## Green Mortgages

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## Financing the green transition

- ▶ Banks play a central role in capital allocation in the economy and are key to financing the transition to a net-zero economy (\$9.2 trillion per year —McKinsey (2022)
- Among the assets they finance, residential real estate is particularly significant in the context of the transition
  - Residential buildings account for approximately 22% of global energy consumption and 17% of CO<sub>2</sub> emissions (Programme, 2020; International Energy Agency, 2023)
- ► However, significant barriers persist in financing energy efficiency improvements (Giglio et al., 2021; Berkouwer and Dean, 2022; Lanteri and Rampini, 2023)
- ► In response, banks are increasingly offering products known as Green Mortgages
  - ⋆ Energy efficient mortgages (EEMs)

## What are green mortgages?

▶ The term 'green' refers to the energy efficiency of the underlying property being financed

#### Objective(s):

- ► Incentivize borrowers to own more environmentally friendly properties
- Purchase energy-efficient properties or retrofit existing ones



## What are green mortgages?



#### nationwide

## Get rewarded for buying a greener home

With our Green Reward offer, you could get up to £500 cashback when you buy an energy-efficient home.



# NatWest What is

# What is a Green Mortgage?

- Our Green Mortgages reward you for purchasing or remortgaging an energy efficient home by offering a reduced mortgage rate on a 2 year or 5 year fixed rate mortgage.
- If you're purchasing or remortgaging a property with a valid Energy Performance Certificate (EPC) rating of A or B then you could get mortgage with a lower interest rate with a Green Mortgage.









## This paper

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- $2. \ \, \text{Test explanations for why lenders offer green mortgages}$

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- ▶ Daily data on the universe of mortgages on offer in the UK mortgage market (Benetton, 2021)
- ▶ Magnitude of financial benefits: compare *green* to similar *non-green* products available on the market on the same day

## This paper

- 1. What financial benefits do lenders offer on green mortgages?
- 2. Test explanations for why lenders offer green mortgages
- ▶ Daily data on the universe of mortgages on offer in the UK mortgage market (Benetton, 2021)
- Magnitude of financial benefits: compare green to similar non-green products available on the market on the same day
- ► Test explanations for **why** lenders offer green mortgages:
  - Lower financing risk, as more energy-efficient properties are less expensive to run and have higher collateral value
  - \* Market segmentation, as part of lenders' product differentiation strategy and customer acquisition
  - \* Other mechanisms: cost of capital, climate commitments NZBA targets

#### 1. Characterization of green mortgages

- ► Green products are significant and have been growing in prominence, particularly in the owner-occupied segment 10% to 15% during our sample period
- Offered by private lenders, without government subsidies or regulatory requirements
- Energy efficiency of the property
  - $\star$  Lenders target either (i) A/B or (ii) A/B/C
  - $\star$  97% green mortgages offered are based on the current energy rating of the property, only 3% for future improvements in energy efficiency

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  - $\star$  97% green mortgages offered are based on the current energy rating of the property, only 3% for future improvements in energy efficiency
- Two types of financial benefits: preferential rate and cashback
  - \* Owner-occupied segment: preferential rate (39%) and cashback (76%)
  - $\star$  Investor segment: preferential rate (78%) and cashback (14%)
- May reflect differences in borrowers' financial conditions

- 1. Magnitude of financial benefits offered by green mortgages
  - Preferential rate:
    - ★ Across lenders: 35 b.p. discount → annual benefits of £700
    - $\star$  Within lender: 9 b.p. discount  $\to$  annual benefits of £180
    - $\star$  Similar in owner-occupied and investor segments

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#### Cashback:

- ★ Similar across and within lenders: 52-53% more likely to offer cashback
- $\star$  Average equivalent annual cashback amount £49-56 higher

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#### Cashback:

- \* Similar across and within lenders: 52-53% more likely to offer cashback
- \* Average equivalent annual cashback amount £49-56 higher
- ▶ Products with preferential rates offer *larger* significant financial benefits
- In contrast, green products offering cashback provide significantly smaller financial gains

#### 2. Potential explanations

- Evidence does not support lower financing risk
  - \* Cashflow channel: Exploit sharp increases energy prices and interest rates
  - \* Collateral channel: Heterogeneity by LTV ratios
- ▶ Evidence supporting customer acquisition particularly for cashback-based products
  - \* Offered to buyers but not to remortgagors
  - \* Financial constraints
    - Owner-occupied vs. investors
    - New builds and shared ownership schemes
- Other mechanisms
  - \* Cost of capital: green bond issuance unrelated to green mortgage offerings
  - \* Climate commitments: "Committed" banks are more likely to offer green mortgages

#### Related Literature

 $1.\,$  Debt contracts targeting climate change + bank lending to firms for climate transition

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Zerbib (2019); Tang and Zhang (2020); Flammer (2021); Baker et al. (2022); Kim et al., (2022); Du et al., (2023); Flammer et al., (2024); Kacperczyk and Peydrö (2022); Houston and Shan (2022); Sachdeva et al. (2024); Green and Vallee (2024); Ivanov et al. (2024)
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ightarrow Menu of green mortgages and their features/benefits (green transition)

2. Motivations of banks to originate green lending

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Giannetti et al., (2023); Haushalter et al., (2023); De Haas (2024); Morse and Sastry (2024); de Bandt et al. (2023)
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- ightarrow Heterogeneity in the nature and magnitudes of the benefits of green mortgages
- 3. Climate change impacts mortgage markets + energy efficiency gap + credit for the adoption of energy savings technologies (government interventions)

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Issler et al., (2020); Gete and Tsouderou, (2021); Allcott and Greenstone, (2012); Berkouwer and Dean (2022); Adelino and Robinson, (2023); Bellon et al., (2024); Fowlie et al. (2018); Clara et al. (2024)
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- → Provision of credit by the private sector and loan features offered by lenders
- 4. Estimates of green premium on offer

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Hachenberg and Schiereck, 2018; Zerbib, 2019; Larcker and Watts, 2020; An and Pivo, 2020; Flammer et al., 2022; Baker et al., 2022
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→ We provide first estimates for households



## The UK mortgage market

'Mortgage Supermarket' (Benetton, 2021):

- ▶ Many different products on offer each day, by different lenders, and with different characteristics
- ▶ Initial period of discounted and fixed interest rate (2- and 5-years), and most borrowers refinance their loans after this period

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#### Moneyfacts Group Plc data (Coen et al. (2023); Benetton et al. (2024)):

- Universe on mortgages on offer in the UK
- ▶ Daily detailed information on: (i) market segment; (ii) product characteristics (including green status and requirements); (iii) lender identity
- ► Around 180,000 unique mortgage contracts (4M obs. 480,000 green obs.) between May 27, 2022 and September 30, 2023

▶ Green Mortgages in the UK

Financial Benefits on Green Mortgages

## Estimating the green premium on offer

#### **Empirical Specification:**

$$y_{ijblt} = \alpha + \beta \cdot \text{Green}_i + \lambda_{jbt} + \varepsilon_{ijblt}.$$
 (1)

- $ightharpoonup \lambda_{jblt}$ : product type  $(j) \times \text{borrower}$  type  $(b) \times \text{day}$  (t) fixed effects
  - \* Product types: interest rate type, initial interest rate fixation period, maximum LTV ratio
  - \* Borrower types: first-time buyers, second-time buyers, remortgagors and others
  - \* Products offered on the same day
- ightharpoonup Products offered by the same lender ightarrow lender (1) fixed effects
- Standard errors clustered by lender
- ightharpoonup eta compares benefits using variation across green and non-green products of the same type, offered to similar borrowers, on the same day, by the same lender

## Magnitude of the financial benefits: Initial rate

|  |                   | Green Produ       | cts Stating "Pr   | eferential Rate   | ' as a Benefit    |                    |  |  |
|--|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|--|--|
| Dependent Variable: Segment:                       | Initial Rate (%)  |                   |                   |                   |                   |                    |  |  |
|  |                   | Owner-occupie     | d                 | Investor          |                   |                    |  |  |
|  | (1)               | (2)               | (3)               | (4)               | (5)               | (6)                |  |  |
| Green  | -0.35<br>(0.30)   | -0.35*<br>(0.19)  | -0.09**<br>(0.04) | -0.36<br>(0.23)   | -0.30<br>(0.18)   | -0.11***<br>(0.01) |  |  |
| Constant   | 5.53***<br>(0.17) | 5.53***<br>(0.13) | 5.56***<br>(0.00) | 5.90***<br>(0.19) | 5.91***<br>(0.15) | 5.94***<br>(0.00)  |  |  |
| Observations                                       | 2,591,029         | 2,563,852         | 2,344,562         | 1,110,279         | 1,097,708         | 1,033,411          |  |  |
| Adjusted R-Squared                                 | 0.53              | 0.64              | 0.95              | 0.53              | 0.62              | 0.94               |  |  |
| Mean Dep. Variable                                 | 5.51              | 5.52              | 5.55              | 5.87              | 5.88              | 5.93               |  |  |
| Fixed Effects:                                     |                   |                   |                   |                   |                   |                    |  |  |
| $Product \times Day$                               | Yes               |                   |                   | Yes               |                   |                    |  |  |
| $Product \times Borrower \times Day$               |                   | Yes               |                   |                   | Yes               |                    |  |  |
| $Product \times Borrower \times Day \times Lender$ |                   |                   | Yes               |                   |                   | Yes                |  |  |

- ▶ Green products offer an average 35 b.p. discount relative to similar non-green products
- Conditioning on similar products offered by the same lender, the discount decreases to 9 b.p.

## Magnitude of the financial benefits: Cashback

| Dependent Variable:                                | Green Products Stating "Cashback" as a Benefit |                   |                   |                      |                      |                                  |  |  |  |
|--|--|-------------------|-------------------|----------------------|----------------------|----------------------------------|--|--|--|
|  | С  | ashback (Binar    | у)                | Cashback Amount (£)  |                      |                                  |  |  |  |
|  | (1)  | (2)               | (3)               | (4)                  | (5)                  | (6)                              |  |  |  |
| Green  | 0.62***<br>(0.06)                              | 0.53***<br>(0.08) | 0.52***<br>(0.14) | 295.98***<br>(55.79) | 241.76***<br>(43.64) | 211.25** <sup>*</sup><br>(43.75) |  |  |  |
| Constant   | 0.29***<br>(0.03)                              | 0.30***<br>(0.03) | 0.31***<br>(0.01) | 123.20***<br>(16.74) | 128.95***<br>(16.22) | 135.22***<br>(4.61)              |  |  |  |
| Observations                                       | 2,718,053                                      | 2,691,805         | 2,469,256         | 2,717,949            | 2,691,701            | 2,469,230                        |  |  |  |
| Adjusted R-Squared                                 | 0.19   | 0.30              | 0.63              | 0.15                 | 0.27                 | 0.67                             |  |  |  |
| Mean Dep. Variable                                 | 0.35   | 0.35              | 0.36              | 151.74               | 152.49               | 157.48                           |  |  |  |
| Fixed Effects:                                     |  |                   |                   |                      |                      |                                  |  |  |  |
| $Product \times Day$                               | Yes  |                   |                   | Yes                  |                      |                                  |  |  |  |
| $Product \times Borrower \times Day$               |  | Yes               |                   |                      | Yes                  |                                  |  |  |  |
| $Product \times Borrower \times Day \times Lender$ |  |                   | Yes               |                      |                      | Yes                              |  |  |  |

- ► Green products are 52-53% more likely to offer cashback
- ► Average cashback amount is £211-241 higher

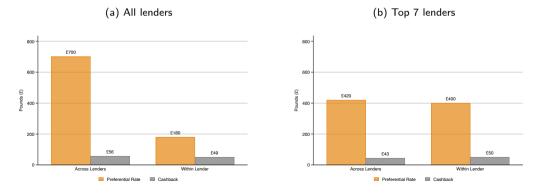


## Back-of-the-envelope calculations

- ► Average owner-occupied mortgage in the UK:
  - $\star$  Loan amount = £200,000
  - \* 5-year fixation period
  - $\star$  Initial interest rate (discount rate) = 5.26% (or 5% within top 7 lenders)
- ▶ Annual equivalent benefits (in £) for both types of products

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- Average owner-occupied mortgage in the UK:
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- ▶ Annual equivalent benefits (in £) for both types of products



### Additional Results

- ► Are the estimated benefits offset by higher fees or a higher reversion rate?
  - $\star$  No statistically significant differences in these features
    - Product fees
    - Reversion rate Go
    - Substitution
- Lender heterogeneity
  - $\star$  Adjusted- $R^2$  increases substantially after including lender fixed effects  $\bigcirc$
- Robustness:
  - \* Financial group fixed effects (based on ultimate ownership)



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**Default Risk:** 

Cash-flow and collateral value channels

#### Default Risk

► All else equal, borrowers seeking mortgages for green properties face lower default risk.

#### ► Cash-flow channel:

- $\star$  Green properties are less expensive to operate  $\Rightarrow$  greater capacity to service debt
  - \* We test: changes in energy prices
  - \* We test: exploit mini-budget announcement Go
- \* Rising energy costs and/or higher debt repayments widen the credit risk gap between energy-efficient and less efficient properties

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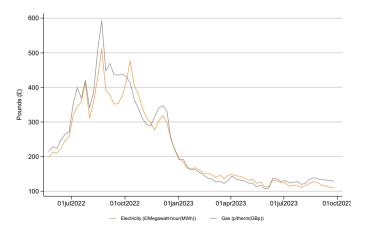
- ★ Green properties are less expensive to operate ⇒ greater capacity to service debt
  - \* We test: changes in energy prices
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- \* Rising energy costs and/or higher debt repayments widen the credit risk gap between energy-efficient and less efficient properties

#### Collateral value channel:

- \* Green properties have higher value ('green premium') and are resilient to 'brown discount'
- \* Particularly important for loans with high LTV ratios
  - ★ Heterogeneity by LTV ratio Distribution of LTV Ratios

## Cash-flow channel: Energy prices

- ► Wholesale forward delivery contracts price (Source: Ofgem)
- ► Significant factor in determining the final price consumers pay for energy
- Weekly frequency



## Cash-flow channel: Energy prices

|  |                           |                           | Owner-oc                  | cupied Segment              |                             |                             |  |
|--|---------------------------|---------------------------|---------------------------|-----------------------------|-----------------------------|-----------------------------|--|
| Dependent Variable:                                      |                           | Initial Rate (%)          | )                         | Cashback amount (£)         |                             |                             |  |
|  | (1)                       | (2)                       | (3)                       | (4)                         | (5)                         | (6)                         |  |
| Green  | -0.0817***<br>(0.0099)    | -0.0768***<br>(0.0106)    | -0.0739***<br>(0.0116)    | 285.2859***<br>(32.6096)    | 287.5036***<br>(34.5314)    | 286.7157***<br>(34.5834)    |  |
| Green × Weekly Electricity Price                         | -0.0001<br>(0.0002)       |                           |                           | -0.3567<br>(0.2566)         |                             |                             |  |
| Green × Weekly Electricity Price (2-Weeks Lead)          |                           | -0.0001<br>(0.0002)       |                           |                             | -0.3722<br>(0.2707)         |                             |  |
| Green × Weekly Electricity Price (4-Weeks Lead)          |                           |                           | -0.0001<br>(0.0002)       |                             |                             | -0.3733<br>(0.2747)         |  |
| Constant   | 5.5565***<br>(0.0020)     | 5.5565***<br>(0.0020)     | 5.5565***<br>(0.0021)     | 135.1765***<br>(4.3449)     | 135.1771***<br>(4.3321)     | 135.1798***<br>(4.3351)     |  |
| Observations<br>Adjusted R-Squared<br>Mean Dep. Variable | 2,344,562<br>0.95<br>5.55 | 2,344,562<br>0.95<br>5.55 | 2,344,562<br>0.95<br>5.55 | 2,469,236<br>0.67<br>157.48 | 2,469,236<br>0.67<br>157.48 | 2,469,236<br>0.67<br>157.48 |  |
| Fixed Effects: Product × Borrower × Day × Lender         | Yes                       | Yes                       | Yes                       | Yes                         | Yes                         | Yes                         |  |

## Cash-flow channel: Energy prices

|  | Owner-occupied Segment    |                           |                           |                             |                             |                             |  |  |  |
|--|---------------------------|---------------------------|---------------------------|-----------------------------|-----------------------------|-----------------------------|--|--|--|
| Dependent Variable:  |                           | Initial Rate (%)          | 1                         | Cashback amount (£)         |                             |                             |  |  |  |
|  | (1)                       | (2)                       | (3)                       | (4)                         | (5)                         | (6)                         |  |  |  |
| Green  | -0.0817***<br>(0.0099)    | -0.0768***<br>(0.0106)    | -0.0739***<br>(0.0116)    | 285.2859***<br>(32.6096)    | 287.5036***<br>(34.5314)    | 286.7157***<br>(34.5834)    |  |  |  |
| $Green  \times  Weekly   Electricity   Price$  | -0.0001<br>(0.0002)       |                           |                           | -0.3567<br>(0.2566)         |                             |                             |  |  |  |
| Green × Weekly Electricity Price (2-Weeks Lead)  |                           | -0.0001<br>(0.0002)       |                           |                             | -0.3722<br>(0.2707)         |                             |  |  |  |
| ${\sf Green}  \times  {\sf Weekly}   {\sf Electricity}   {\sf Price}   ({\sf 4-Weeks}   {\sf Lead})$ |                           |                           | -0.0001<br>(0.0002)       |                             |                             | -0.3733<br>(0.2747)         |  |  |  |
| Constant   | 5.5565***<br>(0.0020)     | 5.5565***<br>(0.0020)     | 5.5565***<br>(0.0021)     | 135.1765***<br>(4.3449)     | 135.1771***<br>(4.3321)     | 135.1798***<br>(4.3351)     |  |  |  |
| Observations<br>Adjusted R-Squared<br>Mean Dep. Variable   | 2,344,562<br>0.95<br>5.55 | 2,344,562<br>0.95<br>5.55 | 2,344,562<br>0.95<br>5.55 | 2,469,236<br>0.67<br>157.48 | 2,469,236<br>0.67<br>157.48 | 2,469,236<br>0.67<br>157.48 |  |  |  |
| Fixed Effects:   | Yes                       | Yes                       | Yes                       | Yes                         | Yes                         | Yes                         |  |  |  |

- \* Same conclusion when exploiting the mini-budget announcement Go
- \* Bell et al. (2023): No evidence of lower rates for energy-efficient homes before green mortgages
- \* Does not support the cash-flow channel

## Collateral value channel

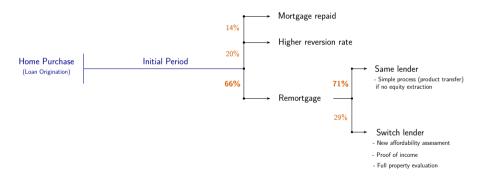
| Segment: Dependent Variable:  | Owner-occupied            |                           |                           |                           |                             |                             |                           | Investor                 |  |
|---|---------------------------|---------------------------|---------------------------|---------------------------|-----------------------------|-----------------------------|---------------------------|--------------------------|--|
|   | Initial Rate (%)          |                           | Cashback (Binary)         |                           | Cashback Amount (£)         |                             | Initial Rate (%)          |                          |  |
|   | (1)                       | (2)                       | (3)                       | (4)                       | (5)                         | (6)                         | (7)                       | (8)                      |  |
| Green   | -0.39<br>(0.24)           | -0.05*<br>(0.02)          | 0.40***<br>(0.13)         | 0.39**<br>(0.17)          | 168.57***<br>(34.06)        | 131.84**<br>(65.85)         | -0.17<br>(0.19)           | -0.10***<br>(0.01)       |  |
| Green $\times$ 65 $<$ LTV Ratio $\le$ 75                                  | -0.01<br>(0.12)           | -0.02<br>(0.01)           | -0.11<br>(0.09)           | -0.09<br>(0.06)           | -19.51<br>(46.30)           | -14.54<br>(38.36)           |                           |                          |  |
| Green $\times$<br>75 $<$ LTV Ratio $\le$ 85                               | 0.23<br>(0.19)            | 0.01<br>(0.02)            | -0.09<br>(0.08)           | -0.01<br>(0.07)           | -12.61<br>(46.74)           | 26.37<br>(42.69)            |                           |                          |  |
| Green $\times$<br>LTV Ratio $>$ 85  | 0.36<br>(0.25)            | 0.03<br>(0.02)            | -0.01<br>(0.07)           | 0.12<br>(0.08)            | -1.15<br>(28.33)            | 41.74<br>(29.55)            |                           |                          |  |
| Green $\times$<br>LTV Ratio = 70  |                           |                           |                           |                           |                             |                             | -0.33<br>(0.22)           | 0.00<br>(0.01)           |  |
| Green $\times$<br>LTV Ratio = 75  |                           |                           |                           |                           |                             |                             | 0.09<br>(0.19)            | 0.05<br>(0.06)           |  |
| Green ×<br>LTV Ratio > 75   |                           |                           |                           |                           |                             |                             | 0.45***<br>(0.17)         | 0.35***<br>(0.10)        |  |
| Constant  | 5.51***<br>(0.13)         | 5.52***<br>(0.00)         | 0.30*** (0.03)            | 0.30***<br>(0.02)         | 128.94***<br>(15.96)        | 133.48***<br>(8.65)         | 5.92***<br>(0.15)         | 5.96***<br>(0.00)        |  |
| Observations<br>Adjusted R-Squared<br>Mean Dep. Variable                  | 2,775,739<br>0.65<br>5.48 | 2,555,194<br>0.95<br>5.51 | 2,775,739<br>0.26<br>0.34 | 2,555,194<br>0.60<br>0.35 | 2,775,635<br>0.24<br>148.71 | 2,555,174<br>0.63<br>152.95 | 1,126,318<br>0.62<br>5.90 | 1,062,06<br>0.94<br>5.95 |  |
| Fixed Effects: Product × Borrower × Day Product × Borrower × Day × Lender | Yes                       | Yes                       | Yes                       | Yes                       | Yes                         | Yes                         | Yes                       | Yes                      |  |

▶ Does not support the higher collateral value explanation



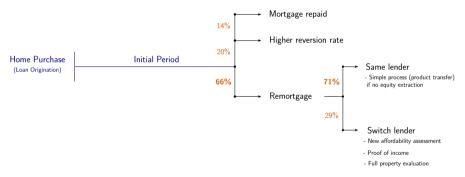
## Customer acquisition: cashback offers to buyers only

► We leverage distinctive features of the UK mortgage market (Belgibayeva et al., 2024))



## Customer acquisition: cashback offers to buyers only

► We leverage distinctive features of the UK mortgage market (Belgibayeva et al., 2024))



▶ Products are differentially available to buyers and remortgagors (observable in the data)

## Customer acquisition: cashback offers to buyers only

| Dependent Variable:                       | Bu                | yers Only (Bina   | ary)              | Available to Remortgagors (Binary) |                    |                    |  |
|---|-------------------|-------------------|-------------------|------------------------------------|--------------------|--------------------|--|
|   | (1)               | (2)               | (3)               | (4)                                | (5)                | (6)                |  |
| Green                                     | 0.31***<br>(0.10) | 0.22**<br>(0.10)  | 0.02<br>(0.03)    | -0.23***<br>(0.07)                 | -0.10***<br>(0.04) | 0.07*<br>(0.04)    |  |
| Cashback (Binary) $[eta_1]$               |                   |                   | -0.12<br>(0.13)   |                                    |                    | 0.28***<br>(0.10)  |  |
| Green $	imes$ Cashback (Binary) $[eta_2]$ |                   |                   | 0.35***<br>(0.12) |                                    |                    | -0.40***<br>(0.10) |  |
| Constant                                  | 0.32***<br>(0.03) | 0.34***<br>(0.01) | 0.38*** (0.04)    | 0.60***<br>(0.04)                  | 0.58***<br>(0.00)  | 0.50***<br>(0.03)  |  |
| Observations                              | 2,802,916         | 2,681,817         | 2,681,817         | 2,802,916                          | 2,681,817          | 2,681,81           |  |
| Adjusted R-Squared                        | 0.10              | 0.25              | 0.27              | 0.11                               | 0.33               | 0.37               |  |
| Mean Dep. Variable                        | 0.36              | 0.37              | 0.37              | 0.57                               | 0.57               | 0.57               |  |
| <i>p</i> -value: $\beta_1 + \beta_2 = 0$  |                   |                   | 0.03              |                                    |                    | 0.02               |  |
| Fixed Effects:                            |                   |                   |                   |                                    |                    |                    |  |
| Product × Day                             | Yes               |                   |                   | Yes                                |                    |                    |  |
| Product × Day × Lender                    |                   | Yes               | Yes               |                                    | Yes                | Yes                |  |

- ► Green products are much more (less) likely to be offered to buyers only (remortgagors)
- ► Driven exclusively by products offering cashback

## Financial constraints: cashback offers prevalent in the owner-occupied segment

| Dependent Variable:   |          | Stated Benefit: Cashback (Binary) |          |          |               |          |  |  |  |  |
|---|----------|-----------------------------------|----------|----------|---------------|----------|--|--|--|--|
| Sample:   | Al       | Green Produ                       | cts      | Top :    | Seven Lenders | Only     |  |  |  |  |
|   | (1)      | (2)                               | (3)      | (4)      | (5)           | (6)      |  |  |  |  |
| Owner-occupied Segment  | 0.517*** | 0.837***                          | 0.721*** | 0.899*** | 0.931***      | 0.871*** |  |  |  |  |
|   | (0.183)  | (0.142)                           | (0.191)  | (0.086)  | (0.088)       | (0.138)  |  |  |  |  |
| Constant  | 0.222    | -0.000                            | 0.080    | 0.064    | 0.053         | 0.106    |  |  |  |  |
|   | (0.151)  | (0.104)                           | (0.139)  | (0.058)  | (0.078)       | (0.122)  |  |  |  |  |
| Observations  | 464,758  | 449,047                           | 433,161  | 256,490  | 251,398       | 235,512  |  |  |  |  |
| Adjusted R-Squared  | 0.62     | 0.91                              | 0.90     | 0.80     | 0.98          | 0.98     |  |  |  |  |
| Mean Dep. Variable  | 0.60     | 0.61                              | 0.61     | 0.85     | 0.87          | 0.88     |  |  |  |  |
| Fixed Effects:  |          |                                   |          |          |               |          |  |  |  |  |
| $Product \times Borrower \times Day$                            | Yes      |                                   |          | Yes      |               |          |  |  |  |  |
| Product $\times$ Borrower $\times$ Day $\times$ Financial Group |          | Yes                               |          |          | Yes           |          |  |  |  |  |
| $Product \times Borrower \times Day \times Lender$              |          |                                   | Yes      |          |               | Yes      |  |  |  |  |

- ► Cashback-based products are more likely to be offered in the owner-occupied segment
- ► Holds within financial group or lender

## Financial constraints: cashback offers target new builds and financially constrained

| Sample:                                   | All Green Pr                     | oducts                       | Top 7 Lende                      | rs Only                      |
|---|----------------------------------|------------------------------|----------------------------------|------------------------------|
| Dependent Variable:                       | Available to New Builds (Binary) | Shared Ownership<br>(Binary) | Available to New Builds (Binary) | Shared Ownership<br>(Binary) |
|   | (1)                              | (2)                          | (3)                              | (4)                          |
| Green                                     | 0.01<br>(0.03)                   | -0.08**<br>(0.04)            | -0.04<br>(0.09)                  | -0.19***<br>(0.02)           |
| Cashback (Binary) $[eta_1]$               | 0.07<br>(0.06)                   | 0.12**<br>(0.06)             | 0.18*<br>(0.10)                  | 0.22***<br>(0.07)            |
| Green $	imes$ Cashback (Binary) $[eta_2]$ | 0.09**<br>(0.05)                 | 0.08*<br>(0.05)              | 0.09<br>(0.09)                   | 0.13***<br>(0.04)            |
| Constant                                  | 0.18***<br>(0.02)                | 0.15***<br>(0.02)            | 0.24***<br>(0.04)                | 0.27***<br>(0.03)            |
| Observations                              | 2,681,817                        | 2,681,817                    | 1,038,145                        | 1,038,145                    |
| Adjusted R-Squared                        | 0.57                             | 0.57                         | 0.37                             | 0.59                         |
| Mean Dep. Variable                        | 0.21                             | 0.19                         | 0.33                             | 0.35                         |
| <i>p</i> -value: $\beta_1 + \beta_2 = 0$  | 0.02                             | 0.00                         | 0.03                             | 0.00                         |
| Fixed Effects:                            |                                  |                              |                                  |                              |
| Product × Day × Lender                    | Yes                              | Yes                          | Yes                              | Yes                          |

#### Green products offering cashback are:

- 1. More likely to be available to new builds Market characteristics by EPC rating
- 2. More likely to be offered under *Shared Ownership* schemes Definitions

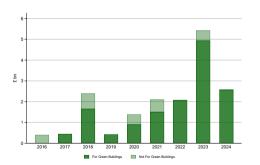
## Other Mechanisms

Cost of Capital and Climate Commitments

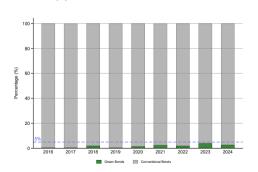
## Cost of Capital

- Banks can lower funding costs by issuing green bonds backed by green mortgages
- ▶ Data on the universe of bonds both green and conventional from Bloomberg's fixed income database

(a) Aggregate Time Series Of Green Bond Issuance

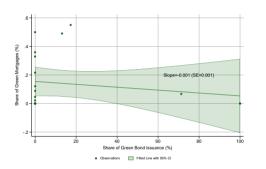


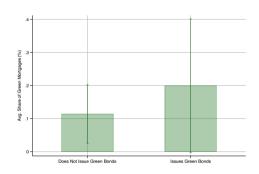
(b) Share of Green Bond Issuance



Distribution of Share of Green Bond Issuance

## Cost of Capital





- ▶ No significant relationship between green bond issuance and green mortgage offerings
- ▶ The cost of capital channel is likely not the primary determinant of the supply of green mortgages

## Climate Commitments

- Reputational and strategic positioning
- ▶ Reinforced by banks (voluntarily) signing climate commitments with explicit sustainability targets
  - \* Net-Zero Banking Alliance (NZBA) initiative

| Dependent Variable:                                      | Offers Green (I        | Binary)                 | Share Green Products (%) |                         |  |  |  |
|--|------------------------|-------------------------|--------------------------|-------------------------|--|--|--|
| Segment:   | Owner-Occupied         | Investor                | Owner-Occupied           | Investor                |  |  |  |
|  | (1)                    | (2)                     | (3)                      | (4)                     |  |  |  |
| NZBA Member  | 0.38***<br>(0.12)      | 0.05<br>(0.10)          | 0.13***<br>(0.05)        | 0.01<br>(0.04)          |  |  |  |
| Constant   | 0.13***<br>(0.04)      | 0.18***<br>(0.04)       | 0.01***<br>(0.01)        | 0.06***<br>(0.02)       |  |  |  |
| Observations<br>Adjusted R-Squared<br>Mean Dep. Variable | 41,033<br>0.14<br>0.22 | 37,914<br>-0.01<br>0.20 | 41,033<br>0.19<br>0.05   | 37,914<br>-0.01<br>0.07 |  |  |  |
| Fixed Effects:<br>Day                                    | Yes                    | Yes                     | Yes                      | Yes                     |  |  |  |

 Banks' climate commitments positively associated with the propensity to offer green mortgages in the owner-occupied segment

### Conclusion

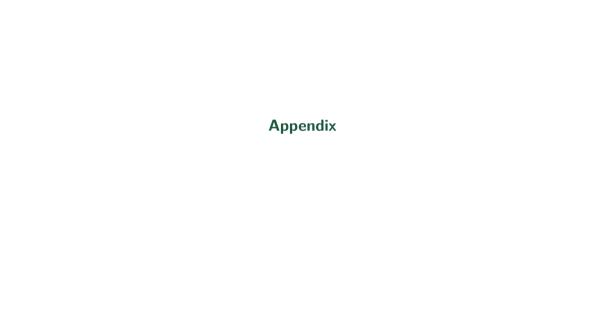
- ► First large-sample characterization of green mortgages <u>on offer</u>
  - \* Offer financial benefits for owning energy-efficient properties rather than improving them
- ▶ Significant heterogeneity in the nature and magnitude of the financial benefits:
  - ★ Preferential rate: 9-35 b.p. discount, annual gains of £180-£700
  - ★ Cashback: annual gains of £49-£56
- Potential Explanations:
  - \* Evidence does not support lower financing risk explanations
  - ★ Evidence supporting customer acquisition, for cashback-based products
  - $\star$  Other evidence supports the importance of climate commitments but not cost of capital

Lenders design products around borrower heterogeneity to segment markets and attract new business in competitive mortgage markets.

## THANK YOU!

Green Mortgages

João F. Cocco, Bernardo Mendes, S. Lakshmi Naaraayanan



## FCA's view of green mortgages



#### The FCA's view of green mortgages

Speeches First published: 19/04/2023 Last updated: 19/04/2023

#### What are green mortgages?

I am here to talk to you about a topic that is becoming increasingly important in today's mortgage market – green home finance, often known as 'green mortgages'. Let's start by exploring what we mean by 'green mortgages', as there isn't a commonly-accepted definition, and regulated returns data do not distinguish between 'green' and 'normal' mortgages.

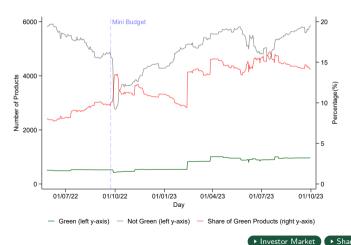
What we do know is that the reference to 'green' relates to the property the mortgage is taken out on, rather than the mortgage itself. So perhaps 'green home finance' is a more accurate term?

But whatever we call it, in essence we are referring to a mortgage which includes an incentive for people to either purchase an energy-efficient property, or improve the energy efficiency of an existing property. The incentives vary, but typically involve a discount to the fixed rate, or cashback payable after completion of the improvement.



## Green mortgages in the UK

#### Owner-occupied Mortgage Market



## Green mortgages in the UK

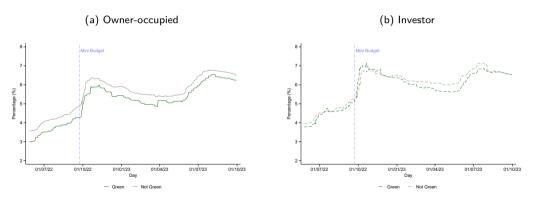
Summary Statistics: Green and Not Green Mortgages

|  |        |            |          | Panel A: O | wner-occup               | ied       |       |        |
|--|--------|------------|----------|------------|--------------------------|-----------|-------|--------|
|  |        | Green (n = | 346,777) |            | Not Green (n = 2,464,183 |           |       | .83)   |
|  | Mean   | Std. Dev.  | p25      | p75        | Mean                     | Std. Dev. | p25   | p75    |
| Fixation Term (Years)                              | 3.75   | 2.28       | 2.00     | 5.00       | 3.43                     | 2.08      | 2.00  | 5.00   |
| Maximum LTV Ratio (%)                              | 78.43  | 10.62      | 75.00    | 85.00      | 77.86                    | 11.89     | 70.00 | 85.00  |
| Fixed Rate Mortgage (Binary)                       | 0.90   | 0.30       | 1.00     | 1.00       | 0.85                     | 0.36      | 1.00  | 1.00   |
| Available to First Time Buyers (Binary)            | 0.69   | 0.46       | 0.00     | 1.00       | 0.66                     | 0.47      | 0.00  | 1.00   |
| Available to Second Time Buyers (Binary)           | 0.64   | 0.48       | 0.00     | 1.00       | 0.65                     | 0.48      | 0.00  | 1.00   |
| Available to Remortgagors (Binary)                 | 0.36   | 0.48       | 0.00     | 1.00       | 0.60                     | 0.49      | 0.00  | 1.00   |
| Available to Other Borrowers (Binary)              | 0.00   | 0.00       | 0.00     | 0.00       | 0.07                     | 0.26      | 0.00  | 0.00   |
| Initial Rate (%)                                   | 5.26   | 1.18       | 4.43     | 6.14       | 5.51                     | 1.52      | 4.48  | 6.37   |
| Reversion Rate (%)                                 | 7.18   | 1.43       | 6.20     | 7.99       | 6.86                     | 1.44      | 5.74  | 7.87   |
| Cashback (Binary)                                  | 0.73   | 0.45       | 0.00     | 1.00       | 0.29                     | 0.45      | 0.00  | 1.00   |
| Cashback Amount (£)                                | 333.91 | 317.11     | 0.00     | 500.00     | 121.55                   | 241.75    | 0.00  | 250.00 |
| Total Flat Fees (£)                                | 517.34 | 523.32     | 0.00     | 999.00     | 626.91                   | 613.89    | 0.00  | 999.00 |
| Total Percent Fees (%)                             | 0.00   | 0.04       | 0.00     | 0.00       | 0.02                     | 0.13      | 0.00  | 0.00   |
| Stated Benefit (Green): Preferential Rate (Binary) | 0.39   | 0.49       | 0.00     | 1.00       | -                        | _         | -     | _      |
| Stated Benefit (Green): Cashback (Binary)          | 0.76   | 0.43       | 1.00     | 1.00       | -                        | _         | -     | _      |
| Stated Benefit (Green): Reduced Fees (Binary)      | 0.01   | 0.08       | 0.00     | 0.00       | _                        | _         | _     | _      |



## Green mortgages in the UK

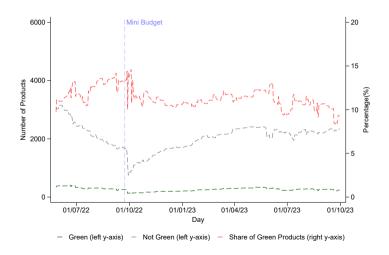
#### Average Initial Rate



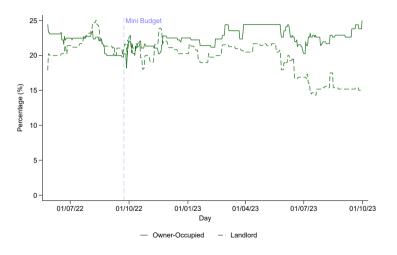


## Green products are significant and increasingly prominent in the UK

## Investor Mortgage Market



## Share of lender offering green mortagages





# UK housing stock

Energy Performance of Dwellings in the UK, 2022

| Dwelling Age |     | % of Properties<br>Within Energy Efficiency Rating |       | Energy Use<br>(KWh/m²/year) | Energy Cost $(£/year)$ | CO <sub>2</sub> Emissions<br>Tonnes/Year | Number of Dwellings<br>(000s) |     |       |
|--------------|-----|--|-------|-----------------------------|------------------------|--|-------------------------------|-----|-------|
|              | A/B | С  | A/B/C | D                           | E/F/G                  |  |                               |     |       |
| Pre-1919     |     | 21   | 21    | 56                          | 23                     | 275                                      | 1,894                         | 5.7 | 5,099 |
| 1919-44      |     | 28   | 28    | 63                          | 9                      | 247                                      | 1,592                         | 4.4 | 3,801 |
| 1945-64      | 1   | 47   | 48    | 45                          | 6                      | 231                                      | 1,370                         | 3.7 | 4,550 |
| 1965-80      | 1   | 49   | 49    | 43                          | 7                      | 235                                      | 1,346                         | 3.7 | 4,674 |
| 1981-90      | 3   | 57   | 60    | 34                          | 6                      | 227                                      | 1,251                         | 3.4 | 1,660 |
| Post-1990    | 13  | 70   | 83    | 15                          | 2                      | 176                                      | 1,074                         | 2.8 | 5,376 |



# Summary statistics: Investor market

|  |        |            |          | Panel  | B: Investor                 |           |       |          |
|--|--------|------------|----------|--------|-----------------------------|-----------|-------|----------|
|  |        | Green (n = | 129,365) |        | Not Green $(n = 1,010,984)$ |           |       | ,984)    |
|  | Mean   | Std. Dev.  | p25      | p75    | Mean                        | Std. Dev. | p25   | p75      |
| Fixation Term (Years)                              | 3.97   | 1.81       | 2.00     | 5.00   | 3.33                        | 1.77      | 2.00  | 5.00     |
| Maximum LTV Ratio (%)                              | 70.65  | 7.32       | 65.00    | 75.00  | 71.18                       | 7.25      | 65.00 | 75.00    |
| Fixed Rate Mortgage (Binary)                       | 0.91   | 0.28       | 1.00     | 1.00   | 0.79                        | 0.41      | 1.00  | 1.00     |
| Available to First Time Buyers (Binary)            | 0.10   | 0.30       | 0.00     | 0.00   | 0.18                        | 0.39      | 0.00  | 0.00     |
| Available to Second Time Buyers (Binary)           | 0.81   | 0.40       | 1.00     | 1.00   | 0.82                        | 0.38      | 1.00  | 1.00     |
| Available to Remortgagors (Binary)                 | 0.80   | 0.40       | 1.00     | 1.00   | 0.81                        | 0.39      | 1.00  | 1.00     |
| Available to Other Borrowers (Binary)              | 0.04   | 0.19       | 0.00     | 0.00   | 0.08                        | 0.27      | 0.00  | 0.00     |
| Initial Rate (%)                                   | 5.70   | 1.30       | 4.84     | 6.65   | 5.91                        | 1.69      | 4.84  | 6.75     |
| Reversion Rate (%)                                 | 7.51   | 1.51       | 6.24     | 8.59   | 7.55                        | 1.56      | 6.25  | 8.74     |
| Cashback (Binary)                                  | 0.27   | 0.44       | 0.00     | 1.00   | 0.15                        | 0.36      | 0.00  | 0.00     |
| Cashback Amount (£)                                | 147.10 | 286.61     | 0.00     | 300.00 | 51.92                       | 128.93    | 0.00  | 0.00     |
| Total Flat Fees (£)                                | 731.81 | 1,173.26   | 0.00     | 995.00 | 842.62                      | 907.12    | 0.00  | 1,495.00 |
| Total Percent Fees (%)                             | 1.51   | 1.23       | 0.00     | 2.00   | 1.64                        | 1.33      | 0.00  | 2.00     |
| Stated Benefit (Green): Preferential Rate (Binary) | 0.78   | 0.41       | 1.00     | 1.00   | _                           | -         | _     | _        |
| Stated Benefit (Green): Cashback (Binary)          | 0.14   | 0.35       | 0.00     | 0.00   | _                           | _         | _     | _        |
| Stated Benefit (Green): Reduced Fees (Binary)      | 0.06   | 0.23       | 0.00     | 0.00   | _                           | -         | _     | _        |



# Summary statistics by lender category

|  |         |           |        | Panel A: Ov | vner-occupi | ied          |                 |           |
|--|---------|-----------|--------|-------------|-------------|--------------|-----------------|-----------|
|  | Тор     | 7 Lender  | E      | Banks       |             | ng Societies | (               | Others    |
| Number of Green Observations                       | 22      | 26,266    | 63,024 |             | 6,791       |              | 50,696          |           |
| Number of Non-Green Observations                   | 826,948 |           | 4      | 57,456      | 5           | 51,451       | 628,328<br>0.07 |           |
| Share of Green                                     |         | 0.21      |        | 0.12        | 0.01        |              |                 |           |
|  | Green   | Non-Green | Green  | Non-Green   | Green       | Non-Green    | Green           | Non-Green |
| Fixation Term (Years)                              | 4.07    | 3.76      | 3.17   | 3.46        | 1.25        | 3.17         | 3.38            | 3.20      |
| Maximum LTV Ratio (%)                              | 78.36   | 78.73     | 78.19  | 77.81       | 84.03       | 80.17        | 78.25           | 74.74     |
| Fixed Rate Mortgage (Binary)                       | 0.92    | 0.86      | 0.87   | 0.94        | 0.15        | 0.70         | 0.93            | 0.90      |
| Available to First Time Buyers (Binary)            | 0.61    | 0.47      | 0.66   | 0.72        | 0.99        | 0.70         | 1.00            | 0.83      |
| Available to Second Time Buyers (Binary)           | 0.55    | 0.44      | 0.66   | 0.77        | 0.99        | 0.68         | 1.00            | 0.81      |
| Available to Remortgagors (Binary)                 | 0.22    | 0.41      | 0.43   | 0.71        | 0.62        | 0.62         | 0.89            | 0.76      |
| Available to Other Borrowers (Binary)              | 0.00    | 0.14      | 0.00   | 0.02        | 0.00        | 0.09         | 0.00            | 0.00      |
| Initial Rate (%)                                   | 5.00    | 4.90      | 5.07   | 5.45        | 4.95        | 4.86         | 6.74            | 6.92      |
| Reversion Rate (%)                                 | 7.03    | 6.66      | 6.41   | 6.83        | 6.66        | 6.27         | 8.74            | 7.78      |
| Cashback (Binary)                                  | 0.92    | 0.30      | 0.53   | 0.38        | 0.08        | 0.25         | 0.21            | 0.23      |
| Cashback Amount (£)                                | 366.76  | 116.08    | 397.04 | 187.13      | 18.00       | 95.88        | 150.61          | 103.53    |
| Total Flat Fees (£)                                | 550.72  | 586.16    | 165.71 | 700.68      | 565.51      | 571.49       | 799.05          | 676.79    |
| Total Percent Fees (%)                             | 0.00    | 0.00      | 0.00   | 0.04        | 0.24        | 0.05         | 0.00            | 0.02      |
| Stated Benefit (Green): Preferential Rate (Binary) | 0.11    | _         | 1.00   | _           | 0.92        | _            | 0.79            | _         |
| Stated Benefit (Green): Cashback (Binary)          | 0.97    | -         | 0.51   | _           | 0.08        | _            | 0.21            | _         |
| Stated Benefit (Green): Reduced Fees (Binary)      | 0.00    | _         | 0.00   | _           | 0.00        | -            | 0.04            | _         |

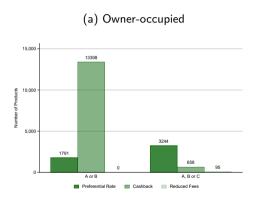


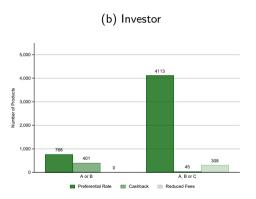
# Summary statistics by lender category

|  |          |           |        | Panel B:  | Investor |                    |         |           |
|--|----------|-----------|--------|-----------|----------|--------------------|---------|-----------|
|  | Top 7    | 7 Lender  |        | Banks     | Buildin  | Building Societies |         | Others    |
| Number of Green Observations                       | 30       | ),936     | 21,931 |           | 1,570    |                    | 74,928  |           |
| Number of Non-Green Observations                   | 22       | 3,841     | 1      | 61,642    | 20       | 02,751             | 422,750 |           |
| Share of Green                                     | (        | 0.12      |        | 0.12      | (        | 0.007              |         | 0.15      |
|  | Green    | Non-Green | Green  | Non-Green | Green    | Non-Green          | Green   | Non-Green |
| Fixation Term (Years)                              | 3.56     | 3.43      | 3.94   | 3.51      | 2.79     | 3.08               | 4.17    | 3.33      |
| Maximum LTV Ratio (%)                              | 67.00    | 67.80     | 70.24  | 72.34     | 77.05    | 70.86              | 72.14   | 72.69     |
| Fixed Rate Mortgage (Binary)                       | 1.00     | 0.89      | 0.90   | 0.90      | 0.43     | 0.60               | 0.89    | 0.79      |
| Available to First Time Buyers (Binary)            | 0.20     | 0.12      | 0.10   | 0.05      | 0.00     | 0.14               | 0.05    | 0.29      |
| Available to Second Time Buyers (Binary)           | 0.35     | 0.66      | 0.87   | 0.89      | 0.95     | 0.67               | 0.97    | 0.95      |
| Available to Remortgagors (Binary)                 | 0.65     | 0.61      | 0.80   | 0.80      | 0.73     | 0.74               | 0.86    | 0.96      |
| Available to Other Borrowers (Binary)              | 0.00     | 0.11      | 0.13   | 0.05      | 0.00     | 0.13               | 0.03    | 0.04      |
| Initial Rate (%)                                   | 5.04     | 5.04      | 5.51   | 5.67      | 4.33     | 5.08               | 6.05    | 6.87      |
| Reversion Rate (%)                                 | 7.44     | 7.27      | 7.22   | 7.76      | 6.37     | 6.74               | 7.66    | 8.06      |
| Cashback (Binary)                                  | 0.33     | 0.33      | 0.25   | 0.11      | 0.53     | 0.19               | 0.24    | 0.05      |
| Cashback Amount (£)                                | 98.37    | 122.53    | 80.86  | 40.21     | 203.23   | 61.64              | 185.48  | 14.35     |
| Total Flat Fees (£)                                | 1,471.05 | 940.84    | 651.44 | 928.07    | 820.24   | 1,105.78           | 106.83  | 464.09    |
| Total Percent Fees (%)                             | 0.00     | 0.89      | 1.59   | 1.85      | 0.00     | 0.49               | 1.67    | 1.96      |
| Stated Benefit (Green): Preferential Rate (Binary) | 1.00     | _         | 0.87   | _         | 0.46     | _                  | 0.67    | _         |
| Stated Benefit (Green): Cashback (Binary)          | 0.00     | _         | 0.00   | _         | 0.05     | _                  | 0.24    | _         |
| Stated Benefit (Green): Reduced Fees (Binary)      | 0.00     | -         | 0.00   | _         | 0.00     | -                  | 0.10    | _         |



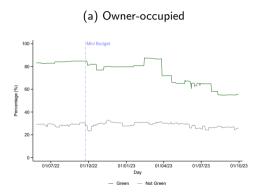
# Stated benefits of green mortgages

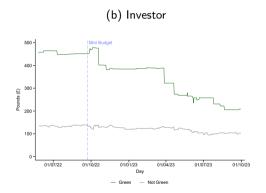






## Time-series of probability of offering cashback and cashback amount







# Magnitude of the financial benefits: Initial rate

|  |                   |                   | All Green         | Products          |                   |                   |  |  |  |
|--|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--|--|--|
| Dependent Variable:                                | Initial Rate (%)  |                   |                   |                   |                   |                   |  |  |  |
| Segment:   |                   | Owner-occupie     | d                 |                   | Investor          |                   |  |  |  |
|  | (1)               | (2)               | (3)               | (4)               | (5)               | (6)               |  |  |  |
| Green  | -0.39**<br>(0.18) | -0.24*<br>(0.14)  | -0.04**<br>(0.02) | -0.18<br>(0.23)   | -0.13<br>(0.19)   | -0.05<br>(0.05)   |  |  |  |
| Constant   | 5.53***<br>(0.17) | 5.51***<br>(0.13) | 5.52***<br>(0.00) | 5.91***<br>(0.19) | 5.92***<br>(0.15) | 5.96***<br>(0.01) |  |  |  |
| Observations                                       | 2,802,916         | 2,775,739         | 2,555,194         | 1,138,870         | 1,126,318         | 1,062,067         |  |  |  |
| Adjusted R-Squared                                 | 0.54              | 0.65              | 0.95              | 0.53              | 0.62              | 0.94              |  |  |  |
| Mean Dep. Variable                                 | 5.48              | 5.48              | 5.51              | 5.89              | 5.90              | 5.95              |  |  |  |
| Fixed Effects:                                     |                   |                   |                   |                   |                   |                   |  |  |  |
| $Product \times Day$                               | Yes               |                   |                   | Yes               |                   |                   |  |  |  |
| $Product \times Borrower \times Day$               |                   | Yes               |                   |                   | Yes               |                   |  |  |  |
| $Product \times Borrower \times Day \times Lender$ |                   |                   | Yes               |                   |                   | Yes               |  |  |  |



## Magnitude of the financial benefits: Initial rate

▶ Restricting the sample to products offered by top 7 lenders

| Dependent Variable:                                |                    |                    | Initial F          | Rate (%)          |                    |                    |
|--|--------------------|--------------------|--------------------|-------------------|--------------------|--------------------|
| Segment:   |                    | )wner-occupie      | ed                 |                   | Investor           |                    |
|  | (1)                | (2)                | (3)                | (4)               | (5)                | (6)                |
| Green  | -0.19***<br>(0.03) | -0.21***<br>(0.04) | -0.20***<br>(0.01) | -0.19**<br>(0.07) | -0.17***<br>(0.05) | -0.10***<br>(0.03) |
| Constant   | 4.90***<br>(0.02)  | 4.90***<br>(0.02)  | 4.90***<br>(0.00)  | 5.06***<br>(0.03) | 5.06***<br>(0.02)  | 5.04***<br>(0.00)  |
| Observations                                       | 849,468            | 845,059            | 822,738            | 254,006           | 246,977            | 230,450            |
| Adjusted R-Squared                                 | 0.90               | 0.91               | 0.96               | 0.84              | 0.85               | 0.85               |
| Mean Dep. Variable                                 | 4.90               | 4.90               | 4.89               | 5.04              | 5.04               | 5.03               |
| Fixed Effects:                                     |                    |                    |                    |                   |                    |                    |
| $Product \times Day$                               | Yes                |                    |                    | Yes               |                    |                    |
| $Product \times Borrower \times Day$               |                    | Yes                |                    |                   | Yes                |                    |
| $Product \times Borrower \times Day \times Lender$ |                    |                    | Yes                |                   |                    | Yes                |



# Magnitude of the financial benefits: Cashback

|  |                   | All Green Products |                   |                      |                      |                     |  |  |  |  |
|--|-------------------|--------------------|-------------------|----------------------|----------------------|---------------------|--|--|--|--|
| Dependent Variable:                                | C                 | ashback (Binar     | y)                | Cas                  | hback Amount         | (£)                 |  |  |  |  |
|  | (1)               | (2)                | (3)               | (4)                  | (5)                  | (6)                 |  |  |  |  |
| Green  | 0.42***<br>(0.13) | 0.34***<br>(0.13)  | 0.39**<br>(0.15)  | 206.17***<br>(52.85) | 158.60***<br>(41.50) | 145.24**<br>(65.51) |  |  |  |  |
| Constant   | 0.29***<br>(0.03) | 0.30***<br>(0.03)  | 0.30***<br>(0.02) | 122.50***<br>(16.39) | 128.96***<br>(15.96) | 133.55***<br>(8.75) |  |  |  |  |
| Observations                                       | 2,802,916         | 2,775,739          | 2,555,194         | 2,802,812            | 2,775,635            | 2,555,174           |  |  |  |  |
| Adjusted R-Squared                                 | 0.13              | 0.26               | 0.60              | 0.11                 | 0.24                 | 0.63                |  |  |  |  |
| Mean Dep. Variable                                 | 0.34              | 0.34               | 0.35              | 147.98               | 148.71               | 152.95              |  |  |  |  |
| Fixed Effects:                                     |                   |                    |                   |                      |                      |                     |  |  |  |  |
| Product × Day                                      | Yes               |                    |                   | Yes                  |                      |                     |  |  |  |  |
| $Product \times Borrower \times Day$               |                   | Yes                |                   |                      | Yes                  |                     |  |  |  |  |
| $Product \times Borrower \times Day \times Lender$ |                   |                    | Yes               |                      |                      | Yes                 |  |  |  |  |



## Magnitude of the financial benefits: Cashback

▶ Restricting the sample to products offered by top 7 lenders

| Dependent Variable:                                | C         | ashback (Binar | y)        | Cashback Amount $(\mathfrak{L})$ |           |           |  |
|--|-----------|----------------|-----------|----------------------------------|-----------|-----------|--|
|  | (1)       | (2)            | (3)       | (4)                              | (5)       | (6)       |  |
| Green  | 0.61***   | 0.50***        | 0.55***   | 249.04***                        | 187.33*** | 214.76*** |  |
|  | (80.0)    | (0.14)         | (0.16)    | (47.35)                          | (29.39)   | (31.83)   |  |
| Constant   | 0.30***   | 0.33***        | 0.31***   | 117.05***                        | 129.52*** | 122.25*** |  |
|  | (0.05)    | (0.05)         | (0.03)    | (22.58)                          | (16.79)   | (6.86)    |  |
| Observations                                       | 1,042,996 | 1,038,697      | 1,015,759 | 1,042,996                        | 1,038,697 | 1,015,759 |  |
| Adjusted R-Squared                                 | 0.27      | 0.44           | 0.60      | 0.23                             | 0.61      | 0.80      |  |
| Mean Dep. Variable                                 | 0.43      | 0.43           | 0.43      | 169.36                           | 169.03    | 168.56    |  |
| Fixed Effects:                                     |           |                |           |                                  |           |           |  |
| $Product \times Day$                               | Yes       |                |           | Yes                              |           |           |  |
| $Product \times Borrower \times Day$               |           | Yes            |           |                                  | Yes       |           |  |
| $Product \times Borrower \times Day \times Lender$ |           |                | Yes       |                                  |           | Yes       |  |



## Lender heterogeneity

## ► Adjusted-R<sup>2</sup> Across Various Fixed Effects Specifications

| Dependent Variable:  | Initial Rate (%) | Cashback (Binary) | Cashback Amount (£) |
|--|------------------|-------------------|---------------------|
| Fixed Effects Specification:                                   |                  |                   |                     |
| Owner-occupied   |                  |                   |                     |
| $Product \times Borrower \times Day$                           | 0.64             | 0.27              | 0.19                |
| $Product \times Borrower \times Day \times Lender \; Category$ | 0.82             | 0.35              | 0.37                |
| $Product \times Borrower \times Day \times Lender$             | 0.95             | 0.67              | 0.60                |
| Investor:  |                  |                   |                     |
| $Product \times Borrower \times Day$                           | 0.62             | 0.18              | 0.16                |
| $Product \times Borrower \times Day \times Lender \; Category$ | 0.73             | 0.32              | 0.29                |
| $Product \times Borrower \times Day \times Lender$             | 0.94             | 0.50              | 0.45                |



## Financial groups

► Consolidated lender classification based on the ultimate ownership of brands or subsidiaries

| Dependent Variable:   | Initial Rate (%)  |                   |                   |                   |                   |                    |  |  |  |
|---|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|--|--|--|
| Segment:  |                   | Owner-occupie     | d                 | Investor          |                   |                    |  |  |  |
|   | (1)               | (2)               | (3)               | (4)               | (5)               | (6)                |  |  |  |
| Green   | -0.35<br>(0.31)   | -0.35*<br>(0.20)  | -0.09**<br>(0.04) | -0.36<br>(0.24)   | -0.30<br>(0.18)   | -0.13***<br>(0.02) |  |  |  |
| Constant  | 5.53***<br>(0.18) | 5.53***<br>(0.14) | 5.55***<br>(0.00) | 5.90***<br>(0.19) | 5.91***<br>(0.16) | 5.94***<br>(0.00)  |  |  |  |
| Observations  | 2,591,029         | 2,563,852         | 2,373,853         | 1,110,279         | 1,097,708         | 1,046,444          |  |  |  |
| Adjusted R-Squared  | 0.53              | 0.64              | 0.94              | 0.53              | 0.62              | 0.94               |  |  |  |
| Mean Dep. Variable  | 5.51              | 5.52              | 5.54              | 5.87              | 5.88              | 5.93               |  |  |  |
| Fixed Effects:  |                   |                   |                   |                   |                   |                    |  |  |  |
| $Product \times Day$  | Yes               |                   |                   | Yes               |                   |                    |  |  |  |
| $Product \times Borrower \times Day$                        |                   | Yes               |                   |                   | Yes               |                    |  |  |  |
| $Product \times Borrower \times Day \times Financial Group$ |                   |                   | Yes               |                   |                   | Yes                |  |  |  |



## Financial groups

► Consolidated lender classification based on the ultimate ownership of brands or subsidiaries

| Dependent Variable:   | C                 | ashback (Binar    | y)                | Cashback Amount $(£)$ |                      |                      |  |
|---|-------------------|-------------------|-------------------|-----------------------|----------------------|----------------------|--|
|   | (1)               | (2)               | (3)               | (4)                   | (5)                  | (6)                  |  |
| Green   | 0.62***<br>(0.07) | 0.53***<br>(0.10) | 0.51***<br>(0.14) | 295.98***<br>(63.27)  | 241.76***<br>(48.45) | 206.06***<br>(48.88) |  |
| Constant  | 0.29***<br>(0.03) | 0.30*** (0.03)    | 0.31***<br>(0.01) | 123.20***<br>(17.03)  | 128.95***<br>(17.10) | 136.04***<br>(5.09)  |  |
| Observations  | 2,718,053         | 2,691,805         | 2,497,826         | 2,717,949             | 2,691,701            | 2,497,806            |  |
| Adjusted R-Squared  | 0.19              | 0.30              | 0.62              | 0.15                  | 0.27                 | 0.67                 |  |
| Mean Dep. Variable  | 0.35              | 0.35              | 0.36              | 151.74                | 152.49               | 157.51               |  |
| Fixed Effects:  |                   |                   |                   |                       |                      |                      |  |
| $Product \times Day$  | Yes               |                   |                   | Yes                   |                      |                      |  |
| $Product \times Borrower \times Day$                        |                   | Yes               |                   |                       | Yes                  |                      |  |
| $Product \times Borrower \times Day \times Financial Group$ |                   |                   | Yes               |                       |                      | Yes                  |  |



## Product fees

## ► Flat fees charged on products offered

| Dependent Variable:                                | Flat Fees (£)        |                      |                     |                      |                      |                      |  |  |
|--|----------------------|----------------------|---------------------|----------------------|----------------------|----------------------|--|--|
| Segment:   |                      | Owner-occupie        | d                   | Investor             |                      |                      |  |  |
|  | (1)                  | (2)                  | (3)                 | (4)                  | (5)                  | (6)                  |  |  |
| Green  | -94.24<br>(65.31)    | -43.22<br>(60.78)    | 28.04<br>(27.80)    | -87.14<br>(255.54)   | -73.21<br>(218.48)   | -157.96<br>(199.79)  |  |  |
| Constant   | 625.24***<br>(26.82) | 618.92***<br>(22.94) | 611.47***<br>(3.75) | 841.07***<br>(56.76) | 833.47***<br>(46.37) | 832.94***<br>(22.25) |  |  |
| Observations                                       | 2,774,254            | 2,750,445            | 2,531,803           | 748,365              | 735,559              | 678,843              |  |  |
| Adjusted R-Squared                                 | 0.04                 | 0.08                 | 0.22                | 0.08                 | 0.12                 | 0.32                 |  |  |
| Mean Dep. Variable                                 | 613.47               | 613.48               | 615.25              | 831.70               | 825.48               | 815.35               |  |  |
| Fixed Effects:                                     |                      |                      |                     |                      |                      |                      |  |  |
| Product × Day                                      | Yes                  |                      |                     | Yes                  |                      |                      |  |  |
| $Product \times Borrower \times Day$               |                      | Yes                  |                     |                      | Yes                  |                      |  |  |
| $Product \times Borrower \times Day \times Lender$ |                      |                      | Yes                 |                      |                      | Yes                  |  |  |



## Product fees

► Percentage fees charged on products offered

| Dependent Variable:                                | Percent Fees (%)  |                   |                   |                   |                   |                   |  |  |
|--|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--|--|
| Segment:   |                   | )wner-occupied    | Investor          |                   |                   |                   |  |  |
|  | (1)               | (2)               | (3)               | (4)               | (5)               | (6)               |  |  |
| Green  | -0.01*<br>(0.01)  | -0.01*<br>(0.00)  | -0.00<br>(0.00)   | -0.22<br>(0.28)   | -0.13<br>(0.23)   | -0.14<br>(0.11)   |  |  |
| Constant   | 0.02***<br>(0.01) | 0.02***<br>(0.01) | 0.01***<br>(0.00) | 1.65***<br>(0.13) | 1.66***<br>(0.08) | 1.74***<br>(0.02) |  |  |
| Observations                                       | 1,208,625         | 1,190,379         | 909,065           | 772,302           | 757,500           | 715,333           |  |  |
| Adjusted R-Squared                                 | 0.20              | 0.25              | 0.97              | 0.21              | 0.35              | 0.62              |  |  |
| Mean Dep. Variable                                 | 0.02              | 0.02              | 0.01              | 1.62              | 1.65              | 1.72              |  |  |
| Fixed Effects:                                     |                   |                   |                   |                   |                   |                   |  |  |
| $Product \times Day$                               | Yes               |                   |                   | Yes               |                   |                   |  |  |
| $Product \times Borrower \times Day$               |                   | Yes               |                   |                   | Yes               |                   |  |  |
| $Product \times Borrower \times Day \times Lender$ |                   |                   | Yes               |                   |                   | Yes               |  |  |

## Reversion rate

| Dependent Variable:                                | Reversion Rate (%) |                   |                   |                   |                   |                   |  |  |
|--|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--|--|
| Segment:   |                    | Owner-occupie     | ł ·               | Investor          |                   |                   |  |  |
|  | (1)                | (2)               | (3)               | (4)               | (5)               | (6)               |  |  |
| Green  | 0.07<br>(0.14)     | 0.14<br>(0.10)    | -0.00<br>(0.00)   | -0.00<br>(0.15)   | 0.06<br>(0.13)    | -0.02*<br>(0.01)  |  |  |
| Constant   | 6.89***<br>(0.10)  | 6.88***<br>(0.08) | 6.94***<br>(0.00) | 7.55***<br>(0.10) | 7.55***<br>(0.09) | 7.59***<br>(0.00) |  |  |
| Observations                                       | 2,662,324          | 2,638,494         | 2,428,978         | 1,071,034         | 1,060,557         | 998,881           |  |  |
| Adjusted R-Squared                                 | 0.74               | 0.78              | 0.99              | 0.64              | 0.73              | 0.98              |  |  |
| Mean Dep. Variable                                 | 6.90               | 6.90              | 6.94              | 7.55              | 7.56              | 7.59              |  |  |
| Fixed Effects:                                     |                    |                   |                   |                   |                   |                   |  |  |
| $Product \times Day$                               | Yes                |                   |                   | Yes               |                   |                   |  |  |
| $Product \times Borrower \times Day$               |                    | Yes               |                   |                   | Yes               |                   |  |  |
| $Product \times Borrower \times Day \times Lender$ |                    |                   | Yes               |                   |                   | Yes               |  |  |



## Interaction between stated benefits and contractual features

|  |                  |                   | Owner-occupied Segment |               |                    |
|--|------------------|-------------------|------------------------|---------------|--------------------|
| Dependent Variable:                                | Initial Rate (%) | Cashback (Binary) | Cashback amount (£)    | Flat fees (£) | Reversion Rate (%) |
|  | (1)              | (2)               | (3)                    | (4)           | (5)                |
| Green × Stated Benefit: Cashback                   | -0.01            | 0.66***           | 281.50***              | -23.66        | -0.00              |
|  | (0.00)           | (0.14)            | (29.16)                | (26.37)       | (0.00)             |
| Green × Stated Benefit: Preferential Rate          | -0.20***         | -0.12             | -119.11                | 116.08*       | -0.00*             |
|  | (0.06)           | (0.11)            | (94.06)                | (65.89)       | (0.00)             |
| Green × Stated Benefit: Both                       | 0.05             | 0.15              | 34.31                  | 87.05         | -0.00*             |
|  | (0.13)           | (0.14)            | (40.06)                | (170.35)      | (0.00)             |
| Constant   | 5.52***          | 0.30***           | 132.93***              | 611.77***     | 6.94***            |
|  | (0.00)           | (0.01)            | (3.73)                 | (3.95)        | (0.00)             |
| Observations                                       | 2,555,156        | 2,555,156         | 2,555,136              | 2,531,765     | 2,428,942          |
| Adjusted R-Squared                                 | 0.95             | 0.65              | 0.66                   | 0.22          | 0.99               |
| Mean Dep. Variable                                 | 5.51             | 0.35              | 152.95                 | 615.25        | 6.94               |
| Fixed Effects:                                     |                  |                   |                        |               |                    |
| $Product \times Borrower \times Day \times Lender$ | Yes              | Yes               | Yes                    | Yes           | Yes                |

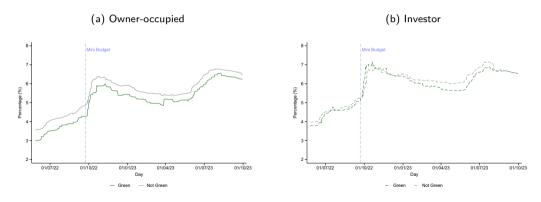


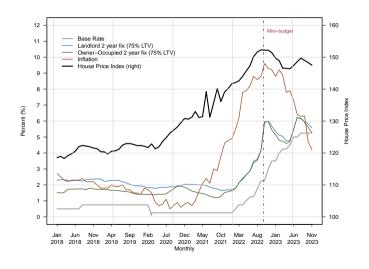
## Cash-flow channel: Energy prices

#### ► Weekly gas price

|  |                        |                        | Owner-occ              | cupied Segment           |                          |                         |  |  |  |  |  |  |
|--|------------------------|------------------------|------------------------|--------------------------|--------------------------|-------------------------|--|--|--|--|--|--|
| Dependent Variable:                                |                        | Initial Rate (%)       | )                      | Cashback amount (£)      |                          |                         |  |  |  |  |  |  |
|  | (1)                    | (2)                    | (3)                    | (4)                      | (5)                      | (6)                     |  |  |  |  |  |  |
| Green  | -0.0786***<br>(0.0112) | -0.0748***<br>(0.0118) | -0.0733***<br>(0.0126) | 279.6319***<br>(30.1707) | 279.8198***<br>(30.7353) | 278.9698**<br>(30.6376) |  |  |  |  |  |  |
| Green × Weekly Gas Price                           | -0.0001<br>(0.0001)    |                        |                        | -0.3165<br>(0.2267)      |                          |                         |  |  |  |  |  |  |
| Green × Weekly Gas Price (2-Weeks Lead)            |                        | -0.0001<br>(0.0001)    |                        |                          | -0.3209<br>(0.2325)      |                         |  |  |  |  |  |  |
| Green × Weekly Gas Price (4-Weeks Lead)            |                        |                        | -0.0001<br>(0.0001)    |                          |                          | -0.3212<br>(0.2346)     |  |  |  |  |  |  |
| Constant   | 5.5565***<br>(0.0020)  | 5.5565***<br>(0.0021)  | 5.5565***<br>(0.0021)  | 135.1797***<br>(4.3574)  | 135.1816***<br>(4.3569)  | 135.1845**<br>(4.3629)  |  |  |  |  |  |  |
| Observations<br>Adjusted R-Squared                 | 2,344,562<br>0.95      | 2,344,562<br>0.95      | 2,344,562<br>0.95      | 2,469,236<br>0.67        | 2,469,236<br>0.67        | 2,469,236<br>0.67       |  |  |  |  |  |  |
| Mean Dep. Variable                                 | 5.55                   | 5.55                   | 5.55                   | 157.48                   | 157.48                   | 157.48                  |  |  |  |  |  |  |
| Fixed Effects:                                     |                        |                        |                        |                          |                          |                         |  |  |  |  |  |  |
| $Product \times Borrower \times Day \times Lender$ | Yes                    | Yes                    | Yes                    | Yes                      | Yes                      | Yes                     |  |  |  |  |  |  |

#### Average Initial Interest Rate

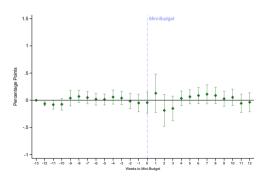




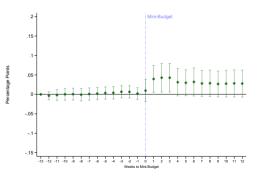
3-month window around the mini-budget announcement — Owner-occupied

Initial Rate<sub>ijblt</sub> = 
$$\alpha + \beta \cdot \text{Green}_i + \sum_{t=1}^{I} \theta_t \cdot \mathbb{1}(t) \cdot \text{Green}_i + \lambda_{jblt} + \varepsilon_{ijblt}$$
 (2)

(a) Product  $\times$  Borrower  $\times$  Week



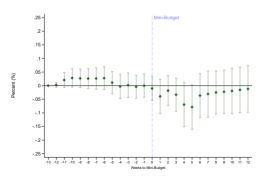
(b) Lender  $\times$  Product  $\times$  Borrower  $\times$  Week



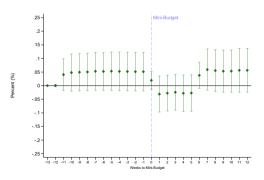
► 3-month window around the mini-budget announcement — Owner-occupied

$$\mathsf{Cashback}_{ijblt} = \alpha + \beta \cdot \mathsf{Green}_i + \sum_{t=1}^{T} \theta_t \cdot \mathbb{1}(t) \cdot \mathsf{Green}_i + \lambda_{jblt} + \varepsilon_{ijblt} \tag{2}$$

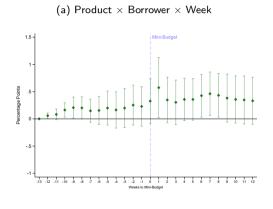
(a) Product  $\times$  Borrower  $\times$  Week



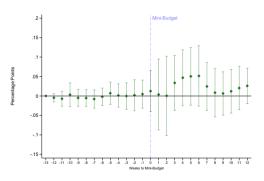
(b) Lender  $\times$  Product  $\times$  Borrower  $\times$  Week



# Cash-flow channel: Mini-budget announcement Investor Market

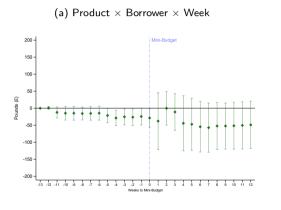




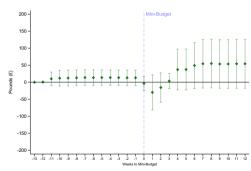




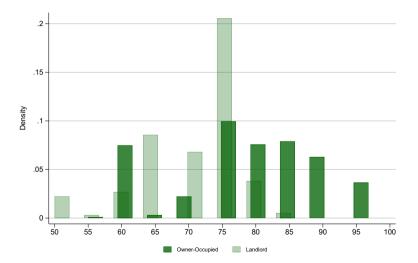
## Cashback amount





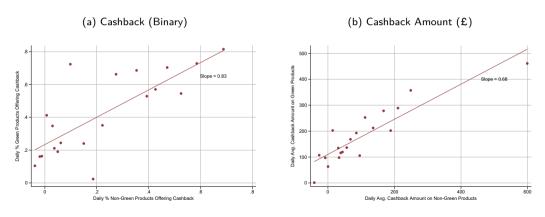


# Distribution of maximum LTV for green products



## Cashback as acquisition strategy

- Lenders offering cashback on non-green products are also likely to do so for green products
- ▶ Suggests cashback on green mortgage is part of a broader customer acquisition strategy



## Market characteristics by EPC rating

#### Data from:

- ► Energy Performance Certificates (EPC): universe of certificates issued
- ► Land Registry Price Paid: universe of properties transacted

|   | EPC Rating: |            |            |            |            |            |            |  |  |
|---|-------------|------------|------------|------------|------------|------------|------------|--|--|
|   | A           | В          | С          | D          | E          | F          | G          |  |  |
| EPC Data (Full Sample):   |             |            |            |            |            |            |            |  |  |
| Nr. of Certificates   | 89,822      | 3,142,365  | 8,156,028  | 9,728,846  | 3,742,943  | 929,358    | 279,740    |  |  |
| Property Construction Year  | 2,006       | 2,005      | 1,971      | 1,950      | 1,938      | 1,930      | 1,923      |  |  |
| New Build   | 0.76        | 0.75       | 0.07       | 0.01       | 0.01       | 0.01       | 0.01       |  |  |
| Owner-Occupied (Binary)   | 0.69        | 0.58       | 0.44       | 0.60       | 0.66       | 0.71       | 0.71       |  |  |
| Total Floor Area  | 114.43      | 86.65      | 77.76      | 87.45      | 97.19      | 107.79     | 102.12     |  |  |
| Index of Multiple Deprivation Rank (1 is most deprived)             | 17,254.06   | 16,206.48  | 14,258.47  | 15,444.79  | 15,752.64  | 16,024.52  | 14,535.48  |  |  |
| Price Paid - EPC Merged Data (Sample Period):                       |             |            |            |            |            |            |            |  |  |
| Nr. of Transactions   | 6,056       | 227,756    | 337,014    | 436,762    | 122,087    | 20,685     | 6,703      |  |  |
| Property Construction Year  | 2,016       | 2,017      | 1,973      | 1,948      | 1,936      | 1,930      | 1,923      |  |  |
| Transaction Price   | 495,629.43  | 403,728.54 | 349,682.18 | 366,000.54 | 408,149.53 | 452,617.84 | 406,759.75 |  |  |
| New Build   | 0.56        | 0.57       | 0.02       | 0.00       | 0.00       | 0.00       | 0.00       |  |  |
| Total Floor Area  | 124.63      | 96.99      | 90.43      | 94.11      | 103.29     | 114.70     | 107.60     |  |  |
| Index of Multiple Deprivation (IMD) Rank (where 1 is most deprived) | 19,830.64   | 18,481.05  | 17,413.28  | 17,248.42  | 17,021.85  | 17,231.68  | 15,377.52  |  |  |



## Help to Buy schemes: Shared Ownership and Shared Equity

#### Shared Ownership

- $\star$  Buy a portion of the property (e.g., 25%) and pay rent on the rest
- \* Example: £200,000 home
  - $\circ$  Buy 25% share = £50,000
  - $\circ$  10% deposit = £5,000; mortgage = £45,000
  - $\circ~$  Pay rent on remaining £150,000 share
  - O → Source

#### Shared Equity

- \* Buy with a small deposit; government or provider offers a loan for part of the price
- \* Example: £200,000 home
  - $\circ$  5% deposit = £10,000
  - 75% mortgage = £150,000
  - o 20% equity loan = £40,000
  - Buyer fully owns the property
  - Source



## Distribution of Share of Green Bond Issuance

