Valuing Energy Performance Certificates in the Portuguese Residential Sector

(Work in progress)

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VI Atlantic Workshop on Energy and Environmental Economics

A Toxa 2014

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Motivation

- Buildings have the largest potential for cost-effective energy savings through energy efficiency (EE) measures.
- There is a large number of market barriers that prevent agents from taking optimal decisions regarding EE, in particular in the residential sector, resulting in a suboptimal level of EE.
- There are evidences suggesting that informational and behavioral failures lead agents to take inefficient decisions regarding EE in the residential sector.

Motivation: labels

- Many governments have adopted informational instruments to mitigate the negative effects generated by both types of failures.
- They have the objective to promote EE by providing agents with necessary information that helps them to take efficient decisions.
- Labeling systems for buildings have experienced a rapid diffusion.

Motivation: the European Energy Performance Certificate System.

- The Energy Performance of Buildings Directive (Directive 2002/91/CE, then recast into the Directive 2010/31/EU) requires owners to show an Energy Performance Certificate (EPC) in the moment the building is sold or rented out.
- This EPC is the product of a common methodology that classifies the building according to its structural characteristics into EE categories (going from A or A+ to G).
- There are similar mechanisms in many other countries (EnergyStar and the LEED programm in the U.S.).

Certificação Energética e Ar Interior
EDIFÍCIOS

Nº CER 1234567/2007

CERTIFICADO DE DESEMPENHO ENERGÉTICO E DA QUALIDADE DO AR INTERIOR

TIPO DE EDIFÍCIO: EDIFÍCIO HABITAÇÃO UNIFAMILIAR / FRACÇÃO AUTÓNOMA DE EDIF. MULTIFAMILIAR

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 Características de Comportamento Térmico dos Edifícios (RCCTE, Decreto-Lei 80/2006 de 4 de Abril), classificando o imóvel em relação ao respectivo desempenho energético. Neste certificado poderão estar identificadas possíveis medidas de melhoria de desempenho aplicáveis à fracção autónoma ou edifício, suas partes e respectivos sistemas energéticos e ventilação, quer no que respeita ao desempenho energético, quer no que respeita à qualidade do ar interior.

1. ETIQUETA DE DESEMPENHO ENERGÉTICO

INDICADORES DE DESEMPENHO		
Necessidades anuais globais estimadas de energia útil para climatização e águas quentes	☐	kWh/m².ano
Necessidades anuais globais estimadas de energia primária para climatização e águas quentes	☐	kgep/m².ano
Valor limite máximo regulamentar para as necessidades anuais globais de energia primária para climatização e águas quentes	☐	kgep/m².ano
Emissões anuais de gases de efeito estufa associadas à energia primária para climatização e águas quentes	☐	Toneladas de CO_2 equivalentes por ano

CLASSE ENERGÉTICA

2. DESAGREGAÇÃO DAS NECESSIDADES NOMINAIS DE ENERGIA ÚTIL

Necessidades nominais de energia útil para...	Valor estimado para as condições de conforto térmico de referência	Valor limite regulamentar para as necessidades anuais
Aquecimento	kWh/m².ano	kWh/m².ano
Arrefecimento	kWh/m².ano	kWh/m².ano
Preparação das águas	kWh/m².ano	kWh/m².ano

Research question

- Despite the high adoption of labeling systems for buildings, little is know about their effectiveness.

We estimate consumers WTP for dwellings with a high EPC (A+, A or B) in the Portuguese residential sector. Portugal was one of the early adopters of the European EPC system, creating a considerable amount of data that allows us to contribute to the previous literature by:

- Providing the second study on the effectiveness of the European EPC system in the residential sector.
- Providing the first case study for the residential sector of a Southern European member state.
- Using quantile regression.

Literature review

- In the U.S. commercial sector Eichholtz, et al., 2010; Fuest and McAllister, 2011a; and Wiley et al., 2010 found a positive WTP for rated commercial buildings going from 16-25%.
- For the European commercial building, Fuerst and McAllister 2011b did not find any effect for the case of U.K.

- Regarding the residential sector, Brounen and Kok, 2011 found that dwellings with an European EPC A, B or C had a price premium of 3.7% in the Netherlands.
- Other researchers (Deng et al., 2012; Yoshida and Sugiura, 2011; Zheng et al., 2012) have studied the effects of different Asian labeling initiatives finding mixed results, what might be due to the own nature of those systems.

Data

- The lack of data represents the largest handicap for this research.
- Our sample consists of dwellings for sale with information about the EPC.
- The data was gathered from the web page of one of the most important real estate companies in Portugal during January-February 2013.
- Unique cross-sectional database with more than 5.300 observations containing a set of detailed dwelling characteristics, including asking price, size, age, location, the EPC, etc.

Data

Variable	**Level**	**Official data**	**Our sample**
Average price per squared meter		1741	1452
EPC	A+	0.5%	2.2%
	A	4.4%	10.3%
	B and B-	31.8%	26.9%
	C	32.3%	32.4%
	D	14.4%	16.5%
	E	8.1%	7.3%
	F	2.5%	2.7%
	G	6%	1.5%
Average year		33.92	20.08
Average area		109.9	140.4
Concentration of dwellings in the coast	coast	67.9%	88.8%
Construction type	apartment	66.2%	70.7%
General condition	no reparation needed	73%	94%

Data

Variable	Level	Portuguese housing stock	Our sample
Geographic distribution	Aveiro	6.2%	1.7%
	Beja	1.9%	0.7%
	Braga	6.9%	2.4%
	BraganÃ§a	1.8%	0.3%
	Castelo Branco	2.6%	0.6%
	Coimbra	4.7%	2.8%
	Evora	1.7%	0.6%
	Faro	6.8%	14%
	Guarda	2.3%	0.1%
	Leiria	5.1%	3.7%
	Lisboa	21%	45.3%
	Portalegre	1.4%	0.4%
	Porto	15%	11.9%
	Santarem	4.8%	2.8%
	Setubal	8.3%	11.8%
	Viana do Castelo	2.7%	0.5%
	Vila Real	2.5%	0.1%
	Viseu	4.3%	1.5%

The initial model

Following previous literature, we define the following price function:

$$l(pricem2_i) = \alpha + \beta AAB_i + \delta_1 year_i + \delta_2 l(size_i) + \delta_3 rooms_i +$$

$$+\delta_4 baths_i + \delta_5 extra_i + \delta_6 apart_i + \delta_6 floor_i + \delta_7 renov_{1\,i} +$$

$$\delta_8 needswork_i + \delta_9 capital_i + \delta_{10} othercenter_i + \delta_{11} privilege_i +$$

$$\delta_{12} coast_i + \delta_{13} urban_i + \gamma D_1 + \epsilon_i (1)$$

l(pricem2): logarithm of price per squared meter.
AAB: dummy equal to 1 if house has label either A+, A or B.
year:categorical variable for construction year.
l(size): logarithm of size in squared meters.
rooms: number of rooms.
baths: number of baths.
extra: dummy equal to 1 if house has any extra feature.
apart: dummy equal to 1 if house is apartment.
floor: number of floor.
renov: dummy equal to 1 if house has been renovated.
needswork: dummy equal to 1 if house needs work.

The initial model

Dummies for location:

- *capital*: dummy equal 1 if the house is located in the district's capital
- *othercenter*: dummy equal 1 if the house is located close to other center.
- *privilege*: dummy equal 1 if the house is located in the beach or historic area.
- *coast*: dummy equal 1 if the house is located in the coast.
- *urban*: dummy equal 1 if the house is located in an urban area.

Table : The value of EPC with OLS

Variable	Coefficient	(Std. Err.)
AAB	0.169***	(0.014)
1960.yearcat1	0.039	(0.044)
1970.yearcat1	-0.012	(0.043)
1980.yearcat1	-0.045	(0.039)
1990.yearcat1	0.010	(0.037)
2000.yearcat1	0.060	(0.038)
2005.yearcat1	0.164***	(0.039)
2010.yearcat1	0.264***	(0.039)
2014.yearcat1	0.296***	(0.040)
lsize	-0.392***	(0.024)
rooms	0.037***	(0.009)
baths	0.161***	(0.009)
extra	0.094***	(0.014)
apart	-0.126***	(0.019)
floor	0.010***	(0.003)
renov	0.037*	(0.022)
needswork	-0.226***	(0.030)
capital	0.379***	(0.023)
othercenter	0.070***	(0.020)
privilege	0.223***	(0.018)
coast	0.138***	(0.030)
urban	0.080**	(0.034)
dummy district	YES	
Intercept	7.744***	(0.117)
N	4251	
R-squared	0.566	

t statistics in parentheses
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

THE VALUE OF EPC VIA OLS AND QR

	OLS	Q(0.10)	Q(0.25)	Q(0.5)	Q(0.75)	Q(0.90)
AAB	0.169***	0.190***	0.171***	0.168***	0.174***	0.176***
	(11.91)	(7.82)	(9.74)	(14.03)	(9.91)	(6.54)
lsize	-0.392***	-0.498***	-0.436***	-0.398***	-0.316***	-0.349***
	(-16.07)	(-13.19)	(-17.17)	(-24.27)	(-13.03)	(-9.70)
rooms	0.0369***	0.0514***	0.0411***	0.0367***	0.0245*	0.0286*
	(3.98)	(3.61)	(4.22)	(5.71)	(2.52)	(2.08)
baths	0.161***	0.162***	0.159***	0.163***	0.162***	0.159***
	(17.28)	(11.87)	(15.76)	(24.52)	(16.34)	(10.45)
extra	0.0942***	0.0504*	0.0480**	0.0587***	0.106***	0.111***
	(6.91)	(2.16)	(2.74)	(5.05)	(6.28)	(4.66)
apart	-0.126***	-0.0413	-0.0931***	-0.126***	-0.127***	-0.243***
	(-6.53)	(-1.27)	(-3.94)	(-7.77)	(-5.29)	(-7.07)
floor	0.0102***	0.0133**	0.0101**	0.0103***	0.00764*	0.00981
	(3.91)	(2.74)	(2.75)	(4.08)	(2.03)	(1.84)
renov	0.0373	0.0278	0.0212	0.0274	0.0486	0.0750*
	(1.73)	(0.79)	(0.83)	(1.59)	(1.94)	(2.00)
needswork	-0.226***	-0.214***	-0.227***	-0.232***	-0.181***	-0.172***
	(-7.49)	(-5.17)	(-7.12)	(-10.44)	(-5.66)	(-3.56)
capital	0.379***	0.389***	0.344***	0.360***	0.418***	0.384***
	(16.72)	(10.08)	(12.07)	(19.00)	(15.81)	(10.28)
othercenter	0.0703***	0.103**	0.0729**	0.0709***	0.0611**	0.0310
	(3.56)	(3.23)	(3.04)	(4.38)	(2.66)	(0.97)
privilege	0.223***	0.205***	0.202***	0.194***	0.228***	0.245***
	(12.35)	(8.06)	(10.08)	(13.27)	(10.08)	(7.15)
coast	0.138***	0.0920	0.143***	0.176***	0.192***	0.216***
	(4.66)	(1.78)	(3.81)	(7.00)	(5.26)	(4.29)
urban	0.0804*	0.163***	0.0827*	0.0311	-0.0356	0.0223
	(2.39)	(3.74)	(2.41)	(1.31)	(-1.03)	(0.44)
dummy for year	YES	YES	YES	YES	YES	YES
dummy for district	YES	YES	YES	YES	YES	YES
N	4251	4251	4251	4251	4251	4251

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Next steps

- Analysis of potential sample selection bias in the data collection.
- More specific analysis of the subsample of dwellings located in Lisbon.

Conclusions

- According to our database, Portuguese consumers value the information provided by the EPC.
- The WTP found is much higher than the one previously found for the Netherlands during the early stage of the Energy Performance of Building Directive.
- This result goes in line with previous literate on consumers WTP for energy products with a high EPC.
- More research is needed on the field of informational instruments.

Thank you for attention!

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Table : The effect of District in the initial OLS estimation

Variable	Coefficient	(Std. Err.)
AAB	0.169**	(0.014)
capital	0.379**	(0.023)
othercenter	0.070**	(0.020)
privilege	0.223**	(0.018)
coast	0.138**	(0.030)
urban	0.080*	(0.034)
Aveiro	0.000	(0.000)
Beja	0.325**	(0.072)
Braga	-0.115*	(0.057)
Braganca	0.344**	(0.106)
Castelo Branco	-0.097	(0.088)
Coimbra	-0.015	(0.046)
Faro	0.154**	(0.039)
Guarda	-0.100	(0.169)
Leiria	0.002	(0.048)
Lisboa	0.468**	(0.035)
Portalegre	-0.086	(0.098)
Porto	0.124**	(0.037)
Santarem	-0.016	(0.054)
Setubal	0.169**	(0.038)
Viana do Castelo	0.097	(0.085)
Vila Real	0.180	(0.326)
Viseu	-0.054	(0.060)
Evora	0.225**	(0.083)
Intercept	7.744**	(0.117)
N	4251	

Table : Results for the initial OLS model excluding FARO

Variable	Coefficient	(Std. Err.)
AAB	0.239**	(0.017)
1945b.yearcat1	0.000	(0.000)
1960.yearcat1	0.038	(0.047)
1970.yearcat1	-0.003	(0.045)
1980.yearcat1	-0.049	(0.044)
1990.yearcat1	-0.038	(0.041)
2000.yearcat1	-0.012	(0.042)
2005.yearcat1	0.071†	(0.043)
2010.yearcat1	0.169**	(0.043)
2014.yearcat1	0.219**	(0.044)
lsize	-0.350**	(0.027)
rooms	0.031**	(0.011)
baths	0.168**	(0.010)
extra	0.048**	(0.017)
apart	-0.087**	(0.023)
floor	0.010**	(0.003)
renov	0.076**	(0.025)
needswork	-0.182**	(0.034)
capital	0.490**	(0.025)
othercenter	0.151**	(0.020)
privilege	0.260**	(0.021)
coast	0.375**	(0.021)
urban	0.056	(0.036)
Intercept	7.581**	(0.121)
dummy for district	YES	
N	3629	

Table : Results for the initial OLS regression including only FARO

Variable	Coefficient	(Std. Err.)
AAB	0.070*	(0.032)
1945b.yearcat1	0.000	(0.000)
1960.yearcat1	0.045	(0.214)
1970.yearcat1	-0.031	(0.191)
1980.yearcat1	0.225	(0.186)
1990.yearcat1	0.330†	(0.184)
2000.yearcat1	0.396*	(0.183)
2005.yearcat1	0.415*	(0.182)
2010.yearcat1	0.432*	(0.181)
2014.yearcat1	0.384*	(0.184)
lsize	-0.573**	(0.060)
rooms	0.051*	(0.025)
baths	0.184**	(0.024)
extra	0.199**	(0.029)
apart	-0.119**	(0.046)
floor	0.002	(0.006)
renov	-0.034	(0.060)
needswork	-0.295**	(0.104)
capital	0.175	(0.110)
othercenter	0.151	(0.106)
privilege	0.001	(0.062)
coast	-0.003	(0.203)
urban	0.098	(0.109)
Intercept	8.734**	(0.343)
dummy for district	YES	
N	622	

Table : Results for the initial OLS model including only LISBON

Variable	Coefficient	(Std. Err.)
AAB	0.184**	(0.023)
1945b.yearcat1	0.000	(0.000)
1960.yearcat1	0.065	(0.052)
1970.yearcat1	-0.011	(0.047)
1980.yearcat1	-0.018	(0.046)
1990.yearcat1	0.036	(0.044)
2000.yearcat1	0.082†	(0.048)
2005.yearcat1	0.139**	(0.050)
2010.yearcat1	0.241**	(0.050)
2014.yearcat1	0.313**	(0.051)
lsize	-0.296**	(0.036)
rooms	0.026*	(0.012)
baths	0.179**	(0.014)
extra	0.064**	(0.021)
apart	-0.092**	(0.030)
floor	0.014**	(0.004)
renov	0.036	(0.027)
needswork	-0.176**	(0.037)
capital	0.626**	(0.037)
othercenter	0.203**	(0.034)
privilege	0.198**	(0.022)
coast	0.397**	(0.104)
urban	0.337**	(0.091)
Intercept	7.027**	(0.207)
dummy for district	YES	
N	1883	

Table : Regression excluding price and age outlier

Variable	Coefficient	(Std. Err.)
AAB	0.165**	(0.014)
1945b.yearcat1	0.000	(0.000)
1960.yearcat1	0.056	(0.043)
1970.yearcat1	0.022	(0.044)
1980.yearcat1	-0.021	(0.040)
1990.yearcat1	0.044	(0.038)
2000.yearcat1	0.096*	(0.039)
2005.yearcat1	0.206**	(0.039)
2010.yearcat1	0.307**	(0.039)
2014.yearcat1	0.340**	(0.040)
lsize	-0.424**	(0.023)
rooms	0.038**	(0.009)
baths	0.152**	(0.009)
extra	0.083**	(0.014)
apart	-0.137**	(0.019)
floor	0.010**	(0.003)
renov	0.036†	(0.021)
needswork	-0.218**	(0.030)
capital	0.367**	(0.022)
othercenter	0.063**	(0.020)
privilege	0.205**	(0.018)
coast	0.140**	(0.029)
urban	0.077*	(0.033)
Intercept	7.906**	(0.115)
dummy for district	YES	
N	4164	