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Energy Performance Certificates – Informing the Informed or the indifferent?

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Abstract

Energy Performance Certificates (EPCs) are intended to provide tenants and buyers with reliable information about the energy performance of buildings. As improved energy performance may increase building sale prices and rents, the EPCs are supposed to generate incentives for owners to invest in energy efficiency. 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 reproduce the positive price premium effect found in earlier studies. However, when we check these results by taking advantage of the fact that the introduction of a mandatory energy certification system represents a quasi-natural experiment, we find no evidence of a price premium. On the contrary, we present evidence that there is no effect of the energy label itself.

Key words: Energy Performance Certificates, Energy savings, Real estate pricing, Environmental regulation, Housing policy.

JEL: Q4, Q5, R2, R3

1. Introduction

Upgrading the energy efficiency of buildings is a major focus of industrialized countries' endeavor to achieve sustainable development. However, the process is a slow one. Although several cost-effective energy-saving measures are available to property owners, their potential for energy conservation is not being realized (Curtain and Maguire, 2011). In the literature, this is often explained by the existence of particular impediments or barriers to 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). In response, researchers and policymakers have called for increased information transparency about 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 promote energy efficiency. The EPBD is intended to provide tenants and buyers with reliable information about the energy performance of buildings at affordable costs and at the appropriate time through the use of Energy Performance Certificates (EPCs). As improved energy performance may increase buildings' sale prices and rents, the information provided to potential buyers by the EPC is supposed to generate incentives to invest in energy efficiency (Bio Intelligence Service et al., 2013).

Several studies have addressed the EU implementation of energy labeling buildings empirically. In the commercial office segment, a well known study by Eichholtz et al. (2010) found that US office buildings with a "green rating" sold for about 16 percent higher prices. On the other hand, in a recent study by Parkinson et al. (2016), the researchers found a much lower, and almost negligible, premium for U.K. office buildings. Brounen and Kok (2011) provided the first evidence of the economic impact of EPC implementation for residential dwellings. They performed a hedonic regression analysis based on some 170,000 housing transactions in the Netherlands and concluded that there is a price premium for houses labeled as more energy efficient. Likewise, a report prepared for the European Commission concluded that EPCs have a significant impact on transaction prices and rents in selected E.U. countries (Bio Intelligence Service et al., 2013). The report contains a literature review of the 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 U.K. It concludes that the analysis “overwhelmingly points to energy efficiency being rewarded by the market” (Bio Intelligence Service et al., 2013, p. 12). In response to this finding, the report recommends that the role of EPCs should be strengthened. In particular, EPCs should be implemented faster, published earlier in the transaction process (e.g., at the time of advertising), made more visible (e.g., with a more eye-catching front page), and made easier to understand (e.g., by 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 using an online questionnaire. She concludes that few householders use the EPC during the transaction process and maintains that the EPC will not have the intended impact even if fully implemented. Similar surveys carried out in the UK (Laine, 2011) and Germany (Amecke, 2012) drew the same conclusion: that 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, Backhaus et al. (2011) concluded that the EPCs have a small or negligible impact on homeowners' investment decisions.

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

We suspect that the contrasting conclusions in the literature may originate from the methodological design of the statistical studies. We believe that the alleged positive price effect of EPCs in some of the statistical studies is due to a misspecification of the regression models, and that the apparent price premium of the energy labels therefore captures something else than the labels themselves. In other words, we suspect that some of these studies face the problem of omitted variables being correlated with the energy label.

By utilizing data from the Norwegian real estate market, we are able to test our suspicion by taking advantage of the fact that energy labels were introduced by the government "overnight" on the 1st of July 2010 in Norway, meaning we have a quasi-natural experimental design with pre- and post-label data. For each dwelling that is sold before the implementation of the EPCs in Norway in 2010, our data makes it possible to identify the energy label that the same dwelling was assigned to when sold in 2014. Using the assigned energy label of a dwelling that was resold in 2014 as a variable in a hedonic regression for dwellings sold before the implementation of the EPCs in 2010, we find the same positive relationship between the energy label and the transaction price of the dwellings. That is, the price premium of the energy label seems to be present even before it was implemented. This strongly indicates that the energy label captures something else than the label itself. We also offer an alternative methodological approach, the fixed effect model, where we confirm the lack of a labeling effect. The present paper thus provides evidence supporting our suspicion that EPCs have a negligible impact on the transaction prices of dwellings.

In section 2, we provide some facts about the energy labeling system of dwellings and houses and its implementation in the EU and in Norway. Next, in section 3, we describe our data and the hedonic method, with and without time dummies. In section 4, we present the results of the hedonic approaches and apply the fixed effect method as a robustness check of the hedonic models. Finally, we discuss the findings and offer some policy implications in section 5.

2. The Energy Labeling System of Dwellings and Houses

The Energy Performance of Buildings Directive (EPBD) is the main legislative instrument of the EU to improve the energy performance of buildings (Directive 2002/91/EC). Rooted in the EPBD, the Energy Performance Certification (EPC) was introduced gradually throughout the various member states from 2006. The final deadline for implementing a mandatory energy labeling scheme in 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 et al., 2013, p. 2).

The EPC is intended to provide reliable information to tenants and buyers about the energy performance of buildings at affordable costs and at the appropriate time. In most of the member states, the energy performance ratings are expressed on a letter scale, for instance, from A to G, where A is very efficient and G 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 et al., 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 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 et al., 2013, p. 18). The adoption rate of EPCs varies 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 et al., 2013). Another concern may be to what extent the EPCs provide reliable information. Burman et al. (2013) provided evidence of a gap between actual energy performance and the standardized and theoretical energy performance.

Based on the EU’s EPBD, the Energy Labeling 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 overall responsibility for its implementation, while the Norwegian Water Resources and Energy Directorate was appointed the managing body of the certification and inspection schemes (Isachsen et al., 2010).[1] The energy performance certification was fully mandatory from the beginning; that is, since July 2010 all transactions must be accompanied by an EPC.

The EPC is a legal document and it is required that it is presented for the buyer. However, as noted by Isachsen et al. (2010, p.2), "parts of the certificate, for instance the Energy Label, can be used as a short version." The document contains, among other things, data identifying the building and the agent responsible for issuing the certificate; the energy label that indicates the energy grade (representing the calculated delivered energy need) on a scale from A to G and the heating grade (representing to what extent heating of space and water can be done with renewable energy sources), which is represented by color; advice on energy that can save energy; and some general recommendations to the buyer (Isachsen et al., 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. The cost associated with the certification process for existing buildings is typically at least NOK 1000.[2] This includes the energy assessment itself and the extra cost of advertising for sale when energy label information is included. However, for new buildings, a qualified expert is required for certification, and it is hence a more costly process. The quality assurance aspect of the Norwegian certification scheme is monitored by the Norwegian Water Resource and Energy Directorate (NVE), where faulty inputs are considered a breach of contract. In such cases, a fine is issued. The NVE carries out a

[1] From 1st of July 2016, Enova was appointed the managing body of the EPC system in Norway.
[2] NOK 1 ≈ € 0.11 (per 28.11-2016)

systematic supervision of whether EPCs are presented at sale, whether the EPCs represent the building object, and whether experts meet the competence requirements (Isachsen et al., 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. Various providers make the property register available on the internet. For our purpose, we have acquired data from the source Eiendomsverdi.no, published by the firm Eiendomsverdi AS (a privately owned firm that collects data from real estate agents), official records, and Finn.no (a Norwegian online advertisement firm). Our dataset spans from 1 January 2000 to 31 of December 2014 and contains information on the transaction and the unit. Transactions on the Norwegian housing market can be characterized as a pure English auction. To our knowledge, this is the first attempt to measure the price premium effect of energy labels in a market where transactions are made in a perfectly competitive bidding context.[3] The buyers compete with open bids, and the highest wins the auction. The first bid of each potential buyer has to be in writing, and proper documentation and ID are required, while later bids may be given by text message. 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 announced open house.[4]

[3] Hence, our data is unique since the Norwegian housing market is one of few, if any, that can be characterized as a pure English auction.

[4] An open house is a scheduled time (usually 1-2 hours) when potential buyers can walk through and view the home.

Eiendomsverdi.no categorizes dwellings by type and city districts. The registration of transactions was conducted in December 2014, including transactions 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. It is important to note that we recorded all resales, meaning that all previous sales of the dwellings registered sold in 2014, were recorded. All transactions back to 1985 are available at the site Eiendomsverdi.no. In addition to information from the property register, eiendomsverdi.no also provides the original internet advertisement from the internet advertisement service Finn.no back to the year 2000. We use these advertisements to collect information about which energy label the dwelling was advertised as having, 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 an energy label through other advertising channels, so such dwellings were left out (less than 1% of the dwellings). Transactions with special characteristics, such as when a 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. This information is marked in Eiendomsverdi.no, and we routinely removed these marked cases, which constituted approximately 2% of the traded dwellings.

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 issued in 2010 is about half that of the succeeding years, since the system was made mandatory for sales from July 2010. Note also that a few residences had already got their energy certificate in 2009. These were mostly new houses where the developer acted in advance, anticipating the upcoming certification system.

Table 1 about here

Table 2 presents the 2014 data with respect to type of dwelling and energy label. Almost 32% of the dwellings are in the lowest energy category, G. The requirements for the A and B type certificates are quite comprehensive, and hence only a very few houses (less than 2%) reach above energy class C. This is confirmed in Table 3, where we report the construction years for dwellings sold in 2014. Even in the group of dwellings constructed after 2011, only about 1% are of the A type, while about 22% fall into the B group. Note that the Norwegian numbers seem to be in line with the European when it comes to energy labeling. For example, in a recent study from Greece, Droutsa et. al. (2016) found only 3% to be in the B- or better energy class, while 34% were in the lowest energy class, G.

Table 2 and 3 about here

3.2 Methods

3.2.1 Hedonic models

The hedonic method is a widely used technique to control for the heterogeneous nature of properties when constructing house price indices. Following Court (1939) and Rosen (1974), it is customarily employed to measure the contribution of individual house characteristics to the overall composite value of the housing asset. It recognizes 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. Our main aim is to estimate the contribution from the different energy labels, and hence we add the energy labels as explanatory variables in our hedonic regression.

In addition, we take advantage of the fact that most of the dwellings sold in 2014 were also sold before the energy labels were introduced in 2010. This makes it possible to perform a hedonic regression for transactions made before the implementation of EPCs in 2010 (we hereafter distinguish the two regressions by calling them the “pre-label” and the “post-label” models, denoting regressions run for dwellings sold before and after the implementation of the EPCs in 2010, respectively). Constructing a new variable by assigning to the dwellings sold before 2010 the energy label they were given when sold in 2014, we are able to test whether there is a misspecification of the “post-label” model. A misspecification is likely to be present if a positive price premium effect of EPCs in the “post-label” model is reproduced in the “pre-label” model. In order to get enough data on dwellings sold in 2014 that were also sold before the implementation of EPCs in 2010, we use transactions from the period 2000-2009. Since we have different years, we pick out the year effect by applying the hedonic time-dummy method for these pre-label data (2000-2009) (Court 1939, see also Malpezzi 2003 and Melser 2005).

The hedonic equation to be estimated is written

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

where *P* is the house price per square meter, *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, and the e_{it} term is the error term. The explanatory variables are first the advertised energy labeling from A to G, and with F as the reference energy label (baseline). F is chosen instead of G as the baseline because it turns out the G category is a little bit special. The G category includes all instances of sellers neglecting to identify the correct energy label for their home, that is, a C label were the owner for some reason neglects to go through the classification procedure, will automatically be labeled with a G label. Second, Age measures the difference between the actual year of sale and the construction year. Since we suspect that this difference is less important the older the dwelling is, we measure age by 1/(sale year-construction year). This simply accounts for the fact that age is a relatively more important factor if we compare a brand new with a one year old dwelling than if we compare a twenty with a twenty-one year old building. Third, we have dummy variables for location based on the different city districts in Oslo, and where the district Frogner is the baseline. Fourth follows dwelling type, where we separate between single-family house, townhouses, and semi-detached houses with dummies, and where apartment is the baseline category. Fifth, we have dummy variables for different size categories based on square meters. Small is a dummy for square meters between 51 and 80, Medium is 81-120 square meters, and Large is above 120 square meters. The baseline size is hence below 50 square meters. Finally, we have year dummies to control for year specific effects in the period before energy performance certificates were introduced, and hence we have time dummies for the years 2000-2009, with year 2000 as the baseline.

We apply the log-linear (semilog) functional form in particular because coefficients can be more easily interpreted, and because the semilog functional form mitigates the statistical problem of heteroscedasticity (Malpezzi, 2003). For the hedonic regression before 2010, we let the term δ_t represent the year 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. Note that when ignoring the year dummies and the time subscript, we have the standard hedonic model. Hence, based on equation (1), we have two models to estimate, the "post-label" hedonic model (Model 1) and the "pre-label" hedonic model (Model 2).

4. Results

4.1 Hedonic results

The results from the hedonic models are presented in Table 4. First, we look at the results from the "post-label" model for sales in 2014 (Model 1, Table 4). The logarithm of the transaction price per square meter is explained by traditional explanatory variables comparable to those in Brounen and Kok (2011), such as the energy label dummies, the age of the building, the neighborhood characteristics identified by the address, the dwelling type, and three dummies for different size categories (in square meters). The adjusted R-square is 0.50 for this model. The intercept in Model 1 is 11.124, and transformed from the log form this equals NOK 67 778 per square meter ($e^{11.124} = 67\,778$).[5] The age, location, year, and size variables are all significant at the 1% level, except the dummy for the location "St. Hanshaugen", and with the expected sign. For example, comparing the baseline location "Frogner" with the location "Gamle Oslo" (Old Oslo) tells us that the square meter price

[5] Approximately EUR 7455 (Exchange rate NOK 1= 0.11 EURO, 28.11.2016).

discount in Gamle Oslo on average is 23.1 percentage (coefficient -0.231). Moreover, comparing the smallest dwellings (less than 50 square meters) with the larger dwellings gives a reduction of 27.5 percent per square meter. In addition, both the dummies for townhouse and semi-detached houses are significant at the 5% level.

The most interesting thing to note in Model 1 ("post-label") is that the energy label dummies have the expected signs, and are 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 not significant because of the very low *n*. The G category is a bit special as we have to take into account that all residences where the owner does not take any action with respect to energy labeling, will automatically be put in the G group. Hence, if the owner, for some reason (such as ignorance or lack of care), neglects to fill in the energy forms, the dwelling will end up in the G category. This means that there may very well be buildings with a high energy performance in this group, even if the label is low, and thus, the "wrong" sign for the G category is not that surprising. The size of the coefficients indicates that energy labels affect the dwelling prices quite a lot. For example, the B, C, and D labels have a price premium of 18.9, 12.2, and 7.5 percent, respectively, compared to the F label. To sum up, when looking at the coefficients for 2014 (Model 1), the main message from the hedonic 2014 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 better energy labels.

We now turn to the results from the hedonic time dummy method, the Model 2 ("pre-label") column in Table 4. As explained in section 3.2, we use the same model as Model 1, but for the period before energy labels were introduced, that is, the years between 2000-2009, and where we have year dummies for each year with year 2000 as the baseline. Note that we have constructed the energy label variable here, by assigning to the "pre-label" transacted dwellings the energy label they were given when sold in 2014. The adjusted R-Square is 0.63 in the data preceding 2010. As expected, the intercept is much lower, equaling NOK 24 984 per square meter as compared to NOK 67 760 in Model 1 ($e^{10.126} = 24984$).[6] Moreover, note that all the traditional explanatory variables (age location, size, dwelling type) are quite similar to the 2014 results, meaning that their relative contribution is about the same as in 2014.

However, quite surprisingly, the energy label coefficients in Model 2 have neither changed much compared to Model 1, even though energy labels were introduced in 2010, after the period for which Model 2 is run. This clearly demonstrates that these coefficients pick up something else than an energy label price premium, indicating there is a misspecification of the "post-label" model. Therefore, we test whether the results hold when we take advantage of the quasi-natural experiment imposed by the introduction of energy labels by looking more in detail at the data with a fixed effect model, as presented below.

Table 4 about here

4.2 Fixed effect model

We can now utilize that we have data with several transactions for the same dwelling to run a fixed effect model. Since the dwellings are not traded on given times or with given intervals, we have an unbalanced dataset with observations from 2000 to 2014, and where observations from 2010 are excluded, since the energy labels were implemented in July 2010.

The advantage of the fixed effect model is that it makes us able to control for time-invariant variables. Even though the hedonic models were able to control for variables like dwelling type, dwelling size, city district, and age, there are still several omitted variables like energy performance, aesthetic appearance, micro location, standard, etc. The fixed effect model allows us to separate the price effect of such time invariant variables from the price effect associated with the new information that was introduced to the Oslo housing marked by the energy performance certificates. By removing all time invariant factors (fixed effects), we are able to reveal, in a more robust way, whether getting a better energy label certificate really gives a price premium.

House price data typically has a clear time trend. The development in house prices over time represents changes in the macroeconomic variables that affect all dwellings. Variables with non-stationarity can cause problems in our statistical inference and may give misleading results due to spurious relationships. To make our dependent variable (price per square meter) stationary, we divide it with an index value from the observation year. We use a weighted price index combining a hedonic index for Oslo from the Norwegian central bank (Eitrheim and Erlandsen, 2004) and a Case Shiller repeated sales index for Oslo by Oust (2015). A scatterplot of the new depended variable is presented in appendix Figure A1. As the scatterplot reveals, the dependent variable is stationary after the price index adjustment, but there seems to be some sign of heteroscedasticity, and hence we run the fixed effect regression with the robust option in STATA to control for heteroscedasticity.

The fixed effect regression equation has the form:

$$Y_{it} = \alpha_i + \beta_1 X_{it1} + ... + \beta_k X_{itk} + u_{it} \text{ , } (i = 1, 2, \ldots, N, \quad t = 1, 2, \ldots, T, \quad k = A, B, \ldots, G)$$

$$Y_{it} = \alpha_i + \beta_1 X_{it1} + ... + \beta_k X_{itk} + u_{it} \ , \quad (i = 1, 2, ...N, \quad t = 1, 2...T, \quad k = A, B, ...G)$$

Y_{it} is the natural logarithm of the dwelling price per square meter deflated by the value of the house price index for the year t that the dwelling has been sold, α_i is the unknown intercept for each dwelling (the fixed effects), X_k are independent dummy variables for the energy performance certificates A-G, and β_k the accompanying coefficients. Note that the certificates came as new information about the dwellings after 2010. All of the independent variables have the value 1 for its given energy performance certificate after 2010 and 0 otherwise. Finally, we have the error term u_{it} where subscript *i* denotes the observation number and subscript *t* denotes the time of the observation.

4.3 Fixed effects results

The results from the fixed effects model are presented in Table 5. With 4674 sale price observations, the panel dataset consists of 2221 groups (dwellings), and with an average number of sales per dwelling of 2.1. The constant term captures the average value of the fixed effects in the regression.[7] The pattern which is revealed when looking at the energy label dummies confirms the results from the hedonic model above. If there is a price premium associated with the energy labels themselves, we would expect that the better labels, in terms of energy performance, say A, B and C, should have positive coefficients, and the worse labels in terms of energy performance, say E, F and G, should have negative energy label coefficients. However, it turns out that the coefficients are close to zero, and in the case of significant coefficients, that is, for energy label E, F and G, the signs do not support the price premium hypothesis, since F and G have positive coefficients. As explained in the hedonic

[7] The results of running the command for fixed effect *xtreg, fe* in STATA are reformulated so that the intercept reports the average value of the fixed effects directly.

case above, the positive sign of the G coefficient may be explained by the special characteristics of the G label, but still the F and B signs are counterintuitive. Overall, when controlling for all time invariant effects for each dwelling, such as energy performance, aesthetic appearance, and standard, etc., comparatively random signs of the energy label coefficients are noticed. Thus, this supports the conclusion from the ”pre-label” model above. This was also confirmed by an adjusted Wald test, which shows that the only coefficients where a better energy certificate significantly yields a higher price is when comparing label C versus D, and C versus E (Table A1 in the appendix). Note also that the within R-square is quite low (0.002). At the same time, the intraclass correlation coefficient, *rho*, which reports the correlation among the observations within each group, is quite high (0.826). This means that nearly 83% of the variance is due to differences across panels.

Table 5 about here

As a robustness check, we estimate the weighted repeat sales method. The results confirm the results from the fixed effect method of no price premium associated with energy labels. See Appendix B for details.

5. Conclusion and policy implications

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 to tenants and buyers about the energy performance of buildings at affordable costs and at the appropriate time through the use of Energy Performance Certificates (EPCs). As improved energy performance may increase a building’s sale prices and rents, the information provided by the EPC is supposed to incentivize owners to invest in energy efficiency (Bio Intelligence

Service et al., 2013). The empirical evidence for a price premium associated with energy labels is inconclusive and partly contradictory, however. While, for example, Brounen and Kok (2011) found clear evidence of an energy label price premium in their hedonic data set for the Netherlands, other studies, even those such as Murphy's (2014) that were carried out in the same country, found only small or negligible effects.

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 running hedonic regressions for the period before energy labels were introduced in 2010, we find the same results with respect to energy labels. Hence, the price premium seems not to be caused by the energy labels. Moreover, when we check these results with a fixed effect model, we find no evidence of a price premium after controlling for the time invariant dwelling fixed effects. Hence, on the basis of our data, we conclude that the energy label itself seems to have a slightly negligible or no effect

Thus, our analysis identified a misspecification of the hedonic regression model; the apparent price premium of the energy labels clearly captures something else than an effect of the labels themselves. Indeed, we face the problem of omitted variables being correlated with the energy label. There are several candidates available.

First, it seems plausible that the energy label of a dwelling is correlated with its energy performance (expected energy consumption). After all, the assigning of the energy label is based on the expected energy consumption. If this is the omitted variable driving the price premium, then the apparent positive price effect of EPCs is due to a confusion of the impact of the energy *performance* with the energy *labeling*. This interpretation implies that some information about the energy performance must have been available even in the absence of EPCs. That is, market failure in the form of imperfect information does not seem to be the impediment or barrier to investment in energy saving measures, as buyers receive information about energy performance by other means than the energy labels. For example, knowledge about the construction year may serve as an indicator of expected energy performance, since it is well known that along with regulations, the requirements concerning energy efficiency in the housing sector has increased over time. Another example may be written information and visual inspection, for example whether the dwelling has triple pane, double pane, or single pane windows.

A second interpretation is that the aesthetic appearance of a dwelling is correlated with the energy label and is responsible for the positive price effect. This interpretation is supported by the work of Parkinson et.al. (2013). In the context of the commercial office segment, they find that the energy label is correlated with various facility services, one of them being facility aesthetics. Indeed, Parkinson et.al. (2013) conclude "that any rental premiums for facilities with high energy performance observed from historical U.K. data would be most likely a result of associations between rental value and occupant satisfaction with facility aesthetics."

Third, as inferred by the survey studies, at the exact moment people buy a dwelling, they are not much concerned with the energy performance, and even less so with the energy label. Indeed, factors that seem to matter the most are the availability of garden and outdoor space, location, the neighborhood, and the size of the property. Costs related to the energy performance come quite low on this list (Backhause et al., 2011, Laine, 2011). It seems that the moment of transaction is a bad timing for influencing the incentives to invest in energy saving measures. There are so many factors that matter significantly more than the energy performance at this moment, meaning that the energy label plays a minor role in determining the transaction prices. Hence, measures to influence the incentives to invest in energy performance is probably more effective if they focus on other phases than the moment of transaction.

Considering the costs associated with the energy performance certification policy, both in terms of direct costs for sellers and buyers, as well as the costs of supervision and control, the question is whether the energy labels should be abandoned entirely? If the main goal is to contribute to a more energy-efficient housing market, one could consider more direct regulation, for instance in terms of legal energy requirements, taxes, and/or subsidies. Another interesting policy-relevant question left for future research is whether our results carry over to real estate markets in other countries. As one anonymous reviewer pointed out, certification systems are usually most important in situations when trust and honesty are lacking. Therefore, even though energy certificates does not matter in Norway, they could matter in other countries. It would therefore be useful to carry out our kind of study in other countries. Moreover, it would also be interesting to see whether our results carry over to other markets, since energy labels are used for a variety of products sold today.

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Appendix A

Figure A1 about here

Table A1 about here

Appendix B

Robustness check: The weighted repeat sales method

As a robustness check 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. We compare the transaction prices of dwellings sold before and after the implementation of the 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.

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

$$\ln(p_n^t / p_n^s) = \sum_{t=0}^{T} \gamma_t D_n^t + \mu_n^t \qquad \text{(B1)}$$

where p_n^t is the price at the time of the resale, p_n^s the price at the previous sale, D_n^t 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, 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 (Case and

Shiller, 1987, 1989). 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. We follow the three-step procedure suggested by Case and Schiller (1987) 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 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 11 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 whether variables are stationary, we use a simple Dickey-Fuller test (Table B1). 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 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:

$$Y^{*} = \beta_0(1-\rho) + \sum \beta_j x_{jt}^{*} + \sum \delta_j s_{jt} + \varepsilon_{jt} \qquad \text{(B2)}$$

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

Table B1 about here

Repeat sales results

To explore the effect of introducing energy labels, we construct price indices for the different labels, and let them all have a value 100 in the year 2000. 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.[8] If energy labeling has the price effect found in the hedonic data, we should expect significant dummy coefficients in Table B2. However, the only significant 2010 dummy is in the F label category (10% level), and with the opposite of the expected sign. Just as in the fixed effect model, we find no evidence to support the price premium effect found in the hedonic model.

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

Table B2 about here

Tables:

Table 1: Number of Energy Performance Certificates issued
The table shows the number of Energy Performance Certificates issued in Norway between 2009 and 2014. Energy labeling was made mandatory on 1 July 2010. Source: Energimerking.no

	Year					
	2009	*2010*	*2011*	*2012*	*2013*	*2014*
Number of dwellings	*258*	*50,183*	*85,591*	*104,587*	*102,587*	*98,909*

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	1163	0	24	126	245	170	266	332
Townhouses	283	0	6	33	51	51	79	63
Semi-detached houses	213	1	2	26	29	17	39	99
Sum	2066	2	42	214	362	316	476	654

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

	Total	A	B	C	D	E	F	G
2011-2014	137	2	31	75	22	3	0	4
2001-2010	380	0	8	115	209	32	5	11
1991-2000	163	0	0	5	72	66	17	3
Before 1991	1386	0	3	19	59	215	454	636
Sum	2066	2	42	214	362	316	476	654

Table 4. Energy labels and transaction prices, hedonic models (dependent variable: natural logarithm of transaction prices per square meter) ¤

	Post-Label		Pre-label	
	Model 1: 2014		Model 2: Before 2010	
	Coef.	(Std. Err.)	Coef.	(Std. Err.)
A	0.043	(0.140)	-	-
B	0.189***	(0.035)	0.246***	(0.092)
C	0.122***	(0.019)	0.115***	(0.021)
D	0.075***	(0.015)	0.097***	(0.015)
E	0.005	(0.014)	0.030*	(0.016)
G	0.054***	(0.012)	0.027***	(0.013)
Age	0.225***	(0.054)	0.260***	(0.055)
Dummy St. Hanshaugen¤	-0.056*	(0.030)	-0.085***	(0.027)
Dummy Gamle Oslo¤	-0.231***	(0.031)	-0.219***	(0.032)
Dummy Grynerløkka og Sagene¤	-0.187***	(0.026)	-0.143***	(0.025)
Dummy Outer Oslo West¤	-0.141***	(0.024)	-0.093***	(0.023)
Dummy Outer Oslo East¤	-0.444***	(0.024)	-0.368***	(0.023)
Dummy Single-family houses	0.027	(0.017)	0.050**	(0.020)
Dummy Townhouses	0.044**	(0.019)	0.035*	(0.020)
Dummy Semi-detached houses	0.022**	(0.017)	0.046**	(0.018
Small	-0.129***	(0.014)	-0.089***	(0.014)
Medium	-0.147***	(0.016)	-0.137***	(0.016)
Large	-0.275***	(0.019)	-0.252***	(0.021)
2009	-	-	0.601***	(0.023)
2008	-	-	0.555***	(0.023)
2007	-	-	0.566***	(0.023)
2006	-	-	0.497**	(0.023)
2005	-	-	0.359***	(0.023)
2004	-	-	0.281***	(0.024)
2003	-	-	0.152***	(0.024)
2002	-	-	0.179***	(0.024
2001	-	-	0.117***	(0.025)
Constant	11.124***	(0.027)	10.126***	(0.031)
Adj R-square	0,50		0,63	
Number of observations	2025		1887	

*** Significant at the 1% level. ** Significant at 5% level. * Significant at 10% level.

¤Table note: The energy label dummies are A, B, C, D, E, and G, with F as the baseline. The Age variable is measured as Age=1/(sale year-construction year). The dummies of St. Hanshaugen, Gamle Oslo, Grynerløkka og Sagene, Outer Oslo West, and Outer Oslo East are dummies for different parts of Oslo (districts), and where the district of Frogner is the baseline. The dummies Single-family house, townhouse and semi-detached houses are dummies for different housing types with apartments as the baseline. The dummies Small, Medium, and Large allow square meter prices to be different at different square meter levels. Small is dummy for Square meters between 51 and 80, Medium is 81-120 square meters, and Large is above 120 square meters. The baseline size is hence below 50 square meters. The year dummies in the hedonic time dummy model from 2001-2009 have a baseline of the year 2000.

Table 5. Energy labels and transaction prices, fixed effect model (dependent variable: natural logarithm of transaction prices per square meter, adjusted with price index) ¤

	Coef.	Robust Std. error	t-value	95% coef. interval	
B	-0.050	0.053	-0.94	-0.155	0.054
C	0.019	0.016	1.24	-0.011	0.050
D	-0.012	0.009	-1.30	-0.031	0.006
E	-0.024**	0.010	-2.35	-0.044	-0.004
F	0.020**	0.009	2.08	0.011	0.038
G	0.051***	0.009	5.74	0.034	0.069
Constant	10.400***	0.003	3729.100	10.395	10.406

R-square: within=0.0211, between=0.0003, overall=0.0002

Number of: obs.=4674, groups=2221

Obs. per group: min=1, average=2.1, max=9

Prob>F =0.000, rho=0.826

*** Significant at the 1% level. ** Significant at 5% level.

¤Table note. The dependent variable is divided by an index value from the observation year to make it stationary. The index is a weighted price index from Eitrheim and Erlandsen (2004) and Oust (2015). The energy label dummies are A, B, C, D, E, F, and G, and where A is omitted due to collinearity. The dataset is unbalanced with observations from 2000 to 2014, and where observations from 2010 are excluded (energy certificates were introduced in July 2010).

Appendix

Table A1: Adjusted Wald test¤

H_0	F (df_1, df_2)	Rejection of H_0	Better energy certificate gives sign. higher price¤¤
B = C	F (1, 2222) = 1.57	No	No
B = D	F (1, 2222) = 0.49	No	No
B = E	F (1, 2222) = 0.24	No	No
B = F	F (1, 2222) = 1.66	No	No
B = G	F (1, 2222) = 3.52	No	No
C = D	F (1, 2222) = 3.02	No	Yes
C = E	F (1, 2222) = 5.41	Yes	Yes
C = F	F (1, 2222) = 0.00	No	No
C = G	F (1, 2222) = 3.15	No	No
D = E	F (1, 2222) = 0.09	No	No
D = F	F (1, 2222) = 5.70	Yes	No
D = G	F (1, 2222) = 23.86	Yes	No
E = F	F (1, 2222) = 9.87	Yes	No
E = G	F (1, 2222) = 30.44	Yes	No
F = G	F (1, 2222) = 5.87	Yes	No

¤ Table note: the Wald statistics test in STATA show whether the coefficients are equal by testing if their difference is zero, e.g. $\beta_2 - \beta_3 = 0$ is run to test if B=C. The third column conclude on the H0 (criticial value at 5% level, F(1,2222)=3.84).

¤¤Concludes whether better certificates gives a price premium based on a transformation from the F-statistics in the Wald test to a one sided t-test, which is straightforward as the F distribution is a squared t-distribution when the F statistics has only one degree of freedom for the numerator. Then, we utilize that the t-distribution is symmetric, and hence the p- value in the one sided case is simply the half of the p-value obtained from the F-test.

Table B1: 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 B2: Dwelling price in different energy label categories

*In this table we compare how well the dummy for when energy labeling was made mandatory, July to December 2010, is 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	1.048***	0.877***	0.732**	1.144***	0.699**
Dummy 2010 July–Dec	0.019	-0.003	-0.049	0.059*	-0.047
Constant	-0.001	0.004	0.016	-0.010	0.022
Adj. R^2	0.529	0.727	0.389	0.777	0.232
DW transf.	2.110	1.393	1.875	2.457	1.685

Figure:

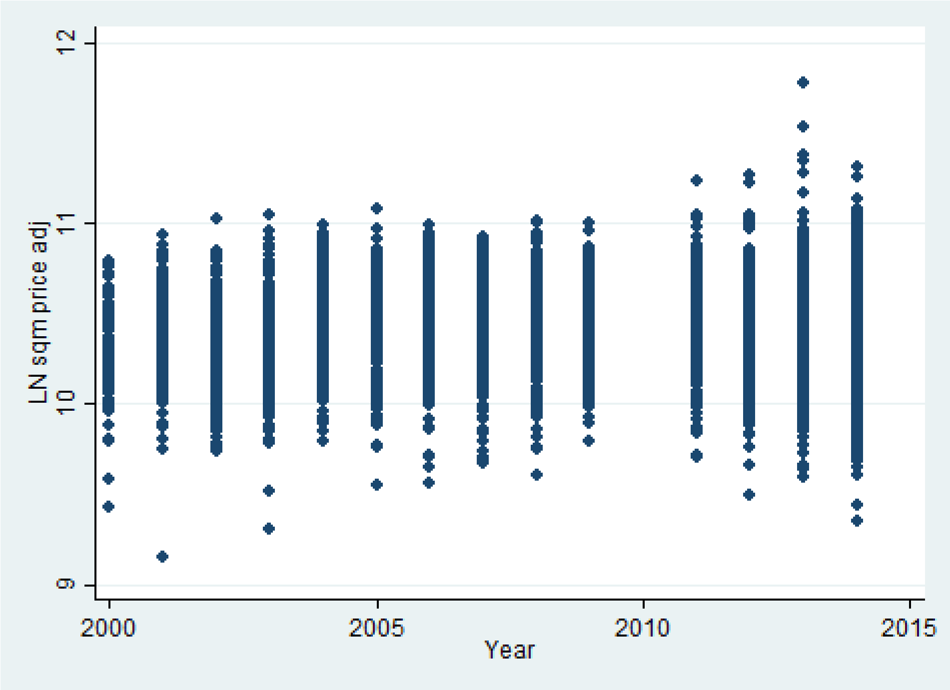

Figure A1. Scatterplot of the dependent variable in the fixed effect model (natural logarithm of transaction prices per square meter, adjusted with price index)