Buildings' Energy Efficiency and the Probability of Mortgage Default: The Dutch Case

Monica Billio **Michele Costola**
Loriana Pelizzon Max Riedel

EEMI Bauhaus 7th Edition

June 18, 2021

The presented study

- **EU Horizon 2020 project**
  Energy efficient Mortgages Action Plan (EeMAP), grant agreement No 746205.
- **Published in**
  Billio, M., Costola, M., Pelizzon, L., & Riedel, M. (2021), "*Buildings' Energy Efficiency and the Probability of Mortgage Default: The Dutch Case*". *The Journal of Real Estate Finance and Economics*, 1-32.

Motivations

- **Buildings account for 40% of EU energy use** and it is predicted that 75-90% of the building stock in the EU will continue to stand in 2050.
- The improvement of buildings' **energy efficiency** (EE) is among **top priority** measures that can help meet EU's commitment to **reduce energy consumption and greenhouse gas** emissions.
- From the perspective of mortgage lenders and investors, investment in building performance improvements seems to be an **attractive market segment**.

Motivations/2

- Homebuyers recognize the contributory value of increased energy efficiency requiring:
  - larger discount for less energy efficient dwellings;
  - energy certifications into the property value.
- While the positive relation between EE and sales prices is well documented, it is less obvious if EE has any **effect on the borrower's credit risk**.

Research Questions

- This provides a challenging research environment for the questions at hand:
  1. **What is the relation between buildings' energy efficiency and mortgage default risk?**
  2. **Does the inclusion of the mortgage-specific attribute "*energy efficient*" or "*green*" into the lender's scoring model provide an additional value?**
  3. **What is the *economic mechanism* behind this relationship?**
- The answer to these questions has the potential to unlock benefits for borrowers, lenders and investors.

Aim of the paper

- We investigate the relation between a building's **energy efficiency** and the probability of **mortgage default**.
  - loan-level data of the **Dutch mortgage market** (residential buildings) issued on more than 120,000 dwellings (European DataWarehouse);
  - energy efficiency ratings are assigned by the Netherlands Enterprise Agency (RVO).
- We employ the **Logistic regression** and the extended **Cox model** to test if energy efficiency is negatively related with the default of the borrower.
- We test if results hold for a battery of **robustness checks**.

Background on Loan Pricing

- The borrower's **probability of default** (PD) is usually assessed through the use of **credit scores**.
- Use of **statistical model** that maps an applicant's characteristics (financial and demographic information)
- Credit scoring methods are continuously refined, either by introducing **new models** or by adding **new variables** or **characteristics**.
- **New studies** has investigated if the inclusion of the mortgage-specific attribute "**energy-efficient**" or "green" in the lender's scoring model adds value.

Background on EE

Some studies have been conducted on this topic.

- Kaza et al. (2014) show that ENERGY STAR-rated houses in US are associated with a significant reduction of default.
- An and Pivo (2020) find that ENERGY STAR or LEED labelled US commercial buildings are 34% less likely to default.
- Guin and Korhonen (2020) show that UK mortgages against energy-efficient properties are less frequently in payment arrears.
- The EeDaPP project (2020) provides evidence of a negative relationship between energy efficiency and the probability of default for a portfolio of Italian residential mortgages.

EE and the probability of default

There are three potential channels that might drive the negative EE-PD relation:

1. **personal characteristics** of the borrowers captured by the choice of an EE building (e.g., environmental consciousness);
2. improvements in building performance that help **free up a borrower's disposable income** through lower utility bills and thus reduce default risk;
3. the positive effect on the **dwelling value** and thus on the loan-to-value ratio (LTV), which lowers default risk.

The Dutch database

- The period is from January 2014 to May 2018 (Netherlands).
- The type of borrower is *individual* and the primary income is between EUR 20,000 and 1,000,000.
- The property type is residential, detached/semi-detached house, apartment, or terraced house.
- The building's occupancy type is restricted to owner-occupied.
- The construction year ranges between 1900 and 2016.
- We focus on fixed-interest rate mortgages and exclude repurchased ones.
- Finally, we require each individual borrower to be associated with exactly one building and vice versa.

The EE variable

- For the classification of buildings into different energy efficiency categories, we rely on the **Dutch energy performance** provided by the RVO.
- The **provisional EPC** indicates the energy performance of a reference building that was developed using **cadastral data** (i.e., area, date of construction, building type, quality of insulation of floors, roof and walls, and systems for heating, hot water, and renewable energy) of the Dutch residential building stock.
- A dwelling is considered **EE** if it has an **A or B rating**.

Controls variables

We include as controls the variables that can exert an impact on the default probability (i.e., An and Pivo, 2015):

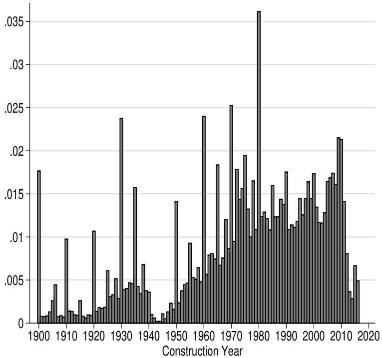
- **mortgage variables:** contemporaneous loan-to-value ratio (LTV), the debt service coverage ratio (DSCR), the debt-to-income ratio (DTI), and the Mortgage term.
- **building variables:** property type, geographical location, and building's age category (3 years, Underwood and Alshawi, 2000).

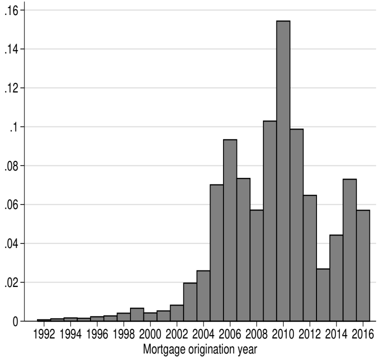
Controls variables

- **borrower information:** total income (sum of primary and secondary income) and borrower age at origination of the earliest loan component.
- **macroeconomic conditions:** quarterly unemployment rate, the 10-year government bond yields, the monthly standard deviation of the 10-year bond yields, and the yield curve slope defined as the difference between 10- and 1-year EUR swap rates.
- **fixed effects:** NUTS 3 region and (origination and current) loan year.

Summary statistics

Property type	Construction year								
	1900–1945	1946–1964	1965–1974	1975–1982	1983–1987	1988–1991	1992–1999	2000–2005	2006 or later
House, (semi-)detached	G	F	D	C	C	C	B	B	A
Flat/Apartment	G	E	F	C	C	C	B	B	A
Terraced House	F	E	C	C	C	C	B	A	A



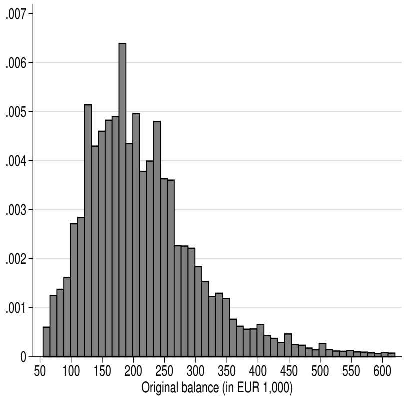


Summary statistics/2

Rating distribution.

Rating category	All	Defaulted
A	14.88	0.25
B	17.73	0.38
C	27.22	0.48
D	9.55	0.69
E	3.99	1.05
F	11.23	0.71
G	15.39	0.81
Total	100	0.55

Mortgage original balance.



Logistic Regression

- A common approach for investigating the relation between the information at the borrower-level and the probability of mortgage default is the **Logistic regression**.
- The probability distribution of Y is modelled as

$$\mathcal{P}(Y_i = 1|\mathbf{x}_i) = \frac{\exp(\beta'\mathbf{x}_i)}{1 + \exp(\beta'\mathbf{x}_i)}, \tag{1}$$

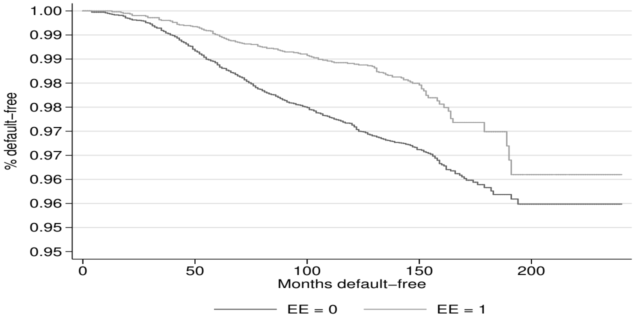
  where Y_i to be equal to one if the mortgage has defaulted and zero otherwise.
- **Default:** 3 months in arrears on the mortgage payment.

Results on the Logistic Regression

- After controlling for the discussed risk drivers and controls, we find that **Energy Efficiency** (EE_i) is **negatively related** to the probability of **default** of a mortgage.
- There is a direct **reduction** in the **probability** of **39 bps**.
- Results survive after a number of **robustness checks** (LTV, total income, DTI, borrower age and building age).
- We also test for association of **the degree of energy efficient** with probability of default (results are confirmed only for the classes A/B).

Extended Cox Model

- Results are confirmed also in the extended Cox Model.
- We compute the time-to-default over a 20-year period for the two mortgages groups.
- The energy efficient mortgages survive for a longer period than their non-efficient counterparts.



Economic Mechanism

- Results provide evidence that there exists a **negative correlation** between EE and the probability of residential mortgage default.
- In the following, we aim to investigate the **economic mechanism**.
- Borrowers' **savings** from energy usage should result in **more income available** in case of emergencies or unexpected events.
- If this is the case, mortgages on energy efficient houses will have **lower risks** relative to standard houses.
- Consequently, a lower default risk should be magnified for **lower income borrowers**.
- To disentangle the effect, we decompose the **EE** variable according to the **income group** of the borrower (low, medium, high).

Economic Mechanism: Results

- We find that the income group shows a decrease on the probability of default of **39 bps (high group)**, **45 bps (medium group)**, and **46 bps (low group)** relative to the non-efficient counterpart.
- Considering that the average default rate for the lowest group is 0.93%, **the reduction in terms of default probability** is economically significant and **is half the average default probability for low-income borrowers**.
- This suggests that energy efficiency better mitigates the default risk of borrowers with lower incomes.
- The economic channel is represented by **savings that come from reduced costs**, which have a greater relative impact on the borrower with less disposable income.

Conclusions

- This study identifies a relationship between building energy efficiency and mortgage default risk.
- We use a unique data set consisting of Dutch loan-level data supplemented with provisional building energy efficiency ratings.
- We exploit the panel structure of the dataset, the technological progress, and the non-simultaneous changes in energy efficiency ratings across construction years and building types.
- We employ two empirical methodologies and find that energy efficiency is negatively related with a borrower's likelihood of default on mortgage payments.

Conclusions/2

- The results hold after accounting for borrower, mortgage, and market control variables.
- A series of robustness checks confirms that the findings are not driven by any particular assumptions.
- As a consequence, the discriminatory power of a model using both the usual credit variables and the EE variable significantly exceeds models that only use the traditional credit variables.
- This suggests that EE ratings complement rather than substitute borrower credit information.
- The positive effect on the dwelling value and thus on the LTV, which lowers default risk, is accounted for by controlling for contemporaneous LTV.

Conclusions/3

- We investigate whether there is evidence of any economic mechanism that mitigates the default risk of lower-income borrowers.
- The income channel from the logit regression shows that savings coming from reduced costs have a greater impact in relative terms on borrowers with less disposable income.
- In the Cox model, the economic channel is confirmed in the mitigation of the default risk for the average household.
- These aspects are not only crucial for shaping future energy policy, but also have implications for the risk management of European financial institutions (i.e., lower interest rates).
- The presented findings are a first step in understanding whether and to what extent energy efficiency plays a role in the European mortgage market.

Thank you.

The paper is open access

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