Implementing Energy Performance Certificates – Informing the Informed?

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Abstract

Energy Performance Certificates (EPCs) are intended to provide reliable information about the energy performance of buildings at affordable costs and at the appropriate time to tenants and buyers. As improved energy performance of buildings may increase sales prices and rents, the EPCs are supposed to generate incentives among tenants to invest in energy efficiency. In this sense, the EPC is a remedy for the market failure of imperfect information. The empirical evidence for a price premium associated with energy labels is however inconclusive and partly contradictory. By utilizing data from the Norwegian housing market, we first use the hedonic approach and manage to reproduce the positive price premium effect found in earlier studies. However, when we check these results with a repeated sales data set, where we take advantage of the fact that the introduction of a mandatory energy certification system represents a natural experiment, we find no evidence of a price premium. On the contrary, we present quite robust evidence that there is no effect of the energy label itself. That is, market failure in the form of imperfect information does not seem to be the impediment or barrier of investment in energy saving measures of buildings.

Key words: Energy Performance Certificates, Energy savings, Hedonic models, Repeated sales model, Housing policy.

JEL: Q4, Q5, R2, R3

1. Introduction

Energy upgrading of buildings is a major focus in the industrialized countries' endeavor to achieve energy efficiency and sustainable development. However, the process of upgrading is slow. Although several cost effective energy saving measures are available for owners, the potential of energy conservation is not realized (Curtain and Maguire, 2011). In the literature this is often explained by the existence of particular impediments or barriers of investment in energy saving measures (Weber, 1997; Murphy, 2014). Market failure in the form of imperfect information is suggested to be one of these barriers (Weber, 1997; Amecke, 2012). Based on this, researchers and policy makers have called for increased information transparency in the energy consumption of buildings.

The imperfect information perspective is clearly reflected in the Energy Performance of Buildings Directive (EPBD), which is the main EU policy instrument used to obtain energy efficiency. The EPBD intends to provide reliable information about the energy performance of buildings at affordable costs and at the appropriate time to tenants and buyers by the use of Energy Performance Certificates (EPCs). As improved energy performance of buildings may increase sales prices and rents, the information provided to potential buyers by the EPC is supposed to generate incentives among tenants to invest in energy efficiency (Bio Intelligence Service, Ronan Lyons and IEEP, 2013).

Several studies have addressed the EU implementation of energy labels of buildings empirically. The first evidence on the economic impacts of the EPC implementation is provided by Brounen and Kok (2011). They perform a hedonic regression analysis based on some 170 000 housing transactions in the Netherlands and conclude there is a price premium for houses which are labeled as more energy efficient. Likewise, a report prepared for the European Commission concludes that the EPCs have a significant impact on transaction prices and rents in selected EU countries (Bio Intelligence Service, Ronan Lyons and IEEP, 2013). The report contains a literature review carried out of 22 studies that use hedonic regression models to examine whether the EPCs affect property values. Moreover, the report itself provides an analysis using the hedonic regression model carried out for datasets obtained from Austria, Belgium, France, Ireland, and the UK. The report concludes that the analysis “overwhelmingly points to energy efficiency being rewarded by the market” (Bio Intelligence Service, Ronan Lyons and IEEP, 2013, p. 12). As a response to the finding the report recommends that the role of EPCs is strengthened. In particular, the EPC should be implemented faster, published earlier in the transaction process (e.g. at the time of advertising), made more visible (e.g. a more eye-catching front page), and made easier to understand (e.g. using plain language and improving the layout).

Other studies indicate that EPCs have a weak or negligible impact on transaction prices. Murphy (2014) studies the role of the EPC in the transaction process of buildings in the Netherlands by an online questionnaire. She concludes that few householders use the EPC during the transaction process and holds that the EPC will not have the impact intended even if fully implemented. Similar surveys carried out in the UK (Laine, 2011) and Germany (Amecke, 2012) come to the same conclusion that the EPCs only have a modest or negligible impact on price negotiations and the purchaser decisions. Moreover, based on in-depth interviews with homeowners in ten European countries, as well as a large survey among homeowners in five European countries, Backhause et.al (2011) conclude that the EPCs have a small or negligible impact on the homeowners investment decisions.

The empirical literature thus draw two very contrasting conclusions when it comes to the role played by the EPCs in energy conservation. We find the case of the Netherlands of particular interest: In the same country, and approximately at the same time, the large statistical study by Brounen and Kok (2011), using a EPC database, a real estate database and economic and voting data, indicates that the EPCs indeed are capitalized into transaction prices while the survey data of Murphy (2014, p. 666) “shows that a higher EPC fails to have a direct influence during negotiation and decision making.”

However, we suspect that the apparently contrasting evidence on the role played by EPCs is due to a confusing of the impact of the energy performance of buildings with the impact of the energy performance *labelling* of buildings. Indeed, even before the implementation of EPCs, the literature review of the Bio Intelligence Service, Ronan Lyons and IEEP (2013) refers to studies that identify a positive relationship between the energy performance and the property value and transaction price of buildings. This implies that information about the energy performance of buildings must have been available even in the absence of EPCs. In accordance with this, we have reasons to believe that the claimed positive effect of the EPCs on transaction prices *per se* is but a reflection of the impact of alternative sources of information which are appropriated by the buyer. That is, the EPCs carry information about the energy performance of a building which the buyer already possesses. The present paper provides evidence supporting our suspicion.

In section 2 we provide some facts about the energy labelling system of dwellings and houses and its implementation in EU and in Norway. Next, in section 3, we describe our data and method. In section 4 we present the results and discuss the findings. Section 5 concludes.

2. The Energy Labelling System of Dwellings and Houses

The Energy Performance of Buildings Directive (EPBD) is the main legislative instrument of EU to improve the energy performance of buildings (Directive 2002/91/EC). Rooted in the EPBD, Energy Performance Certification (EPC) was introduced gradually depending on the various Member States from 2006. The final deadline for implementing a mandatory energy labelling scheme in the Member States was 2009. A recast of the EPBD (Directive 2010/31/EU) in 2010 strengthened the role of EPCs in "… raising awareness of better energy performance of buildings by demanding publication of the energy performance indicator of the EPC at the time of advertising a building for sale or rental rather than only at the time of signing a purchase agreement or rental contract" (Bio Intelligence Service, Ronan Lyons and IEEP, 2013, p. 2).

The EPC provides reliable information about the energy performance of buildings at affordable costs and at the appropriate time to tenants and buyers. In most of the Member States the energy performance ratings are expressed on a letter scale, as for instance from A to G, where A is very efficient and G is very inefficient. As improved energy performance of buildings may increase sales prices and rents, the EPC is supposed to generate incentives among owners to invest in improving energy efficiency (Bio Intelligence Service, Ronan Lyons and IEEP, 2013).

However, the implementation of energy performance certificates has been slow in the EU. The implementation and quality of certification schemes vary from country to country, and it is held forth that "low ambition in implementation leads to certification schemes of poor quality, i.e. not providing sufficient and accurate information or the necessary quality control"

(Bio Intelligence Service, Ronan Lyons and IEEP, 2013, p. 18). The adoption rate of EPCs vary from 10% (Cyprus) to close to 100% (Portugal, France). However, it should be noted, that even in countries with high adoption rates, the EPC is often provided too late in the decision making process to have an impact (Bio Intelligence Service, Ronan Lyons and IEEP, 2013).

Based on the EPBD of EU, the Energy Labelling System for Houses and Dwellings was fully implemented in Norway in July 2010. The Ministry of Petroleum and Energy together with the Ministry of Local Government and Regional Development had the overall responsibility of implementation, while the Norwegian Water Resources and Energy Directorate was pointed out as the managing body of the certification and inspection schemes (Isachsen, Grini and Rode, 2010). The energy performance certification was fully mandatory from the beginning. That is, from July 2010 all transactions are accompanied by an EPC.

The EPC is a legal document and it is required that it is shown to the buyer. However, as noted by Isachsen, Grini and Rode (2010, p.2), “parts of the certificate, for instance the Energy Label, can be used as a short version.” The document contents, among other things, some data identifying the building and the agent responsible for issuing the certificate, the energy label which report the energy grade (representing the calculated delivered energy need) ranging from A to G and the heating grade (representing to what extent heating of space and water can be done with renewable energy sources) represented by colour, advice on energy use which can save energy, and some general recommendations to the buyer (Isachsen, Grini and Rode, 2010).

The certification scheme in Norway is characterized by a self-assessment option for owners of existing apartments and buildings. In most cases these certificates will be more general than those carried out by experts. However, for new buildings , a qualified expert is required for certification. The quality assurance aspect of the Norwegian certification scheme is attended to by controls in the market where faulty inputs may be considered a breach of contract. In such cases a fine may be issued. The transaction process is supervised by the Norwegian Water Resource and Energy Directorate (NVE). The NVE carry out a systematic supervision of whether EPCs are presented at sale, whether the EPCs represent the building object, and whether experts meet the competence requirements etc. (Isachsen, Grini and Rode, 2010).

3. Data and Methods

3.1 Data sources and descriptive statistics

The real property transaction data are compiled from the property register of Oslo. Oslo is the capital of Norway, with a population of approximately 650 000 citizens. Different providers make the property register available on internet. Our data is collected from the source eiendomsverdi.no. Transactions at the Norwegian housing market is best characterized as an English auction. The buyers compete with open bids, and where the highest bid wins the auction. The first bid of each potential buyer has to be in writing and with proper documentation and required ID, while later bids may be given by text messages. There is also a rule that the time limit for acceptance of the first bid cannot be before 12 noon the first day after the showing.

Eiendomsverdi.no categorizes the dwelling by type and city districts. The registration of transactions where conducted in December 2014 including transactions conducted through the entire year. We recorded all transaction prices of each property in the sample, in addition to information about the property's attributes. More specifically, we registered the price and date of all transactions of the property, its address and city district, the size of the dwelling, the type of housing, and the year of construction. In addition to information from the property register, the internet page eiendomsverdi.no also provides the original internet advertisement from the internet advertisement service, finn.no. We use these advertisements to collect information about which energy label the dwelling was advertised with, ranging from A to G. In cases where the energy label was not stated in the advertisement, it is not clear whether the dwelling was advertised with energy label through other advertisement channels, and hence such dwellings were left out. Transactions with special characteristics, such as e.g., when the property is sold to family members or the transaction price for some other reason is significantly higher or lower than the normal price for the property type in the area, were also left out.

Table 1 reports the number of energy labels issued for dwellings in the Norwegian market in the period from 2009-2014. Note that the number of certificates in 2010 is about half of the level in the successive years since the system was made mandatory for sales from July 2010. Note that some few residences got their energy certificate already in 2009. These are mostly new houses were the developer acted in advance anticipating the upcoming certification system.

Table 1: Number of issued energy labels certificates

The table shows the number of issued energy labels certificates in Norway between 2009 and 2014. Energy labelling was made mandatory July 1st 2010. Source: Energimerking.no

	Year					
	2009	*2010*	*2011*	*2012*	*2013*	*2014*
Number of dwellings	*258*	*50183*	*85591*	*104587*	*102587*	*98909*

Table 2 presents the 2014 data with respect to type of dwelling and energy label. The requirements for A and B type certificates is quite comprehensive, and hence only a very few houses reaches above type C. This is confirmed in Table 3, where we report construction year for dwellings sold in 2014. Even in the group of dwellings constructed after 2011, only about 1% is of the A type, and about 22% is in the B group.

Table 2: Dwelling type and energy labels for dwellings traded in 2014

	Total	A	B	C	D	E	F	G
Single-Family houses	407	1	10	29	37	78	92	160
Apartments	1164	0	24	126	245	170	266	332
Townhouses	284	0	6	33	51	51	79	63
Semi-detached houses	213	1	2	26	29	17	39	99
Sum	2068	2	42	214	362	316	476	654

Table 3: Construction year and energy labels for dwellings traded in 2014

	A	B	C	D	E	F	G
2011-2014	2	31	75	22	3	0	4
2001-2010	0	8	115	209	32	5	11
1991-2000	0	0	5	72	66	17	3
Before 1991	0	3	19	59	215	454	636
Total	2	42	214	362	316	476	654

Repeated sales data

In the real property registers in Norway, information on all transactions of a property are recorded at the same place. Hence repeated sales information on properties is easily available.

In the repeated sales data, only dwellings which has been sold more than once over the sample period, are included. Single transactions of a house are hence excluded from the repeated sales sample. A second group of transactions, which we do not include in the repeated sales sample, is transaction pairs where the quality of the properties have changed. Hence, we have excluded transaction pairs of a real property if the size of the yard has been changed or if a new house has been constructed between the two transactions. Ideally, we should also have controlled for other changes in the houses' attributes, such as depreciation, refurbishments, electricity, and sanitary installations, etc. Unfortunately, data on such characteristics are not easily available.

The dwelling type and energy labels are summarized in Table 4. Again, the number of dwellings in the A and B group is very limited. Table A1 in the appendix presents information on what years the transactions took place. For example, the table tells us that of the 1633 dwellings sold in 2014, 129 was sold the previous time in 2013.

Table 4: Type of dwelling and energy labels in repeated sales data set

	Total	A	B	C	D	E	F	G
Single-Family houses	421	0	6	19	51	80	107	158
Apartments	2363	0	17	154	450	352	635	755
Townhouses	399	0	5	42	93	79	115	65
Semi-detached houses	314	1	4	34	49	30	63	133
Sum	3497	1	32	249	643	541	920	1111

3.2 Methods

The hedonic model: Time dummy variable method

The hedonic method is a widely used technique to control for the heterogeneous nature of properties when constructing house price indices. Dating to Court (1939), and with Rosen (1974) as its basis in theory, it is customarily employed to measure the contribution of individual house characteristics to the overall composite value of the housing asset. It recognises that properties are composite products: although attributes are not sold separately, regressing the price of dwellings on their various characteristics yields the marginal contribution of each characteristic. A well-specified hedonic model will estimate the contribution to the total price of each of these features separately.

One of the hedonic models is the time dummy variable method. It is sometimes referred to as a direct method because all the price information comes from the hedonic function: no prices come from an alternative source. Direct methods require estimation of a hedonic function for every index separately. We estimate the house price with an approach often referred to as the "additive model." The way the regression is specified makes the method similar to the median/average/modus price model adjusted for different qualities.

We estimate a hedonic equation of the form

$$\ln(P_{it}) = \gamma_0 + \delta_t + \sum_k \alpha_k c_{kit} + e_{it} \qquad (1)$$

where P is the house price per square metre, c is a set of explanatory variables for the presence of certain characteristics, k, the period t $(t=1,...,T)$, and the dwelling i, respectively. The dummy variables are the dwelling type and dwelling size (square meters and quadrat square meters), location (based on the different city districts), age measured by 1/((sale year-construction year)+1), and dummy variables for the advertised energy labelling, A to G.

We apply the log-linear functional form in particular because coefficients can be more easily interpreted and because it mitigates some statistical problems (Malpezzi, 2003).). For the hedonic regression before 2010, we let the term δ_t represent the time dummy coefficients defined as changes with respect to the base year intercept γ_0, so that $\delta_t = \sum_{s=1}^{S} \delta_s d_{sit}$, where d_{sit} takes the value 1 when $s=t$ and 0 otherwise. In total $(T+1)$ periods are observed.

The weighted repeated sales method

The main advantage of the repeated sales method compared to the hedonic method is that it does not require detailed data on specific characteristics of the dwellings. Thus, the method relies less on dwelling characteristics that may be difficult to observe. Also, the repeated sales method automatically controls for micro location (i.e. address), something that hedonic methods are unable to. A potential disadvantage of the repeated sales method is that frequently sold houses may be lemons, starter-homes or speculation objects, and thus represent a different quality compared to the rest of the market. In addition, new dwellings are likely to be under-represented in the sample at the end of the sample period.

The repeated sales method was introduced by Bailey (1963), and is, as noted above, based on repeated transactions of individual houses. The repeat sales data can be pooled and the model estimated with the standard repeat sales equation Eurostat (2011).

$$\ln(p_n^t / p_n^s) = \sum_{t=0}^{T} \gamma_t D_n^t + \mu_n^t \qquad (2)$$

where p_n^t is the price at the time of the resale, p_n^s is the price at the previous sale, D_n^t is a dummy variable with value 1 in the period in which the resale occurs, -1 in the period in which the previous sale occurs, and 0 otherwise. μ_n^t is the error term. The residuals are assumed to have zero means, constant variances, and to be mutually independent. However, as noted in Case and Shiller (1987, 1989), the variance of the residuals may increase with the time interval between the sales in the transaction pairs, and hence violate the assumption of constant residual variance. Such residual heterogeneity may for instance be due to the fact that it is more likely that unobserved characteristics have changed for transaction pairs that span long time intervals.

Case and Shiller (1987) suggested a three-step procedure to take into account this potential heterogeneity, so that transaction pairs over long time intervals are given less weight than transaction pairs within shorter time intervals. The three steps of the weighted repeat sales method are conducted as follows. In the first step, Equation (1) is regressed by OLS. Then, in the second step, the squared residuals are regressed on a constant and the time interval of each transaction pair using OLS. In the third step, we first divide each variable in Equation (1), i.e.

both the log price differences and the time dummy variables, with the square root of the fitted values from step two, and re-estimate the equation with the generalized method of moments (GMM).

House price indices for each energy label are estimated with the weighted repeated sales method described above. The levels of the indices are represented by the coefficients from step three. Since the estimations are based on logarithmic values of transaction prices, the indices are in logarithms. Hence, to obtain appropriate levels of the indices we take the exponents of the coefficients. The resulting indices represent the expected values of the geometric mean of the house price growth rates.

The data set contains no dwelling constructed before 2010 with energy label A and only eleven dwellings with energy label B constructed before 2010. This leaves us with too few observations to construct house price indices for dwellings with the two highest energy labels. We construct house price indices for the rest of the energy labels C to G in addition to a main index (all) that includes the A and B labels.

To test for whether variables are stationary, we use a simple Dickey-Fuller test (Table A2). All the variables have one unit root, and we therefore differentiate them to make them stationary. To test for autocorrelation we use a Durbin-Watson test and a Portmanteau test for white noise. Since there is indication of autocorrelation AR(1) we apply a Prais-Winsten regression (Prais and Winsten (1954)) to reduce the problem. The Prais-Winsten regression is a modification of the Cochrane-Orcutt estimation (Cochrane and Orcutt (1949). The method assumes that the error term in the residuals is AR(1) noise with a serial autocorrelation of ρ.

By estimating ρ, we transform our variables, obtaining new estimates for slopes and intercept and new residuals. As long as we still have autocorrelations in our residuals, we redo the process until we find a ρ without autocorrelation in the corresponding residuals.
Our regression is:

$$Y^{*} = \beta_0 (1-\rho) + \sum \beta_j x_{tj}^{*} + \sum \delta_s + \varepsilon_t \qquad (3)$$

where β_j is the coefficient for the j_{th} explanatory variable, δ_s is the coefficient for the s_{th} dummy variable, and ε_t is the error term. The * denotes the transformation of our variables. In our regression the explanatory variables is all (index for all the dwelling with different energy labels). In addition we use a dummy for the time when the energy labeling was made mandatory, July to December 2010.

4. Results and discussion

4.1 Hedonic results

The results from the hedonic model is presented in Table 5. The logarithm of the transaction price per square meter is explained by traditional explanatory variables comparable with those in Brounen and Kok (2011), such as the age and size (in square metre) of the building, the neighbourhood characteristics identified by the address, the dwelling type, year dummies before 2010, and the energy label dummies. All the traditional explanatory variables are significant at the 1% level and with the expected sign.

The interesting thing to note here is that the energy labels in the 2014 data have the expected sign, and is significant at the 1% level, for the B, C, and D labels. F is the reference label and may thus explain that E is not significant since the difference between E and F is not too pronounced. The A label is neither significant because of the very low *n*. The G category is also a little surprising, being significant with the wrong sign. But here we have to take into account that the G category may be of a different type than the others. Indeed, all residences where the owner does not take any action with respect to energy labelling will automatically be put in the G group. Hence, if the owner for some reason (ignorance/ lack of care) neglects to fill in the energy forms, the dwelling will end up in this category.

The main message from the hedonic data is that the results in Brounen and Kok (2011) are supported. As higher energy labels are associated with higher sales prices, there seems to be a price premium for buildings with energy labels. The adjusted R-Square is 0.52 in the 2014 cross section data, while it is as high as 0.65 in the data preceding 2010. However, one potential shortcoming of the hedonic model is that it fails to identify the causal relationship between energy labels and transaction prices. One factor is the failure to identify all relevant variables, and another, and perhaps more evident in the present case, is the cross sectional nature of the data. We therefore test if the results hold when we take advantage of the natural experiment the introduction of energy labels imposed.

Table 5. Energy labels and transaction prices (dependent variable: natural logarithm of transaction prices per square meter)

	Before 2010	2014
1/((sale year-construction year)+1)	.0699537***	.2442906***
Ln square meter	-.1969783***	-.2274339***
Dummy St. Hanshaugen	-.0933872***	-.0782426***
Dummy Gamle Oslo	-.2240007***	-.2557866***
Dummy Grynerløkka og Sagene	-.1676332***	-.2200366***
Dummy Outer Oslo West	-.0980722***	-.1497458***
Dummy Outer Oslo East	-.3744087***	-.4561038***
Dummy Single-Family houses	.0875754***	.0844457***
Dummy Townhouses	.0597913***	.0539309***
Dummy Semi-detached houses	.0553514***	.0874117***
A		-.0701462
B	.2118917**	.1519785***
C	.0886721***	.1116743***
D	.0902134***	.0751543***
E	.041364***	.0100414
G	.0257021**	.0558257***
2009	.6023094***	
2008	.5442775***	
2007	.5617245***	
2006	.4911943***	
2005	.3556569***	
2004	.2757366***	
2003	.1461984***	
2002	.1793935***	
2001	.1116181***	
Constant	10.87281***	11.97938***
Adj R-square	0,645	0,5235
Number of observations	1883	2024

*** Significant at the 1% level

4.2 Repeated sales results

Despite the quite convincing adjusted R-squares presented above, we are not able to conclude on causal relationships in such cross sectional data. To test the nature of the potential causal relationship between energy labels and sales price, we utilize the natural experiment that took place when the energy labels were made mandatory in July 2010. The idea is to compare the transaction prices of dwellings when they are sold before and after the implementation of the law regulation in July 2010. If energy labels are important in determining sales prices, two houses sold in e.g. 2008 for approximately the same price, should have approximately the same price when resold after July 2010 if they got the same energy label. On the other hand, if one of them got a higher energy label, it should have a higher resale price if the energy label provides the anticipated positive effect.

To explore the effect of introducing energy labels, we construct price indices for the different energy labels, and let them all have a value 100 in year 2000 (see Table A3 in Appendix). The indices are presented in Figure 1. The adjusted R-squares range from 0.23 for the G- group to 0.78 in the F group, while the Prais-Winsten transformed Durbin-Watson statistics range from 1.39 to 2.46, which means we keep the null hypothesis of zero autocorrelation.[1] If energy labelling has the price effect found in the hedonic data, we should expect a kink with increasing slope after July 2010 for the highest energy labels. However, it is hard to see any shift taking place in July 2010. This is confirmed in Table 6 where the dependent variable is the house price in the different energy label categories, and where we regress on the main index as well a dummy variable for the second part of 2010 when the energy label was made mandatory.

The only significant 2010 dummy is the in the F label category, and with the opposite of the expected sign. It hence seems quite clear that when exploring if the energy label itself has a price premium, we find no such evidence.[2] The reason why higher energy labelled dwellings have a higher price in the hedonic model seems to be that the characteristics of the dwellings

[1] With n=15 and k=2, the keep H0 critical values range from 1.25 to 2.75.

[2] Note also that one potential problem in the resale data is that we have no way of controlling for renovation efforts between the sales. If there is a bias towards renovation in the repeated sales data, we would be likely to find higher resale prices. However, renovation will also be likely to increase the energy label of the dwelling. This would in fact make it more likely to find a price label premium in our data. Hence, despite this potential energy label bias, we still do not find any effect of energy labels.

are different. These different characteristics may very well be associated with energy efficiency, but the labelling in itself seems to have no effect.

Studies based on the hedonic regression model, our own included, suggest there is a price premium for houses which are labelled more energy efficient. On the other hand, various surveys, as well as our own natural experiment based on repeated sales prices, find no evidence of a price effect associated with the energy labelling. A reasonable interpretation of these seemingly contradictory results is that buyers receives information about the energy performance of buildings by other means than the energy labels. Several variables which are important in the determination of the energy performance of buildings are left out of the hedonic regression models. These variables will be closely correlated with the energy label index. Hence, if they are observable for the buyers during the transaction process, they will be responsible for the reported price premium rather than the energy labelling in itself.

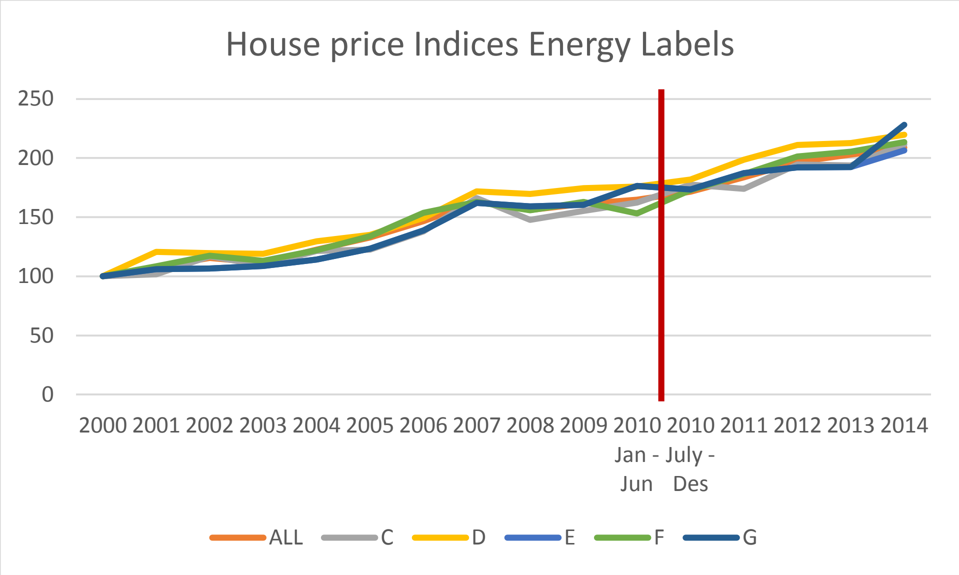

Figure 1: House price Indices Energy Labels

Nominal house price indices between 2000 and 2014. All indices start at 100 in 2000. Since energy labelling was made mandatory July 1st 2010, 2010 has been given two data points in the indices, one for the period January to June and one for the period July to December. The vertical line indicates when the energy labelling was mandatory. All = main index dwellings with all the different energy labels are included, C = index with dwellings with energy label C, D = index with dwellings with energy label D, E = index with dwellings with energy label E, F = index with dwellings with energy label F, G = index with dwellings with energy label G.

Table 6: Dwelling price in different energy label categories

*In the table we compare how well the dummy for when energy labeling was made mandatory, July to December 2010, are able to explain the house price with different energy labels together with the main house price index, All, that includes all the dwellings. All = main index dwellings with all the different energy labels are included, C = index with dwellings with energy label C, D = index with dwellings with energy label D, E = index with dwellings with energy label E, F = index with dwellings with energy label F, G = index with dwellings with energy label G. DW transf. referees to the Durbin-Watson statistic, transformed after using the Prais-Winsten regression. Significance at the 1%, 5% and 10% levels is denoted as ***, **, and * respectively.*

	Ln C	Ln D	Ln E	Ln F	Ln G
Ln All	1.047823***	0.8766127***	0.7320**	1.1438***	0.698527**
Dummy 2010 July - Des	0.0192783	-0.002885	-0.04920	0.05874*	-0.0466735
Constant	-0.0014834	0.0039038	0.01599	-0.0099696	0.02222
Adj. R^2	0.5286	0.7267	0.3891	0.7772	0.2318
DW transf.	2.1095	1.3925	1.8746	2.4571	1.6850

5. Conclusion

The Energy Performance of Buildings Directive (EPBD) is the main EU policy instrument used to obtain energy efficiency. The EPBD intends to provide reliable information about the energy performance of buildings at affordable costs and at the appropriate time to tenants and buyers by the use of Energy Performance Certificates (EPCs). As improved energy performance of buildings may increase sales prices and rents, the information provided to potential buyers by the EPC is supposed to generate incentives among tenants to invest in energy efficiency (Bio Intelligence Service, Ronan Lyons and IEEP, 2013). The empirical evidence for a price premium associated with energy labels is however inconclusive and partly contradictory. While Brounen and Kok (2011) found clear evidence for an energy label price premium in their hedonic data set for Netherland, other studies, even in the same country like in a study of Murphy (2014), find small or negligible effects of energy labels.

By utilizing data from the Norwegian housing market, we first use the hedonic approach and manage to reproduce the positive price premium effect found in Brounen and Kok (2011). However, when we check these results with a repeated sales data set, and where we take advantage of the fact that the introduction of the mandatory energy certification system represents a natural experiment, we find no evidence of a price premium. Hence, based on our data, we conclude that there is no effect of the energy label itself. That is, market failure in the form of imperfect information does not seem to be the impediment or barrier of investment in energy saving measures of buildings.

There are many energy labels for different products that are sold today. One interesting question would be if our results carry over to other markets. Even if this is hard to tell, one clear advantage of our data is that they are created based on English auction transactions. To our knowledge, this is the first attempt to measure the price premium effect of energy labels in a market where the transactions are made in a perfectly competitive bidding context. Another question is whether the implication is that energy labels should be abandoned since they have no effect. We do not wish to conclude, but at least one should ask if not other and more efficient tools should be introduced. Our results suggest that one should consider more direct regulations in terms of legal energy efficiency requirements, and in terms of taxes and/or subsidies if the main goal is to contribute to a more energy efficient housing market.

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Appendix

Table A1: Time of previous sale $\mathbf{p_n^s}$ and resale sale $\mathbf{p_n^t}$

The table shows when the dwellings in the repeated sales dataset that makes up the transaction pares was sold the first and the second time previous sale $\mathrm{p_n^s}$ and resale sale $\mathrm{p_n^t}$.

	Previous sale p_n^s	Resale p_n^t
2014	0	1633
2013	129	150
2012	198	125
2011	234	163
2010 July - Des	103	73
2010 Jan - Jun	139	89
2009	209	134
2008	205	115
2007	194	129
2006	235	113
2005	199	103
2004	178	88
2003	179	106
2002	161	93
2001	147	88
2000	123	55
Before 2000	869	245
Sum	3502	3502

Table A2: Dickey-Fuller tests for unit root of all variables

The 5%interpolated Dickey-Fuller critical values are used. No lags are included in the test. Ln means that natural logarithms have been used. All = main index dwellings with all the different energy labels included, C = index with dwellings with energy label C, D = index with dwellings with energy label D, E = index with dwellings with energy label E, F = index with dwellings with energy label F, G = index with dwellings with energy label G.

	Levels		First differences	
Variables	Test stat.	Crit. Val.	Test stat.	Crit. Val.
Ln All	-0.995	-3.000	-3.740	-3.000
Ln C	-0.663	-3.000	-6.458	-3.000
Ln D	-1.526	-3.000	-5.036	-3.000
Ln E	-0.667	-3.000	-3.607	-3.000
Ln F	-0.898	-3.000	-3.776	-3.000
Ln G	-0.032	-3.000	-3.475	-3.000

Table A3: Rent indices for dwellings with different energy labels.

Year	ALL	C	D	E	F	G
2000	100	100	100	100	100	100
2001	108.07	101.649	120.663	106.137	108.416	106.137
2002	115.394	116.927	119.672	106.506	117.529	106.506
2003	111.344	109.388	119.024	108.626	113.183	108.626
2004	122.514	121.45	129.631	114.073	122.012	114.073
2005	132.714	122.577	134.9	123.409	134.009	123.409
2006	146.556	138.053	149.377	138.775	153.77	138.775
2007	163.265	166.081	171.706	161.992	162.76	161.992
2008	156.18	147.823	169.75	158.972	155.851	158.972
2009	161.375	155.333	174.568	160.35	162.814	160.35
2010 Jan - June	164.631	162.316	175.772	176.352	153.132	176.352
2010 July - Des	171.658	177.546	181.921	173.365	172.902	173.365
2011	183.64	173.939	198.598	187.129	186.305	187.129
2012	196.774	194.499	210.914	192.056	201.301	192.056
2013	202.899	193.79	212.764	192.262	205.254	192.262
2014	208.865	211.704	219.618	206.306	213.363	227.957