0761)
Setúbal	0.142***	(0.0283)	0.247***	(0.0701)
Viana do Castelo	0.138***	(0.0586)	-0.0317	(0.143)
Vila Real	0.332***	(0.110)	0.0431	(0.264)
Viseu	0.128***	(0.0403)	0.552***	(0.104)
Évora	1.011***	(0.0628)	0.690***	(0.145)
Coastal municipalities	0.190***	(0.0102)	0.110***	(0.0253)
Distance to school	3.645***	(0.484)		
Distance to city hall	0.256***	(0.118)		
Distance to garden	-1.142***	(0.0665)		
Distance to hospital	-0.456***	(0.106)		
Distance to shopping center	-0.851***	(0.0576)		

Agency size			-0.000955***	(9.22e-05)
Lambda	0.334***	(0.0744)		
Constant	7.012***	(0.108)	0.869***	(0.260)
Observations	21,170		21,170	

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1