Energy Performance Certificates and Investments in Building Energy Efficiency: A Theoretical Analysis

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Abstract

In the European Union, Energy Performance Certificates (EPCs) provide potential buyers or tenants with information on a property's energy performance. By mitigating informational asymmetries on real estate markets, the conventional wisdom is that they will reduce energy use, increase energy-efficiency investments, and improve social welfare. We develop a dynamic model that partly contradicts these predictions. Although EPCs always improve social welfare, their impact on energy use and investments is ambiguous. This implies that, in a second-best world where energy externalities are under-priced and/or homeowners have behavioral biases hindering investments (myopia), EPCs can damage social welfare. This calls for using mandatory energy labeling in contexts where additional instruments efficiently mitigate the other imperfections.

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1 Introduction

Improving energy efficiency is viewed as a major means to curb greenhouse gas emissions and, more generally, to limit the negative externalities generated by energy production, distribution, and use. This has led many countries to include ambitious energy efficiency objectives in their climate plans. As an illustration, the European Union set a binding target mandating a 20% reduction in energy use by 2020 relative to a business-as-usual scenario and current policy discussions focus on a 30% target for 2030.

Taxing energy taxation the primary policy strategy to reduce energy use, but it is usually combined with sector-specific policies. This is particularly true for buildings, which are responsible for a sizable share of total energy use (e.g. 40% in the EU). Many countries grant tax credits and subsidies to energy retrofits of existing buildings. Building codes include energy performance provisions for new buildings.

Another popular policy approach consists in providing potential buyers or tenants with information on the energy performance. In the European Union, so-called Energy Performance Certificates (EPCs) give information on a property's typical energy use and energy cost, an energy efficiency rating from A (most efficient) to G (least efficient), practical advice on improving such performance. Their publication is compulsory in all advertisements for the sale or rental of buildings since 2007. In other countries, energy labeling is usually voluntary (e.g. Energy Star, Leadership in Energy and Environmental Design).

The rationale for EPCs, and energy labeling more generally, is that buyers/tenants do not observe a dwelling's or an office's energy performance before moving in. In economic parlance, energy performance is an experience-good attribute. That is, a product characteristic which is difficult to observe in advance, but that will be revealed after the transaction. When considering a given property, a potential buyer or a tenant thus depends on the information provided by the seller/landlord who have clear incentives to manipulate this information by overstating the performance.

By limiting these informational asymmetries, EPCs are primarily expected to improve the matching between properties with heterogeneous energy performance and households on the real estate market. In particular, households with high energy needs – and thus a high willingness to pay for energy performance – will be able to choose energy-efficient properties, while households with lower needs will opt for cheaper, but lesser efficient properties. EPCs also raise the incentives to invest in energy efficiency as the price of energy-efficient properties is higher than that of inefficient ones. These two mechanisms are expected to reduce energy use and to improve social welfare.

We develop a dynamic model which examines the impact of EPCs on the level energy use, investments, and social welfare and find results that partly contradict these arguments. The model describes how the building stock of a city evolves over time. It includes two main ingredients: First, homeowners[1] can make investments to upgrade their dwelling's energy performance. Second, a fraction of dwellings is sold on a competitive real estate market in each period. We use this framework to identify the equilibrium investment paths with and without energy certification, and the resulting impact on energy consumption.

We confirm that, in the absence of other market imperfections, the introduction of EPCs improves social welfare in any case. However, the impact on the level of energy use and on the volume of energy efficiency investments is ambiguous. This has a very important policy implication. In a second-best world where energy externalities are under-priced and/or where consumers have behavioral biases that hinder investments (myopia), EPCs can damage social welfare. This calls for using EPCs in contexts where other imperfections are addressed by adequate instruments.

Literature on Building Energy Certification We contribute to the economic literature on energy labeling of buildings with the first theoretical study

[1] Although we cast the model in terms of residential homes, it equally applies to office buildings.

dealing with its impact on energy use, retrofit investments and social welfare. Almost all existing studies are empirical and concentrates on the impact on housing prices and rents (e.g., Brounen and Kok, 2011, Kok and Quigley, 2008, Fuerst and McAllister, 2011, Fuerst et al., 2015, Hyland et al., 2013, Jensen et al., 2016, Kok and Jennen, 2012). They commonly find a positive impact although some studies are not able to identify whether this signals the effects of energy performance *per se* or the sole effect of labeling. The policy implications of these results are however limited. The ultimate objectives of energy labeling is reducing energy use and improving social welfare. In theory, this can occur through two mechanisms: a better matching between heterogeneous households and dwellings and higher investment incentives. The existence of a price premium is a necessary condition for this to occur, but is not sufficient to test for these goal achievements.

An exception is a paper by Comerford et al. [2016] who examine the impact on energy performance. Relying on UK data, they identify a threshold effect. After the introduction of the EPC, more homes have an energy rating just above the D grade and less homes have a rating just below (the color-coded letter grade of the EPC overlaid a pre-existing 0-100 point scale. It illustrates a situation already identified by Dranove and Jin [2010]: sellers might want to game the system when information is disclosed. Here, sellers seem to invest in a strategic way to reach the letter D. This leads to potential inefficiency issues: some sellers might over-invest to reach the letter D, some sellers might under-invest because their letter is already D or above.[2].

Note that we only refer here to schemes which publicly disclose energy performance on real estate markets. There have been many studies on private signals providing home occupiers with informational feedbacks on their home energy consumption (for instance, see Jessoe and Rapson [2012]). The underlying mechanisms are totally different since this information does not reduce informational asymmetries on real estate markets, but is expected to mitigate

[2] In this respect, Sallee and Slemrod [2012] develops an interesting evaluation of the size of such inefficiencies in a different sector (the auto industry).

behavioral biases.

2 Model

2.1 Assumptions

We develop a dynamic model in discrete time, which describes the evolution of the building stock of a city. The stock include dwellings with energy performance θ. Each dwelling can either be energy-efficient ($\theta = 1$) or inefficient ($\theta = 0$). The dwellings are owned and occupied by a continuum of households with heterogeneous energy needs.[3] More specifically, each household consumes a quantity of energy $\theta \times e$ per period where e is distributed over $[0, +\infty)$ with cumulative F. F is continuous and the overall level of energy consumption is bounded: $\int_0^{+\infty} e \, \mathrm{d}F(e) < +\infty$.

Let q_t denote the share of efficient dwellings. We assume that all dwellings are inefficient at the beginning of the game: $q_0 = 0$. Any household can then invest in any period to upgrade its property if $\theta = 0$. The cost is I and $\theta = 1$ after investment, which is irreversible and which has an infinite lifetime (after investment, the energy performance is 1 over the entire time horizon). The share of efficient dwellings at time t is q_t.

In each period, m households exogenously move out and sell their dwelling to the same number of households living outside the city who move in. Incoming and outgoing households are drawn from the same distribution. The exogeneity of moving decisions captures the fact that most people decide to move in or out for professional or family reasons that are not related to home energy performance. The real estate market is competitive.

When there is certification, energy performance is perfectly observable before the sale. Without certification, we assume that incoming households only observe it after moving in. The timing of events within each period t is as follows:

[3] We extend the analysis to the rental case in section XX.

1. m households move out and m households move in.

2. Outgoing households sell their dwellings to incoming households.

3. Incoming households observe the energy performance of their home.

4. Each household living in an inefficient dwelling ($\theta = 0$) decides whether to invest I or not.

5. Payoffs are realized.

Last, we assume that all households form perfect expectations about future housing prices in all scenarios.

2.2 Social optimum

We can now identify the investment path and the allocation of households in the dwellings that implement the first best outcome. Under our assumptions, this optimum minimizes the discounted sum of investment and energy expenditures over the entire time horizon:

Social cost function is

$$C = \sum_{t=0}^{\infty} \delta^t \left(\int_0^{+\infty} \mathbb{P}_t(\theta = 0|e)(1+\alpha)e \, \mathrm{d}F(e) + (q_{t+1} - q_t)I \right)$$

Consider first the socially optimal matching rule in period t contingent on a given building stock with a share of energy efficient dwellings q_t. In this context, perfect marching requires the allocation of households with the highest energy needs in the energy-efficient dwellings. Formally, let g_t^* denote this socially optimal allocation function $e \mapsto \theta$ which maps each household type to a dwelling's level of energy performance in period t. Perfect matching means that:

$$g_t^*(e_t^*) = \mathbb{1}_{\{e \geq e_t^*\}} \tag{1}$$

where e_t^* is the limit type which binds the city capacity constraint: $1 - F(e_t^*) = q_t$.

Turning next to the investment path, recall that the distribution of households' types e does not vary over time: incoming households are drawn from the same distribution as that of the initial population. As a result, an investment in a given dwelling should either be made in the first period or never, which in turn leads to a time-invariant threshold e^*_t. Ignoring the time index, the value of e^* is then obtained by considering that the investment decision in period 1 should be made as if the same household was staying forever. In this context, energy retrofit is socially optimal if the household e is such that the investment cost is lower than the net present value of the energy cost over the infinite time horizon:

$$I \leq \sum_{k=0}^{\infty} \delta^k e = \frac{e}{1-\delta} \tag{2}$$

where δ denotes the household discount factor. This completes the characterization of the social optimum.

Lemma 1 (Social optimum)**.** *In the first best optimum, investments are only made in period $t = 1$ and the share of efficient dwellings is $q^* = 1 - F(e^*)$ with $e^* = I(1-\delta)$ for any $t > 0$. The energy-efficient dwellings should then be occupied by households with types higher than e^*: $g^*_t(e^*_t) = \mathbb{1}_{\{e \geq e^*\}}$).*

3 Decentralized Equilibrium with an EPC

In this section, we examine the equilibrium investment path under perfect information on energy performance. From now on, let $u_t(e, \theta)$ denote the expected lifetime surplus of a household of type e living in a dwelling with performance θ at the beginning of period t. In the case where the dwelling is efficient ($\theta = 1$), this surplus is given by the recurrence relation:

$$u_t(e, 1) = \delta[mp^1_{t+1} + (1-m)u_{t+1}(e, 1)]$$

That is, the energy expenditure is zero in period t while the household moves out in the next period with probability m, thereby selling the dwelling at price

p^1_{t+1}, or stays with probability $1-m$ and derives surplus $u_{t+1}(e,1)$.

When $\theta = 0$, the surplus depends on whether the homeowner invests or not. Denoting $u^I_t(e)$ and $u^\emptyset_t(e)$ the expected utility is:

$$u_t(e,0) = \max\{u^I_t(e), u^\emptyset_t(e)\} \tag{3}$$

with:

$$\begin{aligned} u^I_t(e) &= -I + \delta m p^1_{t+1} + \delta(1-m)u_{t+1}(e,1) \\ u^\emptyset_t(e) &= -e + \delta m p^0_{t+1} + \delta(1-m) \times u_{t+1}(e,0) \end{aligned}$$

We now examine how incoming households are allocated in the different dwellings by the real estate market. To start with, perfect information implies a separating equilibrium with a price premium for the energy efficient dwellings: $p^0_t < p^1_t$. The outcome of the sales is then given by p^0_t, p^1_t, and the allocation function $g_t : e \mapsto \theta$ which satisfies two conditions:

- Market clearing: $\int_0^{+\infty} g_t(e) \mathrm{d}F(e) = q_t$.
- Incentive compatibility: $g_t(e) = \underset{\theta}{\operatorname{argmax}}\ u_t(e,\theta) - p^\theta_t$.

From the incentive compatibility condition easily follows that the market perfectly matches the households with the dwellings. That is, there is a threshold type such that all households with lower types purchase inefficient dwellings whereas the highest types choose efficient ones. Hence $g_t = g^*_t$.

Lemma 2 (Perfect matching)**.** *Under perfect certification, all incoming households with types such that $e \geq \tilde{e}_t$ where $\tilde{e}_t$ is defined by $F(\tilde{e}_t) = 1 - q_t$ purchases energy-efficient dwellings.*

Proof. By contradiction, assume there exists $e_1 < e_2$ such that $g_t(e_1) = 1$ and

$g_t(e_2) = 0$. From the incentive compatibility, this would imply that

$$u_t(e_1, 1) - p_t^1 \geq u_t(e_1, 0) - p_t^0$$
$$u_t(e_2, 1) - p_t^1 < u_t(e_2, 0) - p_t^0$$

This is not possible because the function $u_t(e, 1) - p_t^1 - u_t(e, 0) + p_t^0$ is increasing with e. To see this, note first that p_t^1 and p_t^0 do not vary with e because the market is competitive. This also holds true for $u_t(e, 1)$ which only depends on the price trajectory as shown by Eq.(**??**). Last, from Eq.(3) follows that $u_t(e, 0)$ is decreasing with e as $u_t^{\emptyset}(e)$ is decreasing. The market clearing condition directly gives the value of the threshold $\tilde{e}$. □

A direct implication is that the relative prices in equilibrium are those making the limit type $\tilde{e}$ indifferent between both dwelling types:

Corollary 1. *In the market equilibrium, we have* $p_t^1 - p_t^0 = u_t(\tilde{e}, 1) - u_t(\tilde{e}, 0)$.

In order to predict the investment decisions in this market environment, we now compare u_t^I with $u_t^{\emptyset}$. It is intuitive that investors are the households with the highest energy needs.

Lemma 3. *In period t, a household of type e living in an inefficient dwelling invests if $e \geq \breve{e}$ where $\breve{e}$ is the unique solution of* $u_t^{\emptyset}(e, 0) = u_t^I(e, 0)$.

Proof. u_t^I does not vary with e while $u_t^{\emptyset}$ is strictly decreasing with e. When $e \to \infty$, we have $u_t^{\emptyset} \to -\infty$, implying that $u_t^I > u_t^{\emptyset}$. Last, we show that $u_t^I(0) - u_t^{\emptyset}(0) < 0$ when $e = 0$ by contradiction. Assume that $u_t^I(0) > u_t^{\emptyset}(0) \geq 0$. This implies that have $u_t^I(0) = u_t(0, 0) = -I + u_t(0, 1)$, and thus $u_t(0, 1) - u_t(0, 0) = I$. We know that $u_t(e, 1) - u_t(e, 0)$ is increasing with e, meaning that $u_t(0, 1) - u_t(0, 0) < u_t(\tilde{e}, 1) - u_t(\tilde{e}, 0)$. Corollary 1 then implies that $I < p_t^1 - p_t^0$, which is absurd. □

Establishing that perfect certification implements the first best is then straightforward as we just need to show that $\tilde{e} = \breve{e} = e^*$.

Proposition 1. *Perfect certification implements the first best optimum.*

Proof. $u_t^I(\breve{e}) = u_t^{\emptyset}(\breve{e})$ implies that $-I + \breve{e} + \delta m(p_{t+1}^1 - p_{t+1}^0) + [u_{t+1}(\breve{e}, 1) - u_{t+1}(\breve{e}, 0)] = 0$. From Corollary 1 and $\tilde{e} = \breve{e}$ follows that this equation is equivalent to $-I + \breve{e} + \delta(u_{t+1}(\breve{e}, 1) - u_{t+1}(\breve{e}, 0)) = 0$. Plugging $u_{t+1}(\breve{e}, 1) = u_{t+1}^I + I$ yields that $\breve{e} = I(1 - \delta) = e^*$. □

The intuition underlying this result is as follows. Lemma 2 implies that investing households anticipate that, if they move out in a next period, their home will be purchased by the highest types. As incoming types are drawn from the same distribution, they invest as if they were going to stay forever in the dwelling, trading off the investment cost and the total discounted energy cost $e/(1 - \delta)$.

4 Equilibrium without EPC

The main difference with the certification case is that we now have a pooling equilibrium on the real estate market with $p_t^0 = p_t^1$. This greatly simplifies the analysis as the real estate market gives zero value to energy retrofit ($p_t^0 = p_t^1$) and incoming households are randomly assigned to the dwellings.

When making an investment decision, the households just need to compare the investment cost with the savings in their own energy consumption in the current period and in future periods if they do not move. Household e will thus invest if:

$$I \leq e \times \sum_{k=1}^{\infty} (\delta(1 - m))^k = \frac{e}{1 - \delta(1 - m)} \tag{4}$$

This condition shows a partial internalization of the investment benefit by the investor. As the household may move out and sell its dwelling with per-period probability m, investing households discount the future at rate $\delta(1 - m)$, that is the conventional discount rate times the probability of staying in the next period. Hence, we have:

Lemma 4. *In any period, a household of type e living in an inefficient dwelling invests if $e \geq \hat{e}$ where $\hat{e} = I(1 - \delta(1 - m))$.*

Although individual investment incentives are lower than the first best in a given period, they persist over time in contrast with the first best where all investments are made in the first period. The reason is that the randomized market allocation implies that high types inevitably move in inefficient dwellings in each period. Once installed, they cannot but invest to consume less energy. To be more precise, the process unfolds as follows:

- At $t = 0$, all households occupy inefficient dwellings.
- In period 1, the types higher than $\hat{e}$ upgrades their home. As a result, the share of inefficient dwellings is $F(\hat{e})$ at the end of the period.
- At the beginning of period 2, m households randomly move out. A share $mF(\hat{e})$ of inefficient dwellings are thus (randomly) sold to incoming households. Households moving in these inefficient dwellings invest if their type is higher than $\hat{e}$. The share of efficient dwellings thus increases up to $(1 - m)(1 - F(\hat{e})$.

The process goes on so that we have

Lemma 5. *In period t, the share of efficient dwellings is $q_t = 1 - F(\hat{e})[1 - m(1 - F(\hat{e}))]^{t-1}$. The overall level of energy investment flow is $I_t = mI(1 - F(\hat{e}))F(\hat{e})[1 - m(1 - F(\hat{e}))]^{t-1}$ and the overall level of energy consumption is $E_t = [1 - m(1 - F(\hat{e}))]^t \int_0^{\hat{e}} e \, \mathrm{d}F(e)$.*

Proposition 2. *Households never stop investing so that the share of efficient dwellings converges to 1 in the long run: $q_t \to 1$. The levels of per-period investments and energy use converge to zero: $E_t \to 0$ and $I_t \to 0$*

This dynamics is represented in Figure 1 which compares the evolution over time of q_t with and without certification. Accounting for the dynamics of the building stock thus yields the counter-intuitive results that the absence of energy certification leads to more energy efficiency investments and less energy consumption in the long run. This trajectory however damages social welfare compared to energy certification which implements the first best optimum.

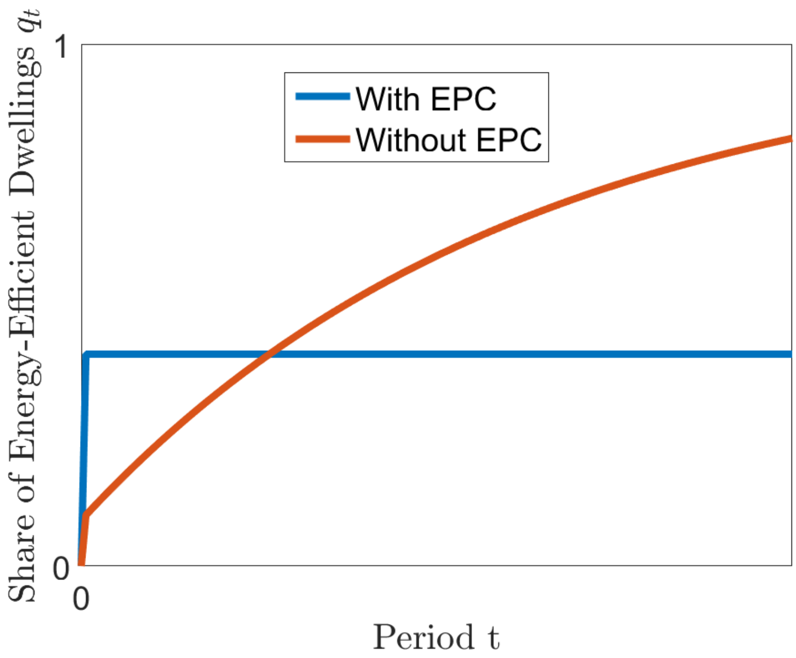

Figure 1: Example of energy-efficient dwellings stock q_t trajectories

Until now, it has been assumed that EPCs are introduced at $t = 0$ (when $q_0 = 0$). From a policy perspective, it is more realistic to consider that certification is introduced in period $\tau > 0$. We now investigate this case, introducing two additional assumptions. First, owners do not anticipate the introduction of certification in previous periods. Before $\tau > 0$, their investment behavior is thus not influenced by future signals on the real estate market. Second, at the beginning of period τ, the share q_τ of energy-efficient buildings and the allocation correspond to those of the trajectory described in Lemma 5. Under these assumptions, it is straightforward that:

Proposition 3. *In the case where the EPC is introduced at the beginning of period τ, all investments are immediately made. This leads to a (constant) share of efficient dwellings such $1 > q_{\tau+1} > q^*$. After τ, per-period energy consumption E_t decreases towards a value E_τ^∞ which verifies $E^* > E_\tau^\infty > 0$.*

The proof and the intuition is straightforward. In period τ, there remains a share q_τ of inefficient dwellings, which can be lower or higher than the first best. Suddenly, a price gap between efficient and inefficient dwellings appears on the real estate market. The households occupying inefficient dwellings whom types lies in between $\hat{e}$ and e^* thus decide to invest. At the end of the period, there however remains one inefficiency: there remain low types who live in efficient dwellings. This imperfect matching will progressively vanishes in the next periods when the low types will move out and sell their property to high types. Note that this result decisively hinges upon the assumption that moving decisions are exogenous. That is, we rule out cases where low types living in efficient dwellings would all move in inefficient dwellings in the city, thereby increasing their surplus by selling at a high price to high types.

5 EPC in a second best world

We have just seen that introducing EPCs may lead to higher energy consumption and lower cumulative investments. This implies that certification may reduce welfare in a second-best world where energy externalities are not sufficiently internalized or where households do not invest enough due to behavioral biases or other imperfections (”myopia).

5.1 Under-priced energy externalities

Assume now that energy expenditure e generates an externality αe which is not internalized with a tax or another policy instruments. Households thus use too much energy under EPCs. More precisely, cumulative energy cost, excluding the externality, is now $\left(\int_0^{e^*} edF(e)\right)/(1-\delta)$ while it should be $\left(\int_0^{e^{**}} edF(e)\right)/(1-\delta)$ in the first best with a threshold $e^{**} = I(1-\delta)/(1+\alpha)$ which is lower than e^*.

Under EPCs, cumulative energy use follows from Lemma 5:

$$\sum_{t=0}^{+\infty} \delta^t \hat{E}_t = \frac{1}{1-\delta[1-m(1-F(\hat{e}))]} \int_0^{\hat{e}} edF(e)$$

It is then clear that the difference with the EPC scenario is ambiguous. In particular, it depends on the cumulative F. If most households lie in between e^* and $\hat{e}$ (the population has intermediary energy needs), they will not invest in the absence of EPCs), leading to a higher energy use[4]. This is just the opposite if most of the households have high energy so that $e > \hat{e}$. Their propensity to invest is identical in the first period, but a fraction of incoming households continue to invest in the next periods without EPCs because they move in an inefficient dwellings.

Depending on the size of the externality, this can lead to a higher social cost with EPCs. Formally, the social cost function is

$$C = \sum_{t=0}^{\infty} \delta^t \left(\int_0^{+\infty} \mathbb{P}_t(\theta = 0|e)(1+\alpha)e \, \mathrm{d}F(e) + (q_{t+1} - q_t)I \right)$$

And straightfoward calculation yields that EPCs improve welfare iff:

$$(1+\alpha)\left(\frac{\int_0^{\hat{e}} e \, \mathrm{d}F(e)}{1-\delta(1-m(1-F(\hat{e})))} - \frac{\int_0^{e^*} e \, \mathrm{d}F(e)}{(1-\delta))}\right)$$
$$+ I\left[\frac{1-\delta(1-m)}{1-\delta(1-m(1-F(\hat{e})))}(1-F(\hat{e})) - (1-F(e^*))\right] > 0$$

The sign of this (cumbersome) welfare difference is ambiguous. If α is very small, the EPC scenario converges to the first best. If α is large, EPCs may damage welfare if q_t quickly converge towards 1. And we have seen that this depends on the distribution F (among other factors). We collect these insights in a new proposition.

Proposition 4. *In the case where energy consumption generates an externality of size α per unit, introducing EPCs may damage social welfare. This ultimately depends on the sets of parameters m, δ, I, α and on the distribution of energy needs F.*

[4]Formally, $F(\hat{e}) \to 1$, implying that the first multiplicative tends to be equal across scenarios $(1/(1-\delta))$ while the integral tends to 0 in the EPC scenario.

5.2 Owner myopia

The empirical literature on residential energy efficiency provide evidence that energy users may under-estimate future private energy savings when making investment decisions (for a general discussion, see Gillingham and Palmer [2014]). This leads to decisions that are not privately optimal and justifies the existence of policies that promote investments (e.g., subsidies, tax credits).

In line with these arguments, assume now that the owners discount future costs with a private discount factor μ which is higher than the social discount rate δ. Again, one can expect that the absence of EPCs, which increases investments in the long run, may be more efficient. By analogy with the previous case, we can easily show that EPCs improve welfare iff:

$$\left(\frac{\int_0^{\hat{e_\mu}} e \,\mathrm{d}F(e)}{1-\delta(1-m(1-F(\hat{e_\mu})))} - \frac{\int_0^{e^*_\mu} e \,\mathrm{d}F(e)}{(1-\delta))} \right) + I \left[\frac{1-\delta(1-m)}{1-\delta(1-m(1-F(\hat{e_\mu})))}(1-F(\hat{e_\mu})) - (1-F(e^*_\mu)) \right] > 0$$

with $e^*_\mu = I(1-\mu)$ and $\hat{e_\mu} = I(1-\mu(1-m))$. This difference is again ambiguous and we have a proposition which is similar to the previous one.

Proposition 5. *In the case where owners discount too much the future, introducing EPCs may damage social welfare. This ultimately depends on the sets of parameters m, δ, I, α and on the distribution of energy needs F.*

6 Conclusions

We have developed a dynamic model featuring a building stock with endogenous energy characteristics. The model includes three main ingredients. First, in the absence of EPCs, potential buyers do not observe energy performance before moving in their new home (experience good). Second, each homeowner can invest in order to increase his/her dwelling's energy performance. Third, an exogenous fraction of dwellings is sold in each period.

If asymmetric information on quality is the only market failure, we show that EPCs implement the social optimum. Less intuitively, the impact on the volume of investments and on the level of energy use is ambiguous. In the short run, that is, holding fixed the energy characteristics of the building stock, EPCs decrease energy use by improving the matching between buyers with heterogeneous energy needs and dwellings with heterogeneous energy performance. In the long run, EPCs can however either decrease of increase investments in energy efficiency, and thus energy use. Two countervailing factors drive this outcome. On the one hand, EPCs create on the real estate market a wedge between the price of efficient dwellings and inefficient dwellings. Homeowners are thus more prone to retrofit their homes because they anticipate a possible resale in the future. On the other hand, EPCs give potential buyers with two instruments to reduce energy use: purchasing an inefficient dwelling and invest or purchasing a dwelling which is already efficient. In contrast, investing is their unique instrument if they do not observe energy performance. In the long run, this increases investments as the random allocation of newcomers inevitably leads to the installation of a fraction of households with high energy needs in inefficient properties.

These results have important policy implications. In a second-best world where energy externalities are under-priced – leading to a too high energy use – and/or where consumers show behavioral biases that hinder investments (myopia), EPCs can thus damage social welfare. It is however extremely difficult to identify the contexts in which this could occur, in particular, because household heterogeneity – captured by the shape of the distribution of e in our setting – strongly influences the equilibrium path. This thus calls for using EPCs in contexts where other imperfections are properly addressed by other instruments.

While the empirical literature on EPCs and energy labeling is well developed as mentioned in introduction, it yields nearly no useful inputs for our conclusions as it does not deal with the impacts on energy use and investments.

These are preliminary results and we plan extending the paper in several directions. First, we want to generalize the results to the rental case. While the above mechanisms would still operate, the investment incentives are clearly lower without EPCs as the owner derives zero benefit from energy savings. Second, we want to calibrate the theoretical model with realistic figures in order to derive more clear-cut results on the impact of EPCs. Third, we also plan to explore the impacts of voluntary labeling.

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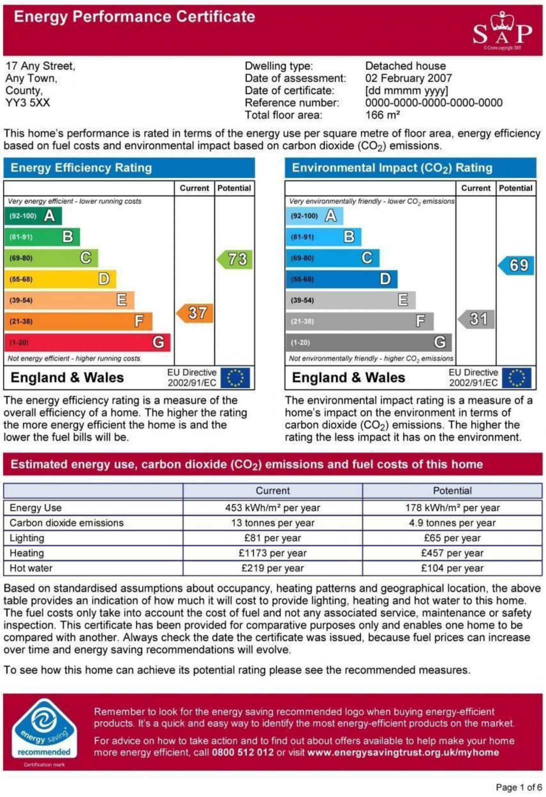
7 Appendix



Energy Performance Certificate

17 Any Street,
Any Town,
County,
YY3 5XX

Dwelling type:	Detached house
Date of assessment:	02 February 2007
Date of certificate:	[dd mmmm yyyy]
Reference number:	0000-0000-0000-0000-0000
Total floor area:	166 m²

This home's performance is rated in terms of the energy use per square metre of floor area, energy efficiency based on fuel costs and environmental impact based on carbon dioxide (CO_2) emissions.

The energy efficiency rating is a measure of the overall efficiency of a home. The higher the rating the more energy efficient the home is and the lower the fuel bills will be.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions. The higher the rating the less impact it has on the environment.

Estimated energy use, carbon dioxide (CO_2) emissions and fuel costs of this home

	Current	Potential
Energy Use	453 kWh/m² per year	178 kWh/m² per year
Carbon dioxide emissions	13 tonnes per year	4.9 tonnes per year
Lighting	£81 per year	£65 per year
Heating	£1173 per year	£457 per year
Hot water	£219 per year	£104 per year

Based on standardised assumptions about occupancy, heating patterns and geographical location, the above table provides an indication of how much it will cost to provide lighting, heating and hot water to this home. The fuel costs only take into account the cost of fuel and not any associated service, maintenance or safety inspection. This certificate has been provided for comparative purposes only and enables one home to be compared with another. Always check the date the certificate was issued, because fuel prices can increase over time and energy saving recommendations will evolve.

To see how this home can achieve its potential rating please see the recommended measures.

Remember to look for the energy saving recommended logo when buying energy-efficient products. It's a quick and easy way to identify the most energy-efficient products on the market.

For advice on how to take action and to find out about offers available to help make your home more energy efficient, call **0800 512 012** or visit **www.energysavingtrust.org.uk/myhome**

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