THE NATIONWIDE GROUP

(Nationwide Building Society and all its subsidiaries and Regional Brands)

Reflecting climate-related financial risks

in capital requirements

Energy efficiency ratings (EPC) and default risk

(IRB Pillar I. capital model based correlation assessment)

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1 EXECUTIVE SUMMARY

Climate change presents a risk to Nationwide and its members. For this reason, managing climate change risk and greening the UK's homes is integral to our strategy. Nationwide is aligned to achieve net-zero by 2050 at the latest. This commitment aims to reach 50% of its mortgage portfolio with an Energy Performance Certificate (EPC) rating of C or better by 2030.

In order to generate incentives for financial institutions to improve the energy efficiency of their portfolios, Nationwide joined the Energy Efficiency Financial Institutions Group (EEFIG) which is a working group established in 2013 by the European Commission and the United Nations Environment Programme Finance Initiative (UNEP FI) to activate private sector investment for energy efficiency improvements in the European housing sector.

As part of this involvement, the IRB team at Nationwide performed an analysis to assess the relationship between credit risk and the energy efficiency ratings of the secured asset. Moreover, the team assessed the impact on regulatory capital and their impact on capital allocation using EPC as a risk driver in the behavioural scorecards.

The results suggest that:

- Customers that hold high and medium energy efficient properties are **~20% less likely to default** than customers that hold low energy efficient properties, "all other things being equal",
- this **relationship is stable and intuitive**, after including control variables that might explain the relationship between EPC and default,
- the **coefficients are statistically significant** with p-value < 0.01 meaning that the probability of the results being random is less than 1%,
- and the results are also **robust to the inclusion of a battery of control variables** and with a large sample of more than 600k properties.
- The inclusion of the EPC as a risk driver into the behavioural scorecards allows for a **more accurate allocation of capital** with higher capital requirements for low energy efficient properties and lower capital requirements for higher energy efficient properties.

2 NATIONWIDE BUILDING SOCIETY ANALYSIS

Nationwide Building Society (NBS) is the UK's largest building society and the second largest mortgage provider in the UK. It is a mutual, which means that NBS is owned by its members, managing £248 billion of assets.

The NBS study conducted as part of the EFFIG[1] attempts to answer the questions:

- What relationship do we observe between energy efficiency and default risk (IRB Default Definition) for UK residential mortgages? Is any observed relationship robust to the inclusion of a range of control variables?
- What might the results suggest for changes to capital requirements?
- Future directions and further analysis.

2.1 Literature

Since 2009 several studies have been developed to try to assess the relationship between default risk and energy efficiency. For example, the Bank of England in its paper entitled "Does energy efficiency predict mortgage performance?" found that mortgages on energy-efficient properties are less frequently in arrears[2]. Moreover, other literature was also considered such as under the Energy Efficient Data Protocol & Portal (EeDaPP) where the authors found that owners of more energy efficient buildings are associated with relatively lower risk of default[3]. The research report "Home Energy Efficiency and Mortgage Risks" by the Institute for Market Transformation found that default rates on ENERGY-Star rated homes are on average 32% lower than in non-rated homes, controlling for other loan determinants, household, and neighbourhood characteristics[4]. The Sustainable Architecture for Finance in Europe (SAFE), in cooperation with the Goethe University (Frankfurt) published a working paper where the authors found that Buildings' energy efficiency is associated with lower likelihood of mortgage default[5]. However, a study developed by the Joint Research Centre found a negative relationship in just three out of the 50 studies reviewed[6].

The study developed by Nationwide is the assessment with the largest sample with more than 600k properties and the only study that looked at it from a capital perspective.

2.2 Correlation Analysis Energy Efficiency and Default Risk

Energy efficiency has so far not been a standard risk factor for the assessment of creditworthiness. Various studies are now pointing towards a statistical relationship, which we would like to corroborate from a NBS perspective.

The UK is fortunate to have a large and publicly accessible EPC national database available through the Ministry of Housing, Communities & Local Government. This database contains information about the energy efficiency of over 19 million properties recorded since 2008 for England and Wales. In addition to the information on EPC rating, this database also contains detailed dwelling information on expected energy costs.

[1] The quantitative relationship between energy efficiency improvements and lower probability of default of associated loans and increased value of the underlying assets - Publications Office of the EU (europa.eu)
[2] Bank of England Staff Working Paper No. 852
[3] Energy Efficient Mortgages Initiative (EEMI): EeDaPP confirms negative correlation between energy efficiency and risk - ECBC (hypo.org)
[4] IMT_UNC_HomeEEMortgageRisksfinal.pdf
[5] Buildings' Energy Efficiency and the Probability of Mortgage Default: The Dutch Case by Monica Billio, Michele Costola, Loriana Pelizzon, Max Riedel :: SSRN
[6] https://publications.jrc.ec.europa.eu/repository/bitstream/JRC113215/jrc113215_kjna29471enn_v2_ipo_final.pdf

NBS was able to match addresses in the EPC database to their portfolio of residential mortgages for September 2019. As seen in Figure 2.2.1, a high matching rate of 67%, on average for all regions, was achieved, with an even higher rate for new-build properties. This first step enabled the NBS IRB modelling team to create a matched EPC and mortgage database of over 600k households.

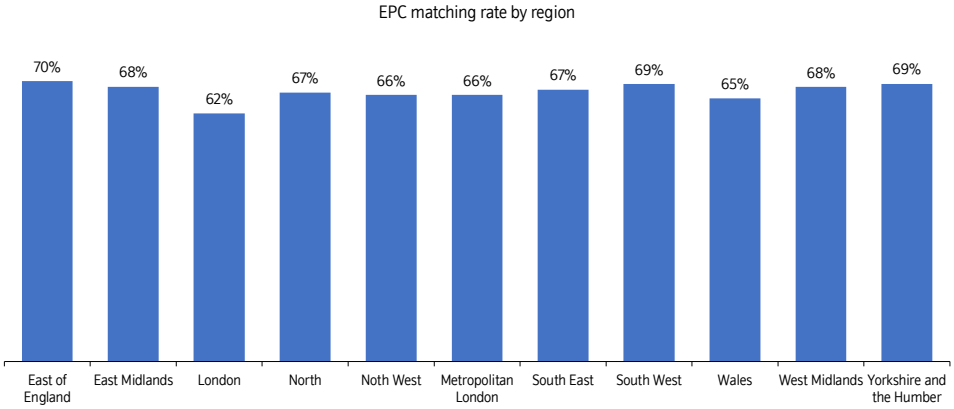

Figure 2.2.1

Nationwide expanded this work by focusing on prime residential mortgages using data from its portfolio in September 2019 with either an IRB default definition (which includes Arrears and Unlikeliness to Pay or Concession statuses) or Arrears only definition (Months in Arrears equal or above 3 months). The sample contains properties whose customers are not in default in September 2019 but might default in the following 12 months.

Before selecting the final sample for analysis, a subsample of certain UK Government funded schemes such as Help to Buy, Shared Ownership or Right to Buy was studied for potential exclusion. Most of the properties whose owners accessed any of these government schemes had a rating of B or C. The default characteristics of these customers were different to the rest of the sample, and for this reason, it was decided to exclude them from the final sample.

As demonstrated in Figure 2.2.2, analysing the proportion of defaults by each EPC band without the government schemes eliminates the anomaly in the default rate relationship and illustrates a clear negative relationship between energy efficiency and defaults (green dots on chart on the right).

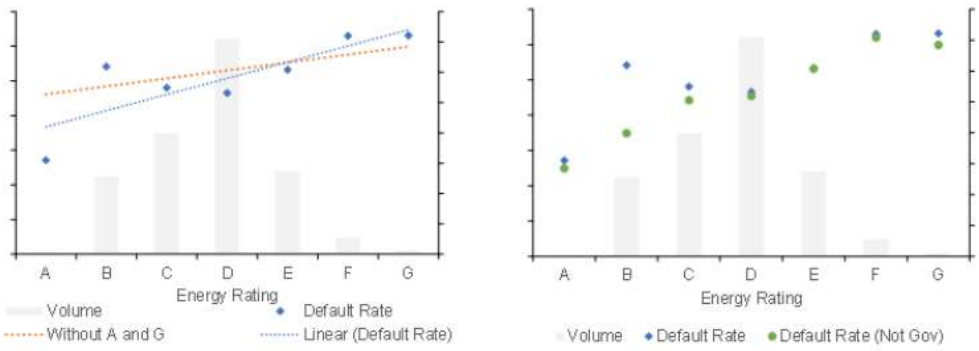

Figure 2.2.2

The left panel includes Govt. schemes and shows no clear relationship. The right chart illustrates the source of bias – government schemes contained both high energy efficiency properties (EPC of B) and a higher proportion of defaulted accounts. Data used to create the chart on the right was then used for modelling purposes to find any relationship between Default and EPC.

However, this relationship might be explained by other factors such as characteristics of the customer, the mortgage, the region, etc. To be able to distinguish the additional effect of energy efficiency, control variables are required, and a clean data set was constructed, which reduces any bias as much as possible. Control variables that were considered in the NBS analysis can be categorised as relating to the borrower (household income, age), the mortgage (loan term and original LTV ratio), and the property (valuation amount and property type). Additionally, NBS included an indicator variable to control for whether the loan was originated before or after the previous recession in the UK.

Table 2.2.1, columns 1-9 display results from a Logistic regression model in which energy efficiency was banded into High (A-C), Medium (D) and Low (E-G) EPC level, starting with a parsimonious model (column 1) and inclusion of additional significant controls in subsequent models (columns 2-9).

	Default (1)	Default (2)	Default (4)	Default (5)	Default (6)	Default (7)	Default (8)	Default (9)
Energy efficiency								
EE Continuous								
High energy efficiency	-0.2699***	-0.2772***	-0.2641***	-0.2688***	-0.2265***	-0.238***	-0.2148***	-0.1979***
	[0.06452]	[0.06453]	[0.06459]	[0.06459]	[0.06474]	[0.06482]	[0.06489]	[0.06497]
Medium energy efficiency	-0.1848***	-0.1868***	-0.18***	-0.1871***	-0.1735***	-0.171***	-0.1463**	-0.1691***
	[0.05857]	[0.05858]	[0.0586]	[0.05861]	[0.05863]	[0.05864]	[0.05867]	[0.05871]
Main control variables								
Household Income (£'000)		-0.00877***	-0.00881***	-0.00977***	-0.00749***	-0.00662***	-0.00379***	-0.00497***
		[0.000888]	[0.000883]	[0.000898]	[0.000963]	[0.00098]	[0.000925]	[0.000934]
Loan Term (Years)			-0.01524***	-0.03767***	-0.029***	-0.02774***	-0.0043	-0.01962***
			[0.003214]	[0.003947]	[0.004032]	[0.004033]	[0.004309]	[0.004457]
Original LTV (%)				0.01415***	0.01017***	0.009742***	0.01199***	0.01244***
				[0.001438]	[0.001488]	[0.001487]	[0.00147]	[0.001439]
Valuation Amount (£/sqm)					-0.00022***	-0.00025***	-0.00026***	-0.00016***
					[0.000024]	[0.000025]	[0.000024]	[0.000024]
House Indicator						-0.2772***	-0.1477**	-0.1097
						[0.06585]	[0.0671]	[0.06721]
Age							0.03663***	0.01869***
							[0.002653]	[0.002988]
Age*Recession								0.0178***
								[0.001228]
Regional x Recession Ind	No	No	No	No	No	No	No	No
Inspection Year FE	No	No	No	No	No	No	No	No
Observations	657,838	657,838	657,838	657,838	657,838	657,838	657,838	657,838
Gini	5.2%	16.09%	16.64%	20.7%	24.8%	25.5%	31.1%	34.0%

Borrower

Mortgage Control

Property Control

Table 2.2.1

The coefficients of high (-0.1979) and medium (-0.1691) energy efficiency are expressed relative to the low energy efficiency category with a coefficient of 0. A negative coefficient for both high and medium ratings means that the likeliness to default for customers that hold these properties is lower than the likeliness to default for customers that hold low energy efficient properties. The difference in the likeliness to default between customers that hold high and medium energy efficient properties is lower than the difference to low energy efficient properties.

The model and the relationship is reassured using reduced form of financial difficulty (serious missed payments) which also suggest that there is also a significant difference between High (A/B/C), Medium (D) and Low energy efficient properties on the likeliness to fall into arrears.

The results suggest that:

- Customers that hold high and medium energy efficient properties are ~20% less likely to default than customers that hold low energy efficient properties, “all other things being equal”,
- this relationship is stable and intuitive, after including control variables that might explain the relationship between EPC and default,
- the coefficients are statistically significant with p-value < 0.01 meaning that the probability of the results being random is less than 1%,
- and the results are also robust to the inclusion of a battery of control variables and with a large sample of more than 600k properties.

Models displayed in Table 2.2.1 tried to include all information which might affect the relationship between EPC and default. However, controlling for all the information of the customer, the property, the mortgage, the region, etc. is not possible due to the lack of data. For this reason, there might exist residual confounding or factors that might explain this relationship and they have not been included into the model due to data availability.

In order to test if the relationship between energy efficiency and default risk still holds after controlling for different factors that predict default risk more accurately, the EPC indicator was included in one of the IRB behavioural scorecards which discriminatory power is around 70%.

2.3 Energy Efficiency Information into IRB Behavioural Scorecard

The IRB behavioural scorecards predict the likeliness of an account defaulting in the following 12 months by using past payment behaviour information. The IRB Credit Score variable holds a very high discriminatory power, with a Gini around 70% and strong accuracy.

In order to test if the relationship between energy efficiency and default risk still holds, the continuous version of this variable was included together with the IRB credit score. These continuous variable ranges from 0 to 100, with properties rated as 100 being the most efficient buildings.

As seen in Table 2.3.1, the results with the inclusion of this energy efficiency rating and the IRB credit score reached the same conclusion, model (3). The negative sign of the coefficients means that the higher the energy efficiency of the property, the lower the likeliness to default, and indicates that we see an effect in-line with the postulated economic rationale. This is an important result as the EPC seems to add value on top of the IRB behavioural scorecard without impacting the accuracy or discriminatory power of the IRB scorecard.

	Default (1)	Default (2)	Default (3)	Arrears (1)	Arrears (2)	Arrears (3)	Arrears (4)
Energy efficiency							
EE Continuous	-0.00898*** [0.001777]		-0.00376* [0.001946]	-0.01572*** [0.002843]		-0.01065*** [0.003129]	
High energy efficiency							-0.3058*** [0.1139]
Medium energy efficiency							-0.2495** [0.101]
Main control variables							
IRB Credit Score		-1.0551*** [0.01164]	-1.0536*** [0.01166]		-1.109*** [0.01673]	-1.1064*** [0.01675]	-1.1069*** [0.01675]
Original LTV							
Loan Term (Years)							
House Indicator							
Valuation Amount (£/sqm)							
Regional x Recession Ind	No	No	No	No	No	No	No
Inspection Year FE	No	No	No	No	No	No	No
Observations	657,838	657,838	657,838	657,838	657,838	657,838	657,838
Gini	4.7%	70.28%	70.31%	7.9%	81.1%	82.0%	81.3%

Table 2.3.1

2.4 Impact on Regulatory Capital Allocation

The IRB team studied the effect of using model (3) from Table 2.3.1 to calculate capital requirements for research purposes (**information about energy efficiency has not been included in the NBS rating system, this exercise has been completed with research purposes only**).

Figure 2.4.1 below demonstrates that whilst the overall capital requirement barely changed for the sample, the potential inclusion of EPC into the IRB rating system might allow for a better allocation of capital with lower capital requirements towards more efficient properties, this is an important aspect at least in a short term for supporting prudential initiates and the portfolio EPC target of Nationwide.

If energy efficiency were used together with other risk drivers to calculate PD which is used directly in capital calculations, Nationwide would be able to hold, on average, 12.44% less capital for its A rated properties portfolio. As long as Nationwide shifts its portfolio to higher energy efficient properties, this will lead to a reduction in total capital requirements.

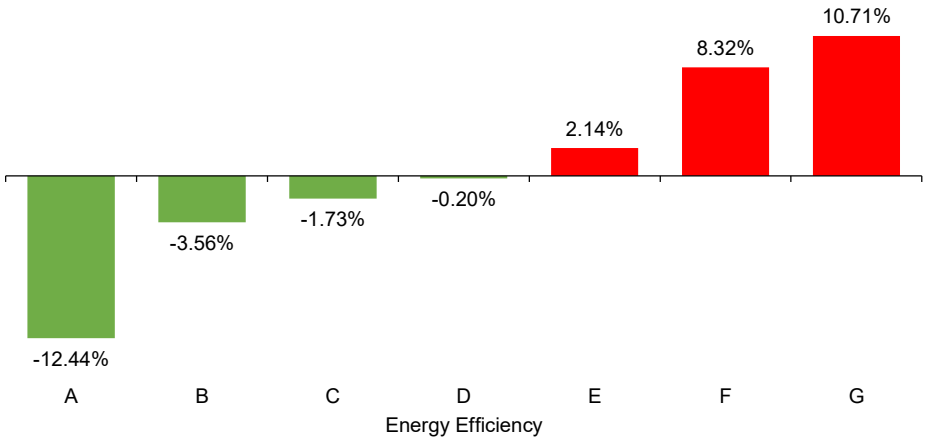

Figure 2.4.1

2.5 Model Validation

Alternative clustering driven by internal reports have also been analysed with similar results: High Energy Efficient (A, B), Medium Energy Efficient (C, D), Low Energy Efficient (E, F, G).

Not extreme correlation between the control variables, levels of the VIF (Variance Inflation Factor) values indicate no violation of the model multicollinearity assumptions.

Treatment of outliers have been done following the scorecard development methodology to not reduce the number of default cases in the sample.

Additional analysis has been conducted to assess for heterogeneities in the EPC-Default relationship for different levels of household income which might improve the results.

2.6 Additional Results

Data about the EPC of properties in **Scotland** is stored in a different database from the Scottish government. The inclusion of Scottish data into the model did not affect the results. With a total sample of 700,000 properties, the negative relationship between energy efficiency and default still holds. However, the issuing of EPCs in Scotland is different that the methodology followed in England and Wales. For this reason, the results must be interpreted carefully.

This analysis has also been replicated in the **Buy To Let (BTL)** portfolio with a sample of 173,000 properties which showed a similar trend that indicates a negative relationship between energy efficiency and probability of default. It has not been possible, however, to control for income or age of the landlord due to the lack of data.

A Cox-Proportional Hazard model with time dependent covariates has also been tested, including variable information from September 2016 to September 2020 with similar results.

Analysis has been replicated using a **data imputation process** to allocate EPCs to properties which matching algorithm has not worked. A machine learning model has been developed to predict the EPC of properties using information from similar properties in the same area. With a total sample of 1.2 million, the same analysis was repeated with similar conclusions.

2.7 Impact of Analysis

These results have been presented on several occasions to the EEFIG members[7]. These results were also presented at the Bauhaus event organized by the European Mortgage Federation – European Covered Bond Council (EMF-ECBC)[8]. Moreover, the authors were invited speakers to the FinTech, Values and Society seminar at the University of Edinburgh[9].

The results were published by Global Capital[10] and included in the Discussion Paper published by the European Banking Authority on the role of environmental risks in Pillar 1 prudential framework (page 26, EBA/EP/2022/02[11]).

2.8 Summary

In summary, the NBS data and analysis suggest that there seems to be a significant difference in the probability of default between high/medium energy efficient (EPC A/B/C/D) properties and low energy efficient (EPC E/F/G) properties.

The relationship is still strong and significant after controlling for characteristics that might affect it, such as information about the customer, the mortgage, or the property. This relationship still holds when including the IRB behavioural score as a control variable. The statistically significant negative relationship is also confirmed by introducing the continuous form of energy efficiency into the model.

Further ongoing work involves examining heterogeneities in the relationship for different income groups to further understand the mechanisms behind the observed relationship between energy efficiency and credit risk.

[7] BAUHAUS-4_NationwideBuildingSociety.pdf (hypo.org)
[8] EEMI Bauhaus Let's Greenstorm! | Fourth Virtual Event - ECBC (hypo.org)
[9] FinTech, Values and Society: Energy efficiency vs. default probability - Edinburgh Futures Institute
[10] Nationwide study shows green mortgages are less risky (globalcapital.com)
[11] On the role of environmental risk in the prudential framework (europa.eu)