Evaluating the Impact of ECO Policies on the Energy Efficiency Performance of Domestic Properties Across the UK

Module Code: ECOM026

Name: Craig Pearce

Student Number: 6842704

Word Count:

Contents

[1. Introduction 3](#_Toc166593126)

[2. Background 4](#_Toc166593127)

[2.1 ECO Policies 4](#_Toc166593128)

[3. Methodology 4](#_Toc166593129)

[3.1. Data 4](#_Toc166593130)

[Figure 1: A Map of Regions In Britain. Sourced from Kedia, N. (2017). 5](#_Toc166593131)

[5](#_Toc166593132)

[Table 1: Description of Dependent Variables 5](#_Toc166593133)

[Table 2: Description of Explanatory Variables 6](#_Toc166593134)

[Table 3: Summary Statistics of Variables 7](#_Toc166593135)

[3.2. Method 7](#_Toc166593136)

[3.3. Robustness Tests 8](#_Toc166593137)

[3.3.1. Normality 8](#_Toc166593138)

[3.3.2. Multicollinearity 8](#_Toc166593139)

[3.3.3. Unit Roots 9](#_Toc166593140)

[3.3.2. Heteroskedasticity 10](#_Toc166593141)

[3.3.3. Autocorrelation 10](#_Toc166593142)

[3.3.4. Cross-Sectional Dependence 10](#_Toc166593143)

[3.3.5. 11](#_Toc166593144)

[11](#_Toc166593145)

[4. Results and Discussion 12](#_Toc166593146)

[4.1 Caveats 13](#_Toc166593147)

[Conclusion 14](#_Toc166593148)

[Recommendations 14](#_Toc166593149)

[Appendix 14](#_Toc166593150)

[References 16](#_Toc166593151)

# Introduction

# Background

### 2.1 Energy Company Obligation (ECO) Policies

[4Katris and Turner (2021)](#_Katris,_A._and) studied the concept of ECO policies using a CGE model, finding that “the underlying driver of sustained (economics gains) is actually realising energy efficiency gains”, with this they relate to information asymmetry where some households may be unaware of either the ECO policies, or how energy efficiency in their property could boost their disposable income, subject to any rebound effects. [6Miu et al (2018)](#_Miu,_L.M.,_Wisniewska,) also find a similar conclusion in their policy review of UK energy efficiency polices, suggesting that a mix of policies such as including tax benefits could work best, as it could potentially cost less than attempting to inform households. For this, a cost-benefit analysis is needed. [2Fawcett, Rosenow and Bertoldi (2018)](#_Fawcett,_T.,_Rosenow,) perform just that and conclude that ECO schemes can deliver great savings over a sustained period, but need to remain flexible as they can become very costly in the future. These studies, however, do not consider the fact that ECO policies must target some regions in the UK more than others, most rural areas in the UK have older and therefore less energy efficient houses – And may also suffer from a lack of technology resources such as limited companies to install solar panels or new boilers. They also may have to travel further to find stores that sell energy efficient appliances such as lightbulbs.

### 3.1 Energy Performance Certificates (EPCs)

[8Olaussen, Oust and Solstad (2017)](#_Olaussen,_J.O.,_Oust,) explain one advantage of EPCs as an incentive to improve a property’s energy efficiency so the property can sell for more, and implement a fixed effects model using panel data on the Norwegian housing market between 2009-2014. They find small, positive relationships between EPC ratings and house prices, and a substantial positive relationship between prices and the unobserved fixed effects. With this finding, they suggest that there is little information asymmetry with EPCs.

# Methodology

## Data

The data used in this empirical analysis is a panel and will consist of quarterly data on new Energy Performance Certificate’s (EPC’s) issued in each of the 10 regions of the England and Wales, which are depicted in Figure 1, between 2013-2023. As well as UK wide data on other characteristics and the England and Wales ECO policies. The variables are described in Tables 1 and 2. Scotland is excluded in this study due to a different EPC system and different ECO policies.

### Figure 1: A Map of Regions In Britain. Sourced from Kedia, N. (2017).

### 

### Table 1: Description of Dependent Variables

According [2Gov.uk](#_GOV.UK._(2024)._A) to when a domestic residence is listed for sale or to rent, the owner must obtain an EPC rating for prospective owners/tenants. The rating is then determined based on several factors such as whether the property was wall/loft insulation or solar panels, the efficiency of the boiler and different appliances, and many of criterion. The property is then given a score from 1-100 and placed in one of the 6 bands described above, where band F is below 38, band E is below 54 band D is below 68, and so on.

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Description | Time Period | Source |
| A | Number of Energy Performance Certificates issued with a rating of A | 2013/Q1-2023/Q4 | [3GOV.UK. (2024). *Energy Performance of Buildings Certificates: Data dashboard*](#_GOV.UK._(2024)._Energy) |
| B | Number of Energy Performance Certificates issued with a rating of A | 2013/Q1-2023/Q4 | [3GOV.UK. (2024). *Energy Performance of Buildings Certificates: Data dashboard*](#_GOV.UK._(2024)._Energy) |
| C | Number of Energy Performance Certificates issued with a rating of A | 2013/Q1-2023/Q4 | [3GOV.UK. (2024). *Energy Performance of Buildings Certificates: Data dashboard*](#_GOV.UK._(2024)._Energy) |
| D | Number of Energy Performance Certificates issued with a rating of A | 2013/Q1-2023/Q4 | [GOV.UK. (2024). *Energy Performance of Buildings Certificates: Data dashboard*](#_GOV.UK._(2024)._Energy) |
| E | Number of Energy Performance Certificates issued with a rating of A | 2013/Q1-2023/Q4 | [GOV.UK. (2024). *Energy Performance of Buildings Certificates: Data dashboard*](#_GOV.UK._(2024)._Energy) |
| F | Number of Energy Performance Certificates issued with a rating of A | 2013/Q1-2023/Q4 | [GOV.UK. (2024). *Energy Performance of Buildings Certificates: Data dashboard*](#_GOV.UK._(2024)._Energy) |

### Table 2: Description of Explanatory Variables

|  |  |  |  |
| --- | --- | --- | --- |
| Price | The quarterly average prices for fuel and energy in the UK, indexed at the beginning of 2015. | 2013/Q1-2023/Q4 | [6Office for National Statistics (2024)](#_Office_for_National) |
| INS | The number of energy efficiency installations (ECO Measures) in the UK every quarter. | 2013/Q1-2023/Q4 | [1Department for Energy Security and Net Zero](#_Department_For_Energy) |
| Y | The average weekly-income of the UK in real terms, indexed at 2005/Q2 | 2013/Q1-2023/Q4 | [5Office for National Statistics (2024)](#_Office_for_National_1) |
| COST | The total costs derived from the ECO policies in each quarter. | 2013/Q1-2023/Q4 | [1Department for Energy Security and Net Zero](#_Department_For_Energy) |
| TEMP | The average temperature of the UK every quarter. | 2013/Q1-2023/Q4 | [7Statista](#_7-_Statista._(2024).) |
| ECO1 | A dummy variable for if the ECO1 policy is active in each quarter. =1 if so, =0 if not. | 2013/Q1-2023/Q4 | [1Department for Energy Security and Net Zero](#_Department_For_Energy) |
| HTH | A dummy variable for if the HTH policy is active in each quarter. =1 if so, =0 if not. | 2013/Q1-2023/Q4 | [1Department for Energy Security and Net Zero](#_Department_For_Energy) |
| ECO3 | A dummy variable for if the ECO3 policy is active in each quarter. =1 if so, =0 if not. | 2013/Q1-2023/Q4 | [1Department for Energy Security and Net Zero](#_Department_For_Energy) |
| ECO4 | A dummy variable for if the ECO4 policy is active in each quarter. =1 if so, =0 if not. | 2013/Q1-2023/Q4 | [1Department for Energy Security and Net Zero](#_Department_For_Energy) |
| AWM | A dummy variable for if the AWM policy is active in each quarter. =1 if so, =0 if not. | 2013/Q1-2023/Q4 | [1Department for Energy Security and Net Zero](#_Department_For_Energy) |
|  |  |  |  |

The 5 dummy variables used are included to analyse the impact of each ECO policy to see whether they have achieved what was intended from them when they were active. Energy prices are included as it is expected that as they increase, households should be aiming to increase their energy efficiency which would in turn increase their EPC rating. The number of ECO measures installed are included because they should also be significant in increasing EPC ratings as it is one of the reasons why ECO policies exist, therefore we should see a positive correlation between the two variables. It is important that we include the COST variable so that we can analyse whether the ECO policies were worth the millions of pounds invested in them, if not then different strategies must be undertaken by the UK government. We expect this to have a positive relationship with the A, B and C dependent variables. Both Y and TEMP are included in the models because they are characteristics of the household and the country that we expect to influence EPC ratings, a higher income should correlated to investment in energy efficiency as the household has more available income to invest in efficiency measures, and if the country is colder then appliances such as the boiler will be used more frequently and for longer, this may encourage investment in a more efficient boiler to lower costs.

### A table of numbers and numbers Description automatically generatedTable 3: Summary Statistics of Variables

Table 3 shows the descriptive statistics of the data described above. We can see that there are 43 observations per region included. One important observation to note is that is that the AWM dummy has a mean of 0.86, this is because the Affordable Warmth Policy was active from the beginning of the data set up until the introduction of ECO4. This mean that AWM may be correlated with the other dummy variables and will likely cause collinearity problems. We can also see that the average cost of the ECO policies per quarter is £170m for 88639 installations of efficiency measures. One more observation more D ratings are given across the UK on average, compared to the other ratings. Also, there are more G ratings given out than A ratings over this time-period, on average.

In the models described later, these variables will be included in log form to linearise the relationships in the model, and to interpret the coefficients as a percentage change in the explanatory variables on a percentage change in the dependent variables.

## 3.2. Method

The estimation method initially chosen for this analysis was that of a fixed effects models for each EPC band, to control for any unobserved heterogeneity and time-invariant characteristics, such as factors that could influence a household’s decision in a specific region to take advantage of any policies or install their own efficiency measures. The estimation is shown as:

Where k (k = A, B, C, D, E, F, G) for every region i in each quarter t. Xt = (lnPrice, lnINS, lnY, lnTEMP, lnCOST) and Pt represents the 5 policy dummy variables, and Ri represents each region in England to capture the regional effects on each EPC rating and represents the individual fixed effects for the region, i.

## 3.3. Robustness Tests

Before the model can be estimated, the data must undergo several robustness tests to assess the statistical properties of this dataset and whether the correct model is being used.

### 3.3.1. Normality

The first test will be to check whether the data is normally distributed, if this is violated then the estimates given from the model will be biased and inconsistent. The Shapiro-Wilk Test was used for this assumption, the test has a null hypothesis that the variable data is normally distributed.

#### Table 4: Shapiro-Will Test for Normality Results

A screenshot of a test

Description automatically generated

Table 4 shows the results of this test on each variable, from this we can see that every variable with the exception of lnC, ECO1 and ECO3 has failed the test as the null hypothesis is rejected at a 1% significance level. However, the assumption may be relaxed if the sample size is sufficiently large.

### 3.3.2. Multicollinearity

Following the normality results, multicollinearity must be tested for. Multicollinearity is where the explanatory variables are linearly dependent and can be predicted by each other with a large degree of accuracy. This can cause problems with the model providing uncertain estimates and inflated standard errors. Each model was examined for using the Variance Inflation Factor (VIF). As expected, the AWM dummy variable had to be removed as it caused a very high mean VIF, the HTH variable also had to be removed meaning that these can no longer be included in the model.

#### Table 5: The VIF Test Results

A screenshot of a test

Description automatically generated

Table 5 shows the mean VIF for each model after the removal of AWM and HTH. A VIF factor of 1 shows no correlation between the explanatory variables, and a factor below 4 indicates moderate correlation, but not severe where the model needs correcting.

### 3.3.3. Unit Roots

Before running the model, each variable must be tested for a unit root. If the variable is stationary, then it’s variance and mean does not change over time. A non-stationary variable could lead to a spurious regression where the estimates could be incorrect. A Levin, Lu and Chu (LLC) test was Implemented for this data which carries a null hypothesis that the series contains a unit root. We aim to reject the null hypothesis. The results are shown in Table 6.

#### Table 6: LLC Unit Root Test Results

From Table 6, we can see that the null hypothesis is rejected decisively for every variable except lnPrice which will need to be differenced, this means that interpretation on the model coefficient for lnPrice will need to be carefully interpreted as it will show the change in percentage points of the variable and not the percentage change.

After plotting lnCOST, it was determined that the variable had no trend, therefore the ‘without trend’ result was taken.

Following these 3 tests, the model and be estimated and post-estimation tests can be implemented.

### 3.3.2. Heteroskedasticity

Heteroskedasticity must be tested for to find out if the variance is constant across all levels of the explanatory variables and the estimates are efficient. A modified Wald test for groupwise heteroskedasticity was used for the estimation, which has a null hypothesis of σ2i = σ2 , indicating homoskedasticity. Using this test, every model rejected the null hypothesis at a 1% significance level except for where B was the dependent variable. The results are shown in Table 7.

### 3.3.3. Autocorrelation

The model was then tested for autocorrelation, if the model’s errors are correlated with the previous observations, then the model will be biased and inconsistent. The Wooldridge test for autocorrelation in panel data was implemented here, the test carries a null hypothesis that there is no first order autocorrelation in the model. The null hypothesis was also rejected in every model at a 1% significance level. The results are also shown in Table 7.

### 3.3.4. Cross-Sectional Dependence

If the assumption of Cross-Sectional independence is violated, then the residuals could be correlated across units. Pesaran’s test is employed to test for this which carries a null hypothesis of no cross-sectional dependence. As we can see in Table 7, the null hypothesis is rejected at a 1% significance level in every model.

#### Table 7: Post-Estimation Test Results

A screenshot of a test results

Description automatically generated

Following the detection of heteroskedasticity, autocorrelation and cross-sectional dependence, clustered standard errors around the regions are implemented. These alter the variance-covariance matrix of the estimator to be robust for these 3 violated assumptions.

### 3.3.5.

The final test to be carried out is the Hausman Test, which tests the assumptions behind choosing between a fixed effects and a random effects model. The test involves running both models and calculating the difference between the coefficients. Because our model has clustered standard errors, a Cluster-Robust Hausman test must be undertaken. The results from this test are shown in Table 8.

#### Table 8: Cluster-Robust Hausman Test Results

# A table with black text and white text Description automatically generated

We can see that every model failed to reject the null hypothesis, suggesting that a Random Effects Model should be used for this data to provide more efficient estimates. This model assumes that the random effects are orthogonal to the set of explanatory variables included in the model.

# Results and Discussion

The results from the Random Effects model with clustered standard errors are shown in Tables 9 and 10.

#### Table 9: Results From Models A-C

A table of numbers and symbols

Description automatically generated with medium confidence

#### A table of numbers with black text Description automatically generated Table 10: Results From Models D-G

From these results we can see that all policy dummies were significant at a 1% level in explaining each EPC rating. However, ECO 1 and 3 both have negative coefficients on lnA, B and C. One reason could be because ECO policies were focused on fuel-poor households with low EPC ratings, higher rated and income-richer households would not be able to take advantage of them, however this would mean that the policy should not be significant, and this should only be with band A. Bands B and C are expected to have the highest coefficients on Installations and the ECO policies, but we find statistically significant, negative coefficients on all of these variables except ECO4. For example, when ECO1 was active, the number of new Band C ratings fell by 15%. (e-0.16 = 0.85, 1 - 0.85 = 0.15), on average, ceteris paribus.

Suggesting a lack of information about energy efficiency

Inappropriate pricing of policies

Barriers are still too high?

Inappropriate regional targeting in the past

## 4.1 Caveats

One major caveat with this analysis is the very strong assumption of the random effects estimator that the random effects are independent of the explanatory variables, theoretically, a fixed effects estimator suits this data setting more to control for household and landlord characteristics, and any information asymmetry.

Another Caveat to be mentioned is the assumption of normality, it is possible that the sample size of 430 may not be high enough to relax this assumption, which could be skewing our results. This analysis would have benefitted from more available data, also if the actual scores were available in each region rather than number of bands awarded then the models will have been less complex, allowing for better interpretation of results.

Also, whilst clustered standard errors were used for the model to be robust to cross-sectional dependence, cross-cluster correlation should also be tested for because this could violate the assumption of the randoms effect estimator, which could lead to biased and inconsistent results. The intra-class coefficient, rho, is also very high in these models, meaning that a large proportion of variances in the date is due to differences between the clusters, rather than within them.

# Conclusion

# Recommendations

# Appendix

##### Table 6: Summary Statistics in Log Form

A table of statistics with numbers

Description automatically generated

# References

#### Department For Energy Security and Net Zero. (2024). Household Energy Efficiency Statistics, headline release January 2024. [online] Available at: <https://www.gov.uk/government/statistics/household-energy-efficiency-statistics-headline-release-january-2024>. (Accessed 10 Mar 2024)

#### Fawcett, T., Rosenow, J. and Bertoldi, P. (2018). Energy efficiency obligation schemes: their future in the EU. Energy Efficiency, 12(1), pp.57–71. [doi:https://doi.org/10.1007/s12053-018-9657-1.](doi:https://doi.org/10.1007/s12053-018-9657-1)

#### GOV.UK. (2024). A guide to Energy Performance Certificates for the construction, sale and let of non-dwellings. [online] [Available at: https://www.gov.uk/government/publications/energy-performance-certificates-for-the-construction-sale-and-let-of-non-dwellings--2/a-guide-to-energy-performance-certificates-for-the-construction-sale-and-let-of-non-dwellings#obtaining-an-epc](Available%20at:%20https:/www.gov.uk/government/publications/energy-performance-certificates-for-the-construction-sale-and-let-of-non-dwellings--2/a-guide-to-energy-performance-certificates-for-the-construction-sale-and-let-of-non-dwellings%23obtaining-an-epc%20) [Accessed 11 March 2024].

#### GOV.UK. (2024). Energy Performance of Buildings Certificates: Data dashboard. [online] Available at: <https://www.gov.uk/government/statistics/energy-performance-of-buildings-certificates-data-dashboard> [Accessed 16 March 2024].

##### Katris, A. and Turner, K. (2021). Can different approaches to funding household energy efficiency deliver on economic and social policy objectives? ECO and alternatives in the UK. *Energy Policy*, 155, p.112375[. doi:https://doi.org/10.1016/j.enpol.2021.112375](.%20doi:https:/doi.org/10.1016/j.enpol.2021.112375).

#### Kedia, N. (2017). Regional UK map in Tableau. [online] Analytics Tuts. Available at: [https://www.analytics-tuts.com/regional-uk-map-tableau/](https://www.analytics-tuts.com/regional-uk-map-tableau/%20) [Accessed 13 April 2024].

#### Miu, L.M., Wisniewska, N., Mazur, C., Hardy, J. and Hawkes, A. (2018). A Simple Assessment of Housing Retrofit Policies for the UK: What Should Succeed the Energy Company Obligation? Energies, [online] 11(8), p.2070. <doi:https://doi.org/10.3390/en11082070>

#### Olaussen, J.O., Oust, A. and Solstad, J.T. (2017). Energy performance certificates – Informing the informed or the indifferent? Energy Policy, 111, pp.246–254. <doi:https://doi.org/10.1016/j.enpol.2017.09.029>.

#### Office for National Statistics. (2024). Average weekly earnings time series - Office for National Statistics. [online] Available at: <https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/averageweeklyearnings>. (Accessed 12 Mar 2024)

#### Office for National Statistics (2024). Fuel and Energy for the Domestic Market - Office for National Statistics. [online] Available at: <https://www.ons.gov.uk/economy/inflationandpriceindices/timeseries/gb7p/ppi> [Accessed 13 April 2024].

#### ‌ 7- Statista. (2024). UK: quarterly average temperatures and deviation 2023. [online] Available at: [https://internal.statista.com/statistics/422848/quarterly-average-of-daily-temperatures-uk-compared-to-mean/](https://internal.statista.com/statistics/422848/quarterly-average-of-daily-temperatures-uk-compared-to-mean/%20) [Accessed 13 April 2024].

‌