An Empirical Comparison of Voluntary and Mandatory Building Energy Performance Disclosure Outcomes

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Abstract

In 2010, the federal Australian government mandated the disclosure of energy performance ratings in advertisements for sale or lease of large commercial office properties. Prior to 2010, participation in the rating scheme was voluntary. This study first develops a theoretical model of mandatory disclosure policy effectiveness. Then, with a dataset of all ratings since inception of the voluntary regime in 1999, it tests the expectation that initial voluntary adopters have a greater tendency towards environmental stewardship and are more likely to manage and invest in environmental performance improvements, potentially dampening the effectiveness of mandatory disclosure policy. However, multiple statistical models of certification are unable to reject the null hypothesis that there is no difference in energy efficiency outcomes between the mandatory and voluntary adopters at equivalent stages. For urban policymakers, the extrapolation of voluntary adopter performance appears to be a good – perhaps even conservative – estimation of mandatory energy performance disclosure outcomes.

Keywords: Australia; Climate Change; Energy Efficiency; Existing Buildings; Mandatory Disclosure; Urban Policy

1. Introduction

The context of climate change and greenhouse gas mitigation provides a scope for urban policymakers to intervene in the energy performance of existing buildings. The United Nations Environment Programme (2007) estimates that buildings generate 30 to 40% of global greenhouse gas emissions, mostly as a by-product of operational energy consumption (Levine et al., 2007). Because buildings are built to last for a very long time, the replacement rate is very low (Holness, 2008; Kok et al., 2012b). Models of future building stock energy performance show a strong sensitivity to assumptions behind investment in existing stock performance (Coffey et al., 2009). Consensus on the need to rapidly mitigate greenhouse gas emissions in order to avoid the negative consequences of a warming planet means that existing buildings must be involved in mitigation efforts. A conservative initial target for the urban built environment is provided by Pacala and Socolow (2004), who suggest a 50-year target of 25% reduction in emissions from 2004 levels.

The limitation of private energy efficiency initiatives is best seen in recent studies that narrate how energy efficiency is a niche product in the market for urban office space. Chegut et al. (2014) find that as the market share of energy efficient buildings increase, the private incentive of capital and rent premiums generated from these assets decreases. Kok et al. (2012b) describe a slowdown in the once rapid growth seen in private energy efficiency certifications in the United States market for new and existing buildings. Even after this rapid growth period, the market share of privately-labelled stock is less than 10% of the total commercial stock in the United States. Hence government intervention is seen as a means to rapidly increase adoption of energy efficiency.

One policy intervention being considered for increasing operational energy efficiency in existing buildings is mandatory disclosure of operational energy consumption in any lease or sale advertisement (Kontokosta, 2013). This is an indirect “market-based policy” in that it relies on the market to price energy efficiency, creating an incentive for private investment in greenhouse gas mitigation. Governments do not set a statutory minimum in a market-based policy so the outcome of mandatory energy performance disclosure is unknown and relies on the willingness of consumers to pay for energy efficiency in a competitive market. Some argue that a market-based policy approach is preferred because traditional top-down regulation, while effective, is costly, rigid, inefficient, and adversarial (Borck and Coglianese, 2009).

Typically, the required information in a mandatory disclosure is previously available for use on a voluntary basis; in other words, the government simply mandates that the market must participate in what was once a voluntary scheme. This study is the first systematic comparison of energy performance outcomes resulting from voluntary certification (i.e. a “no action” scenario for policymakers) and mandatory certification. It enables urban policymakers considering mandatory disclosure to forecast an outcome based on existing data available from voluntary schemes. Specifically, this paper investigates outcomes in Australia, which is one of the first governments to test the policy of mandatory energy consumption disclosure in the urban built environment.

2. Mandatory Energy Performance Disclosure: History and Theory

The Australian Capital Territory (ACT) was one of the earliest to experiment with mandatory disclosure of energy consumption potential in the built environment as a means to influence private housing development. Since 1999, sales advertisements for detached residential houses are required to display an Energy Efficiency Rating (EER) that simulates the cost of energy used to heat and cool the dwelling in a typical year. Because performance is simulated, this type of rating is commonly referred to as an “intrinsic” rating, or an energy consumption estimate based on standardised operating conditions. Actual consumption data is not collected for an intrinsic rating. Research on the outcomes of this early attempt at mandatory disclosure in the ACT is limited to a government-sponsored statistical model showing that house sale prices in 2005 and 2006 are positively correlated with EER scores in a hedonic price model (Soriano, 2008).

Closely resembling the ACT regulation, European Union Directive 2002/91/EC mandated in 2002 that all member states make an Energy Performance Certificate (EPC) available to interested parties during the sale or lease of commercial and residential property. The European directive relaxes the ACT restriction on building type but in practice, EU states implemented the directive in stages starting with detached residential and gradually expanding into different commercial building sectors. Despite the word "performance" in the title, an EPC is also an intrinsic rating, just like the ACT EER.

Research on the outcomes of the European directive concentrates on the relationship between market prices and EPC rating, but also on the process of implementation by member states. Kok and Jennen (2012) found that EPC ratings above a government threshold for energy efficiency garnered higher rents in Dutch office buildings. Fuerst et al. (2013) found similar evidence in the UK, but raised questions over the cause when observing that only newer buildings received premiums. Andaloro et al. (2010) have criticised the slow implementation of the directive among EU members, while Fuerst and McAllister (2011) comment on shortcomings with EPC availability to prospective buyers or lessees. As of yet, there is no study looking at the efficacy of an EPC to reduce measured energy consumption of existing buildings in-use.

In 2010, the federal Australian government became the first to mandate consumption rating disclosure, although the mandate is restricted to large commercial office buildings greater than 2000 square metres. Unlike intrinsic ratings, "consumption ratings" are based on measured energy performance audited to a common standard. The Building Energy Efficiency Disclosure (BEED) Act was enacted in early 2010 with effect from November 2010, and as a result, large office buildings must disclose a National Australian Built Environment Rating System (NABERS) Energy rating conspicuously in advertising materials for lease or sale. Similar mandatory disclosure laws using consumption ratings have since been enacted at the local and state level in the United States; for example, Kontokosta (2013) discusses the plan for mandatory performance disclosure in New York City.

Prior to the mandate in Australia, NABERS Energy was available as a voluntary certification tool. Gabe (2016) reported that, on average, owners participating in NABERS Energy audits for approximately five years met the Pacala and Socolow (2004) target of 25% reduction in greenhouse gas emissions. The question pursued in this research is the variance in energy efficiency outcomes between voluntary adopters and outcomes from later mandatory adopters forced into the auditing process by government policy.

One can hypothesise that mandatory adopters are disinterested in energy efficiency and thus mandatory disclosure policies could have less effect on energy efficiency outcomes than would be expected if one projects outcomes using the voluntary cohort performance. Building owners forced to disclose via mandatory disclosure have implicit success in the market outside of a disclosure regime and thus less likely to see value in operational energy efficiency investment. The question facing these owners is whether perceived societal costs of disclosing poor energy ratings exceed the value in continuing business as usual. Since voluntary disclosure would occur in the absence of policy intervention, policy outcomes are dependent on owners forced to disclose.

A simple theoretical model is used to illustrate this hypothesis. First, consider the total change in urban energy consumption within a private market and the option to participate in a voluntary energy efficiency initiative:

$$\Delta = P_V \times \Delta_V + (1 - P_V) \times \Delta_S \quad (1)$$

Δ: Average change in energy consumption per building over the whole stock
Δ_V: Average change in energy consumption per building for a voluntary adopter
Δ_S: Average change in energy consumption per building for a non-participant[1]
P_V: Fraction of the market participating in voluntary initiative
Conditions: $0 < P_V < 1$; $\Delta_V < \Delta_S$

This model is adopted from Borck and Coglianese (2009), who devise a similar equation to estimate the effectiveness of voluntary certification schemes. Note that Δ is a variable measuring change in energy consumption. Negative values indicate energy consumption savings, so the more negative Δ becomes, the greater the energy efficiency outcome.

Next, the total change in urban energy consumption within this market if the government decides to implement mandatory disclosure adds the contribution of those forced into participation:

$$\Delta = P_M \times \Delta_M + P_V \times \Delta_V + (1 - P_M - P_V) \times \Delta_S \quad (2)$$

Δ_M: Average change in energy consumption per building for a mandatory adopter
P_M: Fraction of the market forced into participation by mandatory disclosure
Conditions: $0<P_M<1$ and $P_M + P_V \leq 1$

Mandatory disclosure policy will only be a useful tool if Δ from Equation 2 is less (i.e. greater energy savings) than Δ from Equation 1:

$$(P_M \times \Delta_M + P_V \times \Delta_V + (1 - P_M - P_V) \times \Delta_S) < (P_V \times \Delta_V + (1 - P_V) \times \Delta_S)$$

Using a conservative assumption that voluntary participants do not change behaviour as a result of the introduction of mandatory disclosure, this equation simplifies to a necessary condition for mandatory disclosure.[2] The reductions in energy consumption for those forced into energy efficiency scheme the must be greater than the "spillover effect", or the reductions in energy consumption of non-participants under a voluntary scheme:

$$\Delta_M < \Delta_S$$

In line with the literature (Borck and Coglianese, 2009), this study assumes the spillover effect (Δ_S) is non-zero, but can only be observed qualitatively. What can be observed quantitatively is Δ_V. Since it is a necessary condition that $\Delta_V < \Delta_S$, a helpful comparison may exist between Δ_V and Δ_M; if $\Delta_M \leq \Delta_V$, then mandatory disclosure is certainly an effective policy. However, if, as hypothesised above, $\Delta_V < \Delta_M$ (because mandatory adopters are assumed less interested in energy efficiency) then the benefit of implementing mandatory disclosure is less clear. This study will empirically compare Δ_V and Δ_M in the Australian market.

This paper complements early research investigating the exogenous determinants of energy efficient urban development. Kok et al. (2012a) examined lagged effects of property market conditions and local economic variables on the diffusion of energy efficient buildings to find a positive association with income and electricity prices. Fuerst et al. (2014) test the effectiveness of a variety of market-based policies to increase green building development, finding that only mandatory green building procurement policies have any effect.

3. NABERS Energy Certification

The NABERS Energy auditing methodology was developed by the New South Wales state government (Department of Environment Climate Change and Water NSW, 2010) and has been used since 1999. Prior to 2008, NABERS Energy was branded as the Australian Building Greenhouse Rating (ABGR). Third-party auditors assess 12 months of building energy consumption and produce a rating from 0 to 6 stars based on estimated greenhouse gas emissions resulting from that measured energy consumption. Star ratings are calibrated regionally such that 2.5 stars are assigned to a building with average energy consumption in each metropolitan area. Certificates are freely available via the programme website (www.nabers.gov.au). Besides a star rating, the certificate includes raw data from the audit on measured site energy consumption and its conversion into greenhouse gas emissions.[3]

The boundaries of certification are typically “Base Building” services, which exclude tenant power consumption (computers and plug-in appliances). Included in the Base Building rating are whole-building lighting, space conditioning, hot water production, and all common area power consumption. Base Building ratings conveniently match the boundaries of energy and greenhouse gas costs paid by the party liable for operating expenses in a rental contract.

Owners wishing to improve NABERS Energy ratings have three options: invest in on-site operational energy efficiency, purchase Green Power offsets, or fuel-switch to maintain site energy consumption while reducing source greenhouse gas emissions. This study only measures the first option – investment in on-site operational efficiency – which is the most common approach. Green Power is a national Australian scheme administered by the federal government that allows an electricity consumer to pay a premium for electricity that goes to renewable energy producers in exchange for certification that the consumer’s electricity was generated by zero-emission renewable energy. Because Green Power must be excluded from disclosure under the BEED Act, it is not a common option.[4] Fuel switching is also rare. The correlation from first to final certification of the ratio of greenhouse gases per unit of energy is above 0.9, which most likely reflects minor variability in electricity production from year-to-year.

4. Method & Data

The objective of this study is to measure quantitative energy reduction outcomes from two groups of commercial office buildings in Australia: those that voluntarily entered the NABERS certification process and those that entered the NABERS certification process as a result of mandatory disclosure.

Between the commencement of ABGR and October 2013, all publicly available ABGR and NABERS Energy certificates and NABERS certificates were obtained from the internet (www.abgr.gov.au and www.nabers.gov.au respectively). Only Base Building ratings are used in this paper. Whole Building ratings are valid for mandatory disclosure, but are not comparable with Base Building ratings because they include tenant power loads.[5] Hence, in this paper, “energy rating” always refers to a Base Building rating. The first energy certificate in the dataset was issued in August 1999.

All data in this paper is extracted from each NABERS Energy certificate. Raw energy consumption data, measured as site energy use intensity ($MJ/m^2/year$),[6] star ratings, and total greenhouse gas emissions (kg/year) are consistently disclosed on each certificate.

All energy information used in this study excludes any effect associated with Green Power purchasing. Information to identify the building is also provided in the form of an address, postcode, state, and contact details for the certification applicant.

To clean the data, multiple certificates for the same building with the same expiry date were removed, with the chosen certificate having the most recent NABERS ID Number (a proxy for the issue sequence). A very small number of certificates are missing data that clearly identifies the certified building. As a result, 71 were removed from the dataset. In total, the cleaned dataset contains 3,323 certificates. There are 1,152 unique certified buildings across Australia, with 818 multi-certified.

Separating voluntary adopters from mandatory adopters is not straightforward. While there is a date for passing of the BEED Act (28 June 2010) and a date disclosure obligations commenced (1 November 2010), discussions on the legislation began as early as 2008. Figure 1 is a histogram showing the number of buildings entering the NABERS Energy disclosure program by quarter. There are two distinct peaks in activity – Q1 2006 and Q4 2010. The first peak is correlated with the positioning of a number of private Australian property funds as green and sustainable (Bauer et al., 2011). These are voluntary adopters motivated by competitive strategy to position their portfolio in the market. The second peak neatly corresponds to the commencement of mandatory disclosure obligations.

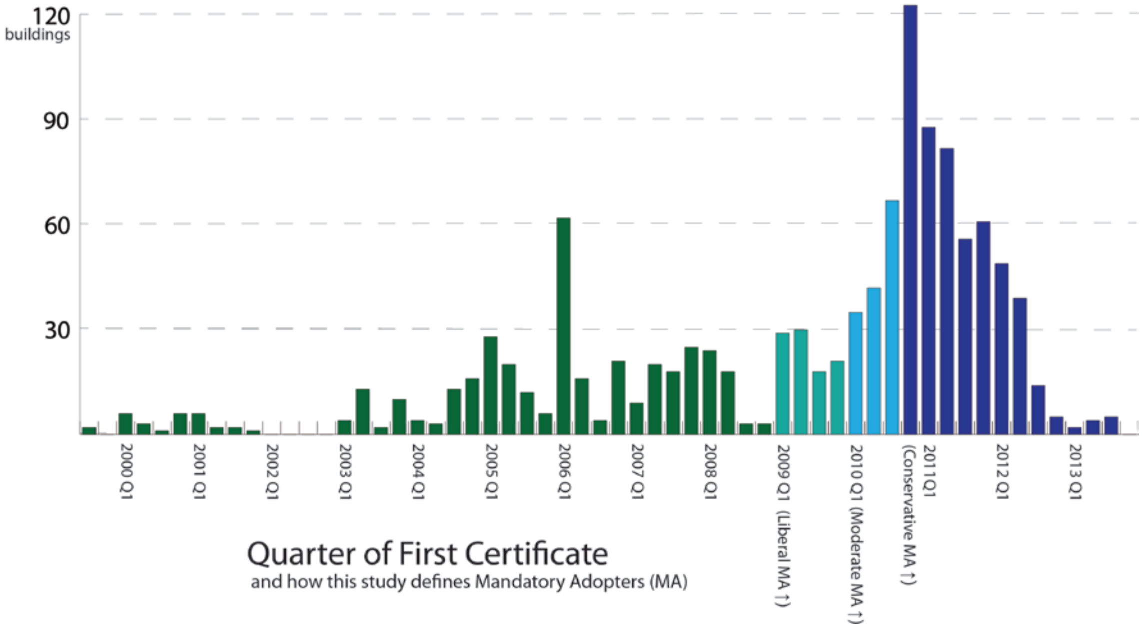

Figure 1. Histogram of NABERS Energy adoption across all of Australia.

This paper will test three separation points. The conservative approach defines mandatory adopters as any building obtaining its first NABERS Energy certificate on or after the commencement of disclosure obligations on 1 November 2010. But as Figure 1 demonstrates, there is clear growth in participation prior to mandatory disclosure enforcement; hence the conservative approach likely omits buildings motivated by anticipation of mandatory disclosure. But where is a more liberal break to be placed? The drop in voluntary certification in late 2008 is likely due to the global financial crisis, but it does provide a notable separation between peaks. Thus, the liberal approach is to assume all certification entrants from Q1 2009 were motivated by upcoming mandatory disclosure legislation. To test the sensitivity of these two extremes, a moderate approach defines mandatory disclosure participants as those entering certification in or after Q1 2010.

A multiple regression model is constructed to test the hypothesis that mandatory adopters of NABERS Energy will not be as inclined to invest in operational energy efficiency as voluntary adopters. This model estimates the contribution of a number of predictor variables described below on dependent variable Δ_j, being the energy use intensity (EUI) change observed for each building *j* between the time of initial certification and the time of a subsequent re-certification, *c*:

$$\Delta_j = EUI_{c_j} - EUI_{1_j} = \alpha + \boldsymbol{\beta_1 LOC_j} + \beta_2 CAP_j + \beta_3 GP_j + \beta_4 DAYS_j + \beta_5 MD_j + \varepsilon$$

EUI: Energy use intensity (MJ/m^2/year)
LOC: Fixed locational effects
CAP: Capacity of building to reduce energy consumption (initial EUI)
GP: “Green Owner” purchasing Green Power offsets (1=yes)
DAYS: Average days between re-certification audits
MD: Variable identifying building as a mandatory adopter (1=yes)

where α is an estimated intercept, β is an estimated coefficient, and ε represents stochastic error. Vector variables are indicated in bold type. The predictor variable of interest is MD_j, a binary variable taking the value 1 if building *j* meets the specified definition of a mandatory adopter as described above. To connect with the theoretical models presented earlier, if MD=1, the dependent variable in the model above is the value of Δ_M in Equation 2 while if MD=0, the dependent variable is the value of Δ_V in

Equation 1. Coefficient β_5 measures the difference between Δ_V and Δ_M, testing the null hypothesis that $\Delta_V = \Delta_M$.

The observed distribution of the dependent variable is shown in Figures 2 and 3 for *c*=2 and c=3 respectively, plotted as a density curve. As discussed earlier, a negative value indicates a building has improved its energy efficiency by reducing consumption. Because of changes to greenhouse gas conversion factors over time and space, the only energy measurement consistently comparable over the entire duration of the ABGR and NABERS Energy programme is annual site energy use intensity (EUI). Thus this study only considers changes in EUI as opposed to measuring greenhouse gas mitigation directly. Nearly all energy consumption in commercial office buildings in Australia is sourced from electricity, so the use of site energy consumption as a proxy for greenhouse gas emissions represents a good proxy for on-site management of emissions.

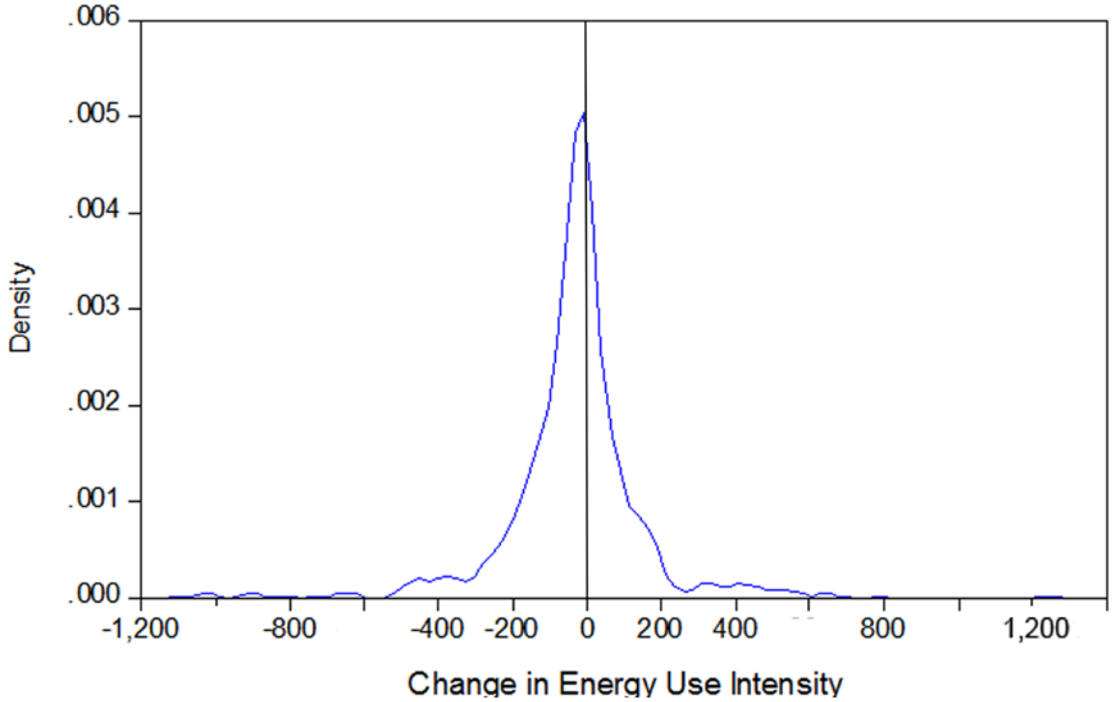

Figure 2. Distribution of change in EUI between first and second certificates.

N=818, μ= -32.7, σ=187.

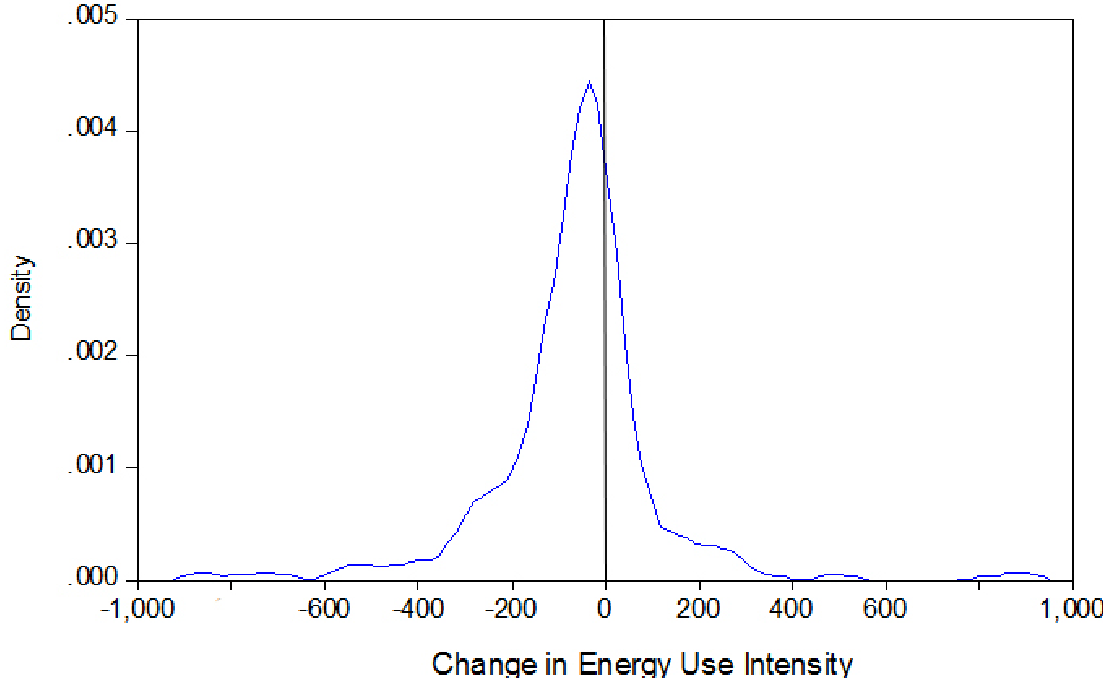

Figure 3. Distribution of change in EUI between first and third certificates. N=576, μ= -67.2, σ=178.

Mandatory disclosure is relatively recent, so the analysis will only investigate early performance outcomes of both the voluntary and mandatory cohorts. Of 818 multi-certified buildings, only 10 meeting the conservative definition of a mandatory adopter have obtained four NABERS Energy certifications. This limits robust statistical analysis of the conservative mandatory adopter definition to a building's first three certificates.

The first independent vector variable, ***LOC***, represents fixed effects metrics associated with location, including a binary variable for each Australian state or territory and a binary variable indicating whether a building is located in a capital city central business district. In the event of any significant coefficients, the state variables enable the model to control for an unobserved range of fixed effects specific to each state that may lie behind the differentiation, such as climactic zones, state policy, property market cycles and economic conditions. To improve the imperfect proxy of state boundaries to estimate these fixed effects, a capital city variable isolates intrastate market differentiation. In particular, office markets in a central business district (CBD) offer prospective tenants greater choice than smaller provincial or suburban centres. Greater competition between owners may lead to greater investment in energy efficiency in major cities as part of an asset positioning strategy.

Because an initial certificate is used to benchmark improvement, it is necessary to estimate the capacity to improve, *CAP*. Buildings operating at high levels of energy efficiency (i.e. low EUI) at the time of initial certification are likely to have invested prior to entry into NABERS Energy certification. Hence it is necessary for the comparison to discount an expected lack of improvement in buildings operating at best practice when entering the certification programme. Two measurements of *CAP* were tested for the models in this study – initial EUI and initial star rating – and it was concluded that initial EUI, with is finer data resolution, produces a superior modelling outcome. Using initial star rating as the proxy for capacity does not alter any result of the study.

The Green Power purchase decision (*GP*) is useful to proxy management strategy. In the dataset, all building owners electing to purchase over 1% of their electricity via the Green Power scheme in each NABERS re-certification are identified using a binary variable. Recall that owners wishing to improve star ratings can opt to invest in on-site energy efficiency and opt to invest indirectly in off-site greenhouse gas mitigation using Green Power offsets. As can be seen in Table 1, some mandatory adopters have chosen to purchase Green Power, so this variable is not perfect correlated with adoption strategy.

The remaining independent variable, *DAYS*, represents the average number of days between re-certification. Since buildings are compared with regard to the certificate sequence, this metric is needed to control for variability in the amount of time between certificates. An alternative specification using the rate of change in energy performance (Δ / *DAYS*) as the dependent variable was also considered, with similar results. However, the separation of *DAYS* as an independent variable is preferred to ease interpretation, particularly because *DAYS* has a lognormal distribution.

Table 1 provides a descriptive overview of the data gathered for all multi-certified buildings, with a breakdown by the three definitions of mandatory adopters. In general, EUI declines over time on average, though variance does not noticeably decline until the third certificate. Green Power offsets are uncommon, with only 12.3% of all building owners choosing to purchase it to reduce greenhouse gas emissions. As for location, just over half of multi-certified buildings are located in the central business district of capital cities. On recertification frequency, voluntary adopters are less likely than mandatory adopters to recertify annually.

--Insert Table 1 Here--

5. Results

Table 2 presents the estimated models explaining the change in energy consumption between first and second NABERS Energy certificates as a function of the predictor variables described earlier. Table 3 presents the model of the change in energy consumption between first and third certificates while Table 4 is the model explaining the change between the first and fourth certificates.

--Insert Table 2 Here--

--Insert Table 3 Here--

The headline result is that there is no significant signal of differentiation between mandatory and voluntary adopters after multiple cycles of NABERS Energy re-certification. In the two-certificate model (Table 2), the three estimates of the mandatory adopter coefficients suggest that stricter definitions of mandatory adopters are associated with a *greater* tendency to reduce energy consumption at the time of an asset's first re-certification. But there is no statistical significance to these results, leading to the conclusion that it is not possible to reject the null hypothesis that $\Delta_V = \Delta_M$ after two certification cycles. The story is similar when the population of buildings certified three times is analysed (Table 3); all three mandatory disclosure coefficients are very close to zero, and once again it is not possible to reject the null hypothesis that $\Delta_V = \Delta_M$.

--Insert Table 4 Here--

The four-certificate model (Table 4) is little changed from the three-certificate model. Because only 10 buildings meet the definition of conservative mandatory adopter, this category was excluded from the model given the low statistical power of a binary coefficient with so few observations. The moderate and liberal definitions of mandatory adopters are consistent with the story from the first two re-certification periods – no significant difference between voluntary and mandatory adopter energy reduction outcomes.

Two certification cycles provide ample time for some initial investment to take effect, as it is in line with the lag used in Kok et al. (2012a). But what could be behind a finding that, although that signal is weak and insignificant, owners anticipating mandatory disclosure obligations improve performance *faster* than voluntary adopters? The risk behind technology development provides the most plausible narrative. Voluntary adopters are also the innovators in the market for building energy efficiency, having invested four years prior to the mandatory adopters according to the median year of first certification in Table 1. Some of these innovative investments may not have functioned as expected; hence the risk of non-improvement was greater for the voluntary adopter cohort. By the time that mandatory adopters arrived in the market, the innovators had developed successful strategies and technologies that could diffuse into the market with less risk of non-improvement.

As for the remaining metrics in the model, improvement potential is consistently able to differentiate the likelihood of improving office building energy performance. All else equal, each additional increase in a building's EUI at the start of the certification process results in a 0.2, 0.2, and 0.5 MJ/m^2/year reduction in EUI after two, three, and four certification cycles respectively. The big drop between certifications three and four is consistent with earlier models of energy consumption reductions in Australian buildings reported in Gabe (2016). Combined with the finding of little, if any, difference between mandatory and voluntary adopters, the significance of this result is that depth of participation in the audit process is the most important determinant of building energy efficiency. What led the owner to participate is unimportant.

The other control variables help to validate the model. Although not displayed in the modelling results, the fixed locational effects tell the same story as Gabe (2016); there is no significant differentiation between states with the lone exception of Queensland, which had an undersupply of space with uncharacteristically low office vacancy rates during much of this study's timeframe. Undersupply meant that owners were motivated to get new supply on the market as quickly as possible; energy efficiency was not needed to entice new tenants. Although it is not significant in the early certification models, there is a consistent signal that Green Power purchasing is a complement to operational energy efficiency and thus valid as an instrument for green ownership strategies. The coefficient in all models is negative, with later specifications indicating it is statistically significant. This observation fits with a narrative that Green Power offsets are used to minimise greenhouse gas emission liabilities beyond best operational practice, not in lieu of operational improvements. So owners invest in operational efficiency first, then head to the market to purchase off-site mitigation as part of a more stringent GHG emissions reduction strategy.

Finally, readers should be cautious about these interpreting these results too generally, particularly the two-certificate models. Building energy efficiency investment, particularly in the short-term, is a very stochastic outcome. The two-certificate models can, at best, only explain just over 10% of energy savings variability. Additional predictor data, such as building quality ratings, climate indicators and more direct measures of building size, were tested on truncated samples of the buildings in this dataset, but did not improve the model. Instead, the increase in explanatory power to roughly 18% of observed variance in the three-certificate model, and 36% in the four-certificate model suggests that much of the noise is due to the research trying to measure an outcome empirically before it settles in equilibrium. Despite this need for caution, the degree of explanatory power in the four-certificate models is on-par with earlier research (Fuerst et al. 2014; Gabe, 2016; Kok et al. 2012b) exploring the relationship between exogenous predictors and building energy efficiency investment. At the very least, it is possible to conclude that these models reveal a cohort of mandatory adopters that are investing in building energy efficiency, even though it is not possible to know the final equilibrium state.

6. Conclusions and Policy Implications

Energy efficiency outcomes from Australian buildings required to disclose energy performance are similar to buildings whose owner chose to voluntarily disclose energy performance prior to the mandate. Approximately three years, and up to four certification periods, after mandatory disclosure regulation was enforced, there is no evidence that mandatory adopters are managing operational energy efficiency any differently than voluntary adopters at an equivalent time in their adoption process.

A theoretical model of the outcome of mandatory disclosure policy was presented (Equation 2), with the critical determinant of success being a more negative value of Δ_M, the energy consumption change per mandatory adopter, relative to Δ_S, the passive energy consumption change for non-participants in a market with a voluntary energy reduction scheme (the "spillover effect"). An empirical value of the spillover effect is not observable with any reliability (Borck and Coglianese, 2009), so the contribution of this research is valuable because it concludes that $\Delta_M = \Delta_V$, the energy consumption change for participants in a voluntary scheme. By definition $\Delta_V < \Delta_S$, so these findings are strong evidence that $\Delta_M < \Delta_S$, meaning mandatory disclosure is an effective policy action to reduce greenhouse gas emissions in the urban built environment.

For policymakers, this means that effect per participant in the mandatory disclosure scheme is, on average, similar to the effect per voluntary participant. The increase in participation without any loss on effect per participant means mandatory disclosure has delivered environmental benefits despite the lack of traditional environmental performance thresholds. Of course, policymakers should understand that the framework for this success in Australia was a pre-existing voluntary scheme that was widely used. Later adopters benefit with lower risk and a mature market for energy efficiency upgrades as a positive externality of the pioneering voluntary adopters. One may thus expect that attempting to mandate a disclosure system that has little or no voluntary participation may lead to a longer lag between implementation and measurable success, given the need to develop a market for energy efficiency upgrades in that scenario.

As a further aide to policymakers wishing to forecast the impact of a mandatory disclosure policy on energy efficiency in the built environment, the best predictor of performance improvement was pre-intervention energy use intensity (EUI) for buildings entering the disclosure programme. Therefore, a mandatory disclosure policy will have the greatest impact in markets with high average EUI among non-participants in a voluntary scheme.

Given the mid-equilibrium nature of this research, further data on mandatory adopters may change these initial conclusions. Earlier research (Gabe, 2016) found voluntary adopters continued to improve, on average, over five years before reaching an apparent equilibrium. It is possible that as mandatory adopters reach their limits to improvement in the next few years that voluntary adopters may have better relative performance after five years. Additionally, an interesting further question is whether the introduction of mandatory adoption affects the equilibrium of voluntary adopters. To re-establish the market differentiation that drove their initial investment, voluntary adopters may enter a second round of private investment in improved energy performance, creating a positive feedback effect to enhance policy success. But for most policymakers, the differential between early and later adopters is less important than the knowledge that a successful mandatory disclosure policy has led to a large increase in scheme participants without any apparent loss of the effect of the scheme on each participant.

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[1] One might assume this variable takes the value of zero, but non-participants may also reduce energy consumption as a result of "spillover effects", or the positive benefits of innovation by participants that spills over into the general market. Borck and Coglianese (2009) review the literature on spillover effects

and find they are difficult to measure but qualitatively exist. Simcoe and Toffel (2013) present an example of a study that concludes spillover effects of building energy efficiency as a result of public sector procurement policies are non-zero.

[2] This is a conservative assumption because it is also possible to assume that the original voluntary adopters will seek to maintain market differentiation and choose to invest further, meaning Δ_V is not constant across policy regimes. If this assumption is relaxed and model was to include behaviour by voluntary adopters after the introduction of mandatory disclosure, the equation for policy effectiveness becomes:

$$\Delta_M + (\Delta_{V_{after}} - \Delta_{V_{before}}) < \Delta_S$$

where the additional term represents the marginal increase in Δ_V following the introduction of mandatory disclosure. However, the effect on earlier voluntary adopters is certain to be dependent on the magnitude of Δ_M, making the effect of mandatory disclosure on voluntary adopters endogenously determined. The necessary condition for policy success defined below, $\Delta_M \geq \Delta_V$, must hold for voluntary adopters to have an incentive to maintain their market position. Thus, the conservative assumption that voluntary adopters do not respond to mandatory disclosure policies is a useful first step and future research can investigate the structure and magnitude of positive feedback created when a mandatory disclosure policy is effective.

[3] The NABERS Energy auditing guidelines (Department of Environment Climate Change and Water 2010) specifies temporal and spatial boundaries for site energy data collection. The resulting energy consumption per square metre of net lettable area disclosure is used in this study. However, to assign a star rating, the energy data is converted to greenhouse gas emissions and then to a “Benchmarking Factor” that further takes into account fixed regional effects and intensity of building use. Because the greenhouse gas emission and Benchmarking Factor conversion methodology is not publicly disclosed, there is no means of ensuring that it is consistent and comparable across time and space, so those data are not used in this study.

[4] Because of this condition, all NABERS certificates provide ratings that exclude any Green Power purchase.

[5] There are an insufficient number of Whole Building re-certifications for separate statistical analysis.

[6] 1 MJ/m^2/year = 0.278 kWh/m^2/year

References

Andaloro, A. P. F., Salomone, R., Ioppolo, G. and Andaloro, L., (2010). Energy certification of buildings: A comparative analysis of progress towards implementation in European countries. Energy Policy 38, 5840-5866.

Bauer, R., Eichholtz, P., Kok, N. and Quigley, J. M., 2011. How Green is Your Property Portfolio? The Global Real Estate Sustainability Benchmark. Rotman Int. J. Pension Manag. 4 (1), 34-43.

Borck, J. C. and Coglianese, C., 2009. Voluntary Environmental Programs: Assessing their Effectiveness. Ann. Rev. Environ. Resour. 34, 305-324.

Chegut, A., Eichholtz, P. and Kok, N., 2014. Supply, Demand, and the Value of Green Buildings. Urban Stud. 51 (1), 22-43.

Coffey, B., Borgeson, S., Selkowitz, S., Apte, J., Mathew, P. and Haves, P., 2009. Towards a very low-energy building stock: modelling the US commercial building sector to support policy and innovation planning. Build. Res. Inf. 37, 610-624.

Department of Environment Climate Change and Water NSW. 2010. NABERS Energy and Water for Offices: Rules for collecting and using data, NSW Government, Sydney.

Fuerst, F., Kontokosta, C. and McAllister, P., 2014. Determinants of green building adoption. Environ. Plan. B. 41 (3), 551-570.

Fuerst, F. and McAllister, P., 2011. The Impact of Energy Performance Certificates on the Rental and Capital Values of Commercial Property Assets. Energy Policy, 39 (10), 6608-6614.

Fuerst, F., van de Wetering, J. and Wyatt, P., 2013. Is intrinsic energy efficiency reflected in the pricing of office leases?, Build. Res. Inf. 41 (4), 373-383.

Gabe, J., 2016. Successful greenhouse gas mitigation in existing Australian office buildings. Build. Res. Inf. 44 (2): 160-174.

Holness, G. V. R., 2008 . Improving Energy Efficiency in Existing Buildings. ASHRAE J. 50 (1), 12-26.

Kok, N. and Jennen, M., 2012. The Impact of Energy Labels and Accessibility on Office Rents. Energy Policy 46, 489-497.

Kok, N., McGraw, M. and Quigley, J., 2012a. The Diffusion Over Time and Space of Energy Efficiency in Building. Ann. Reg. Sci. 48 (2), 541-564.

Kok, N., Miller, N. G. and Morris, P., 2012b. The Economics of Green Retrofits. J. Sustain. Real Estate 4, 5-22.

Kontokosta, C. E., 2013. Energy disclosure, market behavior, and the building data ecosystem. Ann. N. Y. Acad. Sci. 1295 (1), 34-43.

Levine, M., Ürge-Vorsatz, D., Blok, K., Geng, L., Harvey, D., Lang, S., Levermore, G., Mehlwana, A. M., Mirasgedis, S., Novikova, A., Rilling, J. and Yoshino, H., 2007. Residential and Commercial Buildings, in: Metz, B., Davidson, O. R., Bosch, P. R., Dave, R. and Meyer, L. A. (Eds.), Climate Change 2007: Mitigation. Contribution of Working Group Three to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, pp. 387-446.

Pacala, S. and Socolow, R., 2004. Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies. Science 305, 968-972.

Simcoe, T. and Toffel, M. W., 2013. Government Green Procurement Spillovers: Evidence from Municipal Building Policies in California. J Environ. Econ. Manag. 68 (3), 411-434.

Soriano, F., 2008. Modelling the Relationship of Energy Efficiency Attributes to House Price: The Case of Detached Houses Sold in the Australian Capital Territory in 2005 and 2006, in: Department of the Environment Water Heritage and the Arts (Ed.), Energy Efficiency Rating and House Prices in the ACT. Australian Government, Canberra, pp. 9-48.

United Nations Environment Programme. 2007. Buildings and Climate Change: Status, Challenges and Opportunities. United Nations Environment Programme, Paris.

Table 1. Descriptive statistics comparing voluntary and mandatory adopters of NABERS Energy across Australia. Mean (Standard Deviation).

	Conservative (1 November 2010)		Moderate (1 January 2010)		Liberal (1 January 2009)		All Obs.
	Voluntary	Mandatory	Voluntary	Mandatory	Voluntary	Mandatory	
Number of Buildings	558	260	431	387	343	475	**818**
Initial Star Rating	2.75 (1.33)	2.53 (1.64)	2.72 (1.26)	2.63 (1.61)	2.56 (1.21)	2.76 (1.58)	**2.68 (1.44)**
Initial EUI (MJ/m^2/yr)	596 (212)	695 (422)	602 (194)	656 (381)	628 (190)	627 (358)	**627 (299)**
Second EUI (MJ/m^2/yr)	574 (224)	638 (408)	573 (197)	619 (377)	591 (193)	597 (353)	**595 (297)**
Third EUI (MJ/m^2/yr)	537 (204) [N=476]	645 (447) [N=100]	540 (192) [N=387]	586 (372) [N=189]	557 (178) [N=313]	553 (342) [N=263]	**555 (266) [N=576]**
Fourth EUI (MJ/m^2/yr)	494 (163) [N=374]	501 (494) [N=10]	498 (154) [N=332]	474 (220) [N=52]	510 (152) [N=277]	453 (188) [N=107]	**495 (165) [N=384]**
% Purchasing Green Power	15.4%	5.8%	16.9%	7.2%	15.2%	10.3%	**12.3%**
% Located in Capital CBD	56.6%	38.8%	60.3%	40.6%	62.7%	42.5%	**51.0%**
Avg. Days Between Cert.	569 (364)	408 (133)	601 (394)	425 (160)	637 (423)	432 (168)	**518 (319)**
Median Year of 1st Cert.	2007	2011	2006	2011	2006	2010	**2009**

Table 2. Regressions on the change in energy use intensity between first and second NABERS Energy certifications.

Definition of Mandatory Adopter	Conservative	Moderate	Liberal
Mandatory Adopter	-22.34 (14.97)	-1.174 (14.54)	10.51 (14.87)
Initial EUI	-0.204*** (0.022)	-0.210*** (0.022)	-0.211*** (0.022)
Owner Purchased Green Power	-28.44 (19.22)	-24.92 (19.19)	-23.75 (19.02)
Located in Capital City CBD	-17.25 (13.14)	-14.17 (13.24)	-12.26 (13.19)
State Fixed Effects	*Included*	*Included*	*Included*
Average Days Between Audits (Nat. Log.)	5.535 (11.50)	11.14 (11.86)	15.71 (12.30)
Constant	87.21 (76.83)	48.58 (80.14)	13.62 (84.84)
R-Squared **Adjusted R-Squared**	**0.120** **0.107**	**0.118** **0.105**	**0.119** **0.105**

Notes: Statistics are estimated coefficient (standard error). N=818. *** indicates a value that is statistically non-zero at the 99% confidence level.

Table 3. Regressions on the change in energy use intensity between first and third NABERS Energy certifications.

Definition of Mandatory Adopter	Conservative	Moderate	Liberal
Mandatory Adopter	17.07 (20.12)	-1.174 (14.54)	10.51 (14.87)
Initial EUI	-0.260*** (0.026)	-0.210*** (0.022)	-0.211*** (0.022)
Owner Purchased Green Power	-34.48* (19.39)	-24.92 (19.19)	-23.75 (19.02)
Located in Capital City CBD	-19.74 (14.65)	-14.17 (13.24)	-12.26 (13.19)
State Fixed Effects	*Included*	*Included*	*Included*
Average Days Between Audits (Nat. Log.)	32.15* (17.27)	28.91 (18.48)	40.67** (19.76)
Constant	-74.31 (111.1)	48.58 (80.14)	13.62 (84.84)
R-Squared **Adjusted R-Squared**	**0.190** **0.173**	**0.118** **0.105**	**0.119** **0.105**

Notes: Statistics are estimated coefficient (standard error). N=576. *, **, and *** indicate a value that is statistically non-zero at the 90%, 95%, and 99% confidence level respectively.

Table 4. Regressions on the change in energy use intensity between first and fourth NABERS Energy certifications.

Definition of Mandatory Adopter	**Moderate**	**Liberal**
Mandatory Adopter	-6.73 (22.88)	-8.31 (18.56)
Initial EUI	-0.517*** (0.037)	-0.520*** (0.038)
Owner Purchased Green Power	-12.65 (18.07)	-12.20 (17.87)
Located in Capital City CBD	-5.31 (14.66)	-5.48 (14.63)
State Location	*Included*	*Included*
Average Days Between Audits (Nat. Log.)	46.93** (21.47)	43.97* (23.17)
Constant	-79.83 (136.2)	-58.28 (150.4)
R-Squared **Adjusted R-Squared**	**0.368** **0.350**	**0.369** **0.350**

Notes: Statistics are estimated coefficient (standard error). N=384. *, **, and *** indicate a value that is statistically non-zero at the 90%, 95%, and 99% confidence level respectively. As only 10 of 384 observations meet the definition of a conservative mandatory adopter, this category is excluded owing to low statistical power.