The Simpler the Better? Threshold Effects of Energy Labels on Property Prices and Energy Efficiency Investments

By Rodolfo Sejas-Portillo, Mirko Moro, and Till Stowasser

Group 18
GALASSI Damiano
GLUD Elizabeth
MJAKI Natyra
HU Mengxi

REPLICATION

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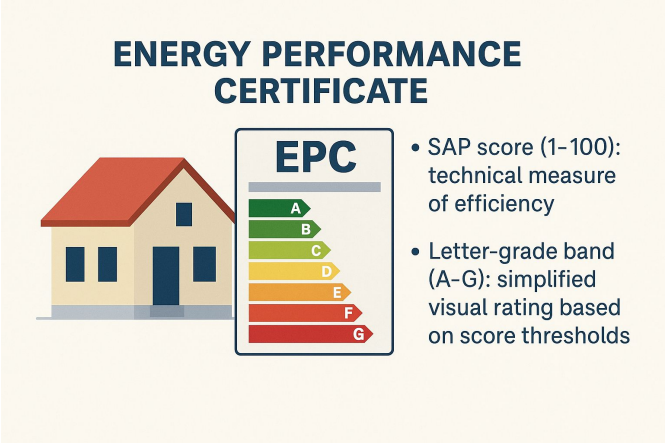
Introduction

Context and Motivation

- Energy efficiency is central to climate policy
- In the UK, all homes for sale or rent must have an Energy Performance Certificate (EPC)
- The EPC includes:
  - A SAP score (1–100), where higher means better efficiency
  - A letter-grade (A–G) based on fixed thresholds
- Simplified labels help consumers, but can also mislead through attention bias and heuristic reasoning



Introduction

- **Research Questions:**
  - Do EPC rating thresholds generate discrete jumps in housing prices, independent of true energy efficiency?
  - Do sellers invest more when their home is just below a threshold?

- **Contribution to the literature:**
  - Threshold effects on prices and investments
  - Attention bias and heuristic behavior
  - Strategic upgrades by sellers
  - Policy design implications

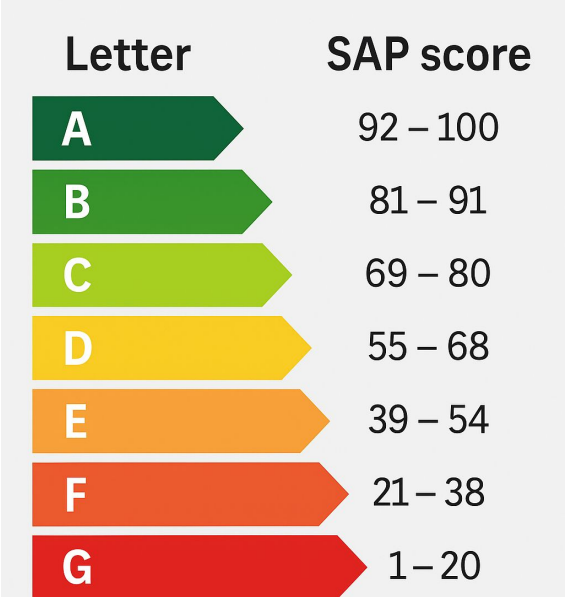
Methodology

Data and Sample

- Administrative dataset: 7+ million residential transactions (England & Wales, 2012–2022)
- Merged from:
  - Land Registry: prices, location, property features
  - EPC Register: SAP score and letter band
  - Urban–rural classification
- Focus on sales after July 2012 (EPC made mandatory in ads).
- Subsample of ~161,000 homes with two EPCs used for investment analysis.

Methodology

- Method: **Regression Discontinuity Design** (RDD)
  - Running variable: SAP score
  - Treatment: crossing EPC threshold (e.g. 54 → 55)
  - Outcome: change in price & EE investment probability
- **Causal inference:** comparing similar homes around the cutoff
- **Estimation:** local linear regressions, optimal bandwidths
- **Robustness checks:**
  - Strategic upgrade exclusion
  - Covariate balance
  - Placebo thresholds
  - Donut hole
  - IV using initial SAP score



Empirical Strategy

Baseline local linear RDD model adjusted for covariates (Table 3) :

$$P_{igt} = \alpha + \tau T_{igt} + \beta\_SAP_{igt} + \beta_{+} T_{igt} \times SAP_{igt} + \mathbf{X}'_{igt}\boldsymbol{\gamma} + \kappa_g + \lambda_t + \varepsilon_{igt},$$

where τ captures the **percentage jump** in price exactly at the band threshold.

Baseline RDD Linear Probability Model adjusted for covariates (Table 4) :

$$I_{igt} = \alpha + \tau T_{igt} + \beta\_SAP^0_{igt} + \beta_{+} T_{igt} \times SAP^0_{igt} + \mathbf{X}'_{igt}\boldsymbol{\gamma} + \kappa_g + \lambda_t + \varepsilon_{igt}.$$

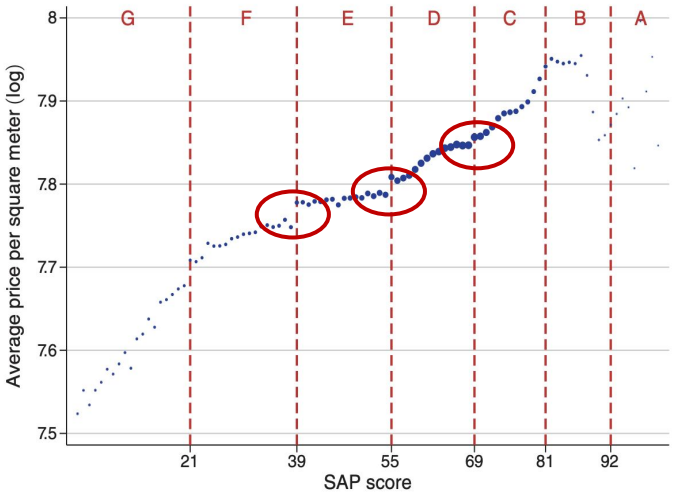
where τ measures the **discontinuous change** in retrofit probability at the cutoff.

Main Results: Threshold Effects on Property Prices

Table 3—Local Linear RDD Estimates for Price Discontinuities

	(1)	(6)
[F–E]		
τ	0.029***	0.007***
Robust SE	(0.003)	(0.001)
Effective N	113,639|245,331	88,883|187,296
[E–D]		
τ	0.019***	0.011***
Robust SE	(0.002)	(0.001)
Effective N	404,837|740,804	404,572|740,328
[D–C]		
τ	0.009***	0.004***
Robust SE	(0.001)	(0.000)
Effective N	886,646|964,063	886,028|963,158

Figure 3. Price per Square Meter (log) by SAP Score



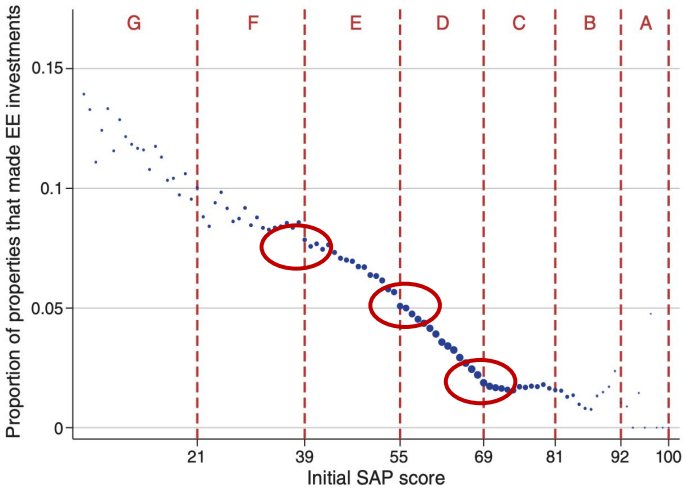
Threshold effect of **2.9%** ≈ Average price increase of **£8,500**
(for a 102m² property priced at £2,890/m²)

Main Results: Threshold Effects on EE Investment

Table 4—Local Linear RDD Estimates for Discontinuities in EE-Investment Probabilities

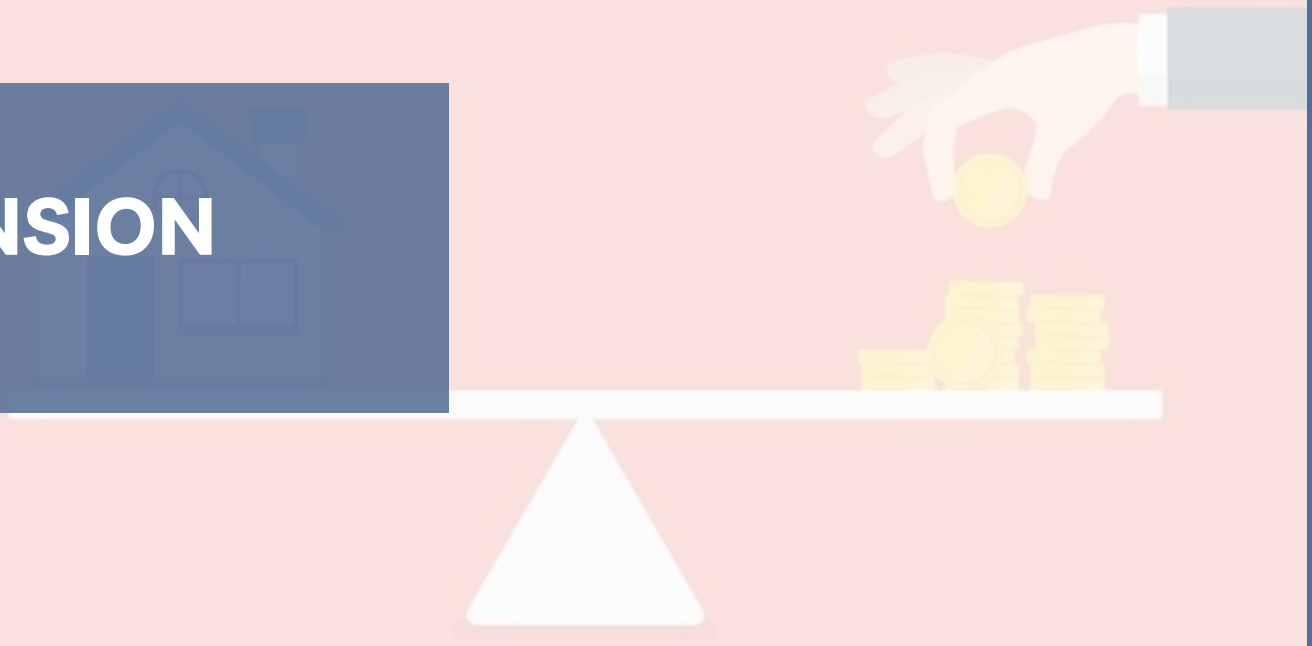
	(1)	(6)
[F–E]		
τ	−0.008***	−0.008***
Robust SE	(0.001)	(0.001)
Effective N	79,049|156,927	62,081|119,802
[E–D]		
τ	−0.003***	−0.003***
Robust SE	(0.001)	(0.001)
Effective N	310,795|559,013	310,546|558,606
[D–C]		
τ	−0.001***	−0.001***
Robust SE	(0.000)	(0.000)
Effective N	908,484|706,590	762,101|648,402

Figure 6. Proportion of Properties That Received EE Investments by SAP Score—Sales before April 2018



Threshold effect of **-0.8%** ≈ A relative **reduction of 19.5%** in upgrade likelihood
(4.1% of properties in the sample carry out EE upgrades)

EXTENSION



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Motivation & Research Question

Main Findings:

- **Significant price discontinuities** at band thresholds suggesting inattention to the SAP rating
- Sellers are **more likely to make an EE investment** if they are right below a threshold

The Gap:

There are **no evidences against strategical minimal upgrades** («minimum investment needed to jump over the next band»)

*Do property owners **strategically** make minimal energy efficiency **investments** just sufficient **to cross** EPC rating band **thresholds and capture** potential price **premiums**?*

Hypothesis

Sellers whose **initial EPC score** is **just below a** rating band **threshold** are **more likely to make *an investment*** (confirmed by the authors' findings)

Sellers whose initial EPC score is just below a rating band threshold are **more likely to make an investment that just crosses the threshold**, rather than exceeding it by a large margin (i.e., a **"strategic upgrade"**)

Specifically, the **closer a property's initial SAP score** is **to** a **threshold** from below, the **higher the probability of** observing a **"strategic upgrade"**

Data & Sample Overview

Source

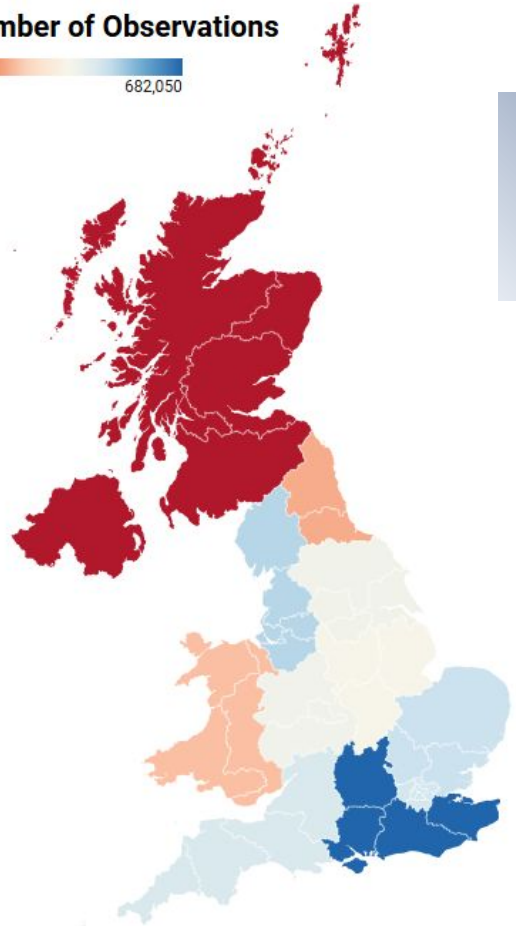
Same novel administrative dataset of UK property sale transactions as Sejas-Portillo et al. (~7M obs.)

Sample

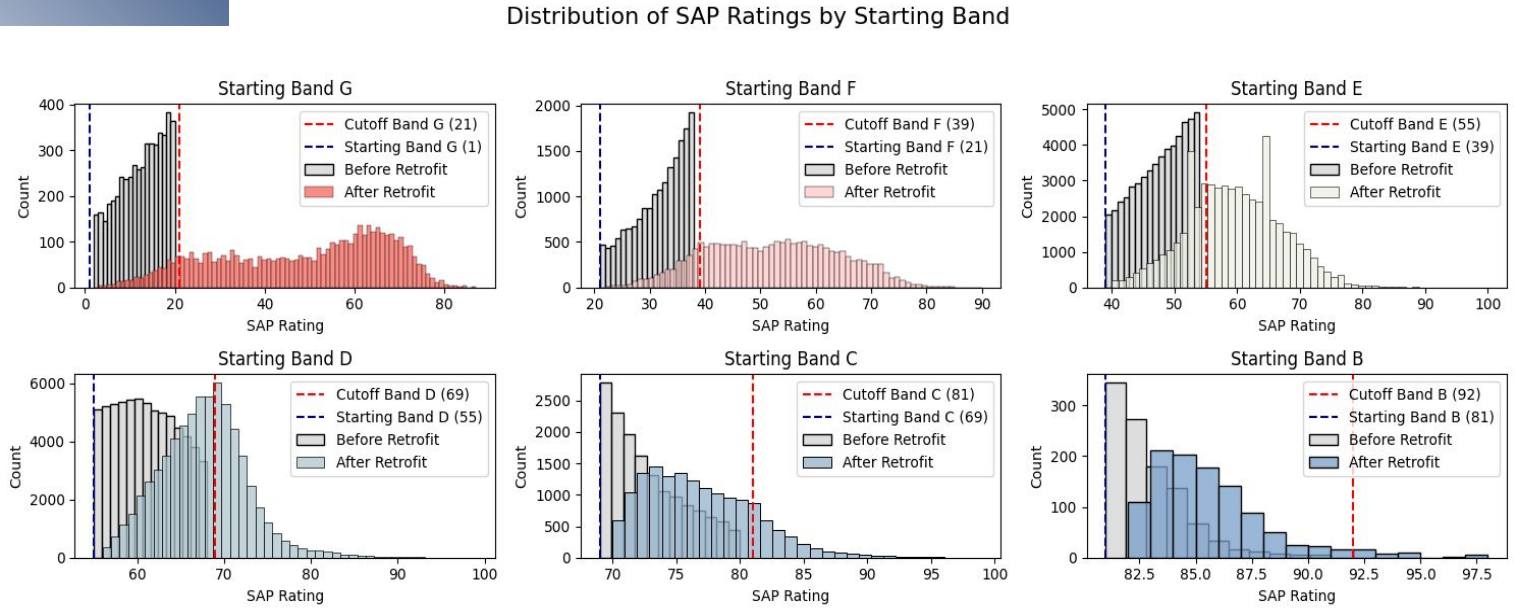
Properties that underwent pre-sale retrofitting and excluding transaction after Apr 2018 (due to policy changes)

Starting Variables

SAP (energy efficiency) score before and after retrofit, property characteristics (type, size, rooms), location (region, urban/rural) and sale date (year, month)



Descriptive Distributions I



Low starting band (G & F) tend to **overshoot** and invest aiming at jumping more than one band

Middle starting band (E & D) **retrofit** mostly to the **next SAP band**

High starting band (C & B) invest lightly. They **do not jump bands** (on average)

Running and Outcome Variables

What a «strategic upgrade» is ?

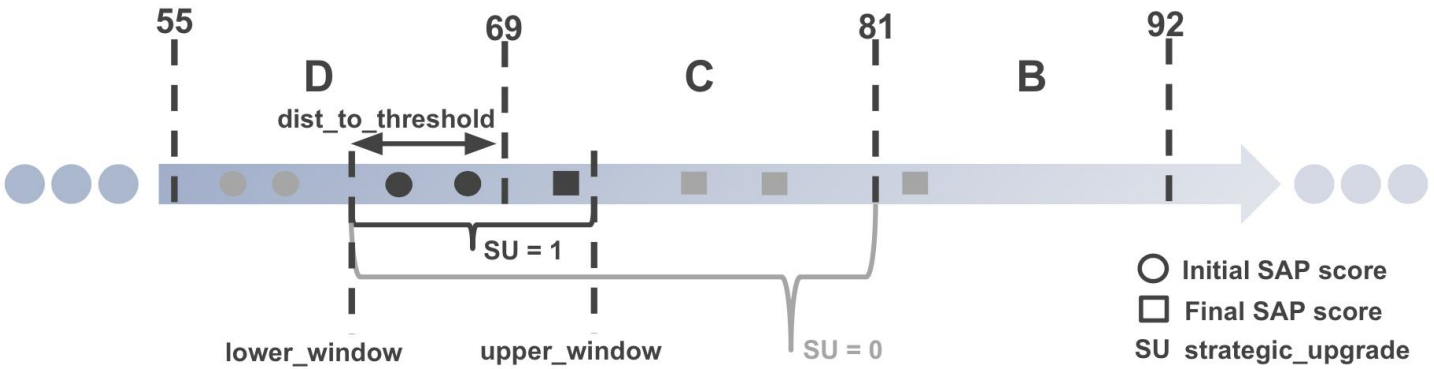
It is the **outcome variable** representing an energy efficiency investment improving the SAP score **just enough** to cross into the next EPC rating band

How is it identified?

It is binary variable: 1 If the property's initial SAP score is **just below** a threshold, and the final SAP score is **just above** it. 0 otherwise

What «distance to threshold» is?

It is the **running variable** measuring how many SAP points the initial score is below the next SAP rating band



Regression Framework

Estimate whether properties that start closer to an EPC threshold are more likely to *strategically upgrade*

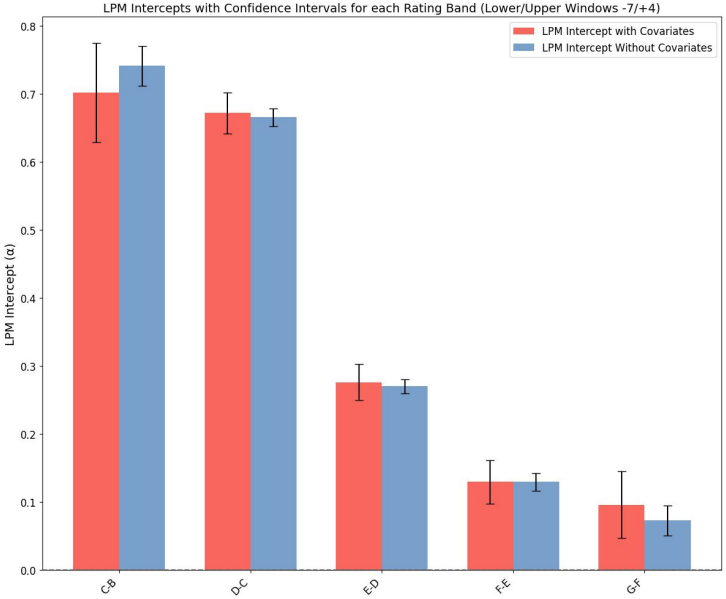
$$StrategicUpgrade_i = \alpha + \beta \cdot DistToThreshold_i + \gamma' X_i + \epsilon_i$$

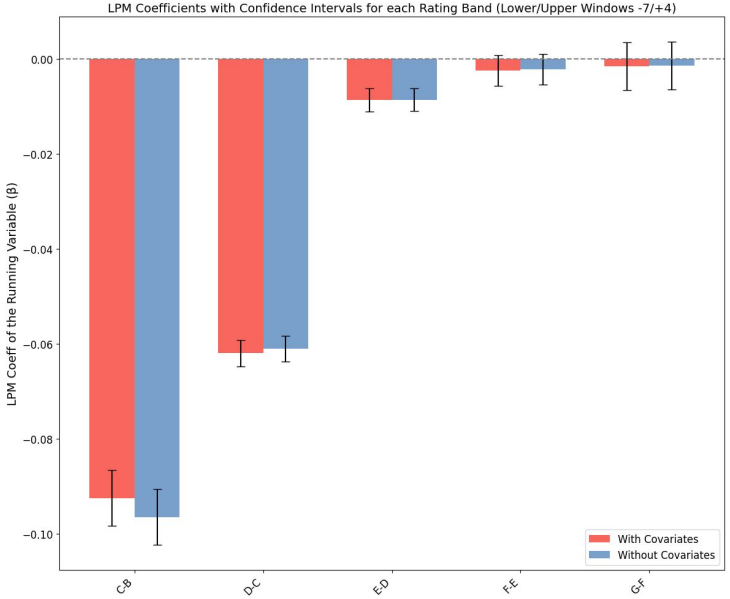
X_i: covariates (property type, region, sale date…)
ϵ_i: error term

Looping in each band including only observation starting 1 – k point below the threshold, ensuring focus on a local decision margin

*We predict a **β<0** → the closer the initial SAP score to the next cutoff the higher the chance of a strategic upgrade*

Effect of Proximity to Threshold on Strategic Upgrades





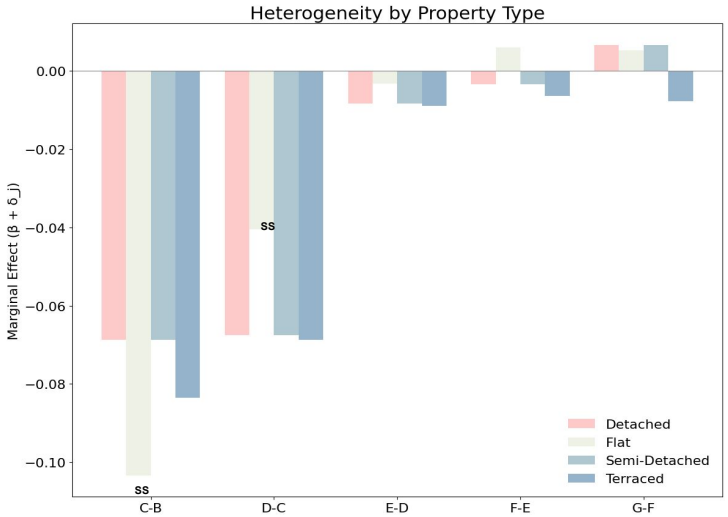
β □ Estimated effect of being 1 SAP point closer to the threshold on the probability of upgrading strategically
α □ Estimated probability of a strategic upgrade at cutoff
C-B & D-C □ Strong and significant results (1-point reduction in dist_to_threshold increases the change of strategic_upgrade by 6-9%
F-E & G-F □ Weak results, mostly because of the higher jumps not captured by our sliding window

B – A exluded due to low no. obs

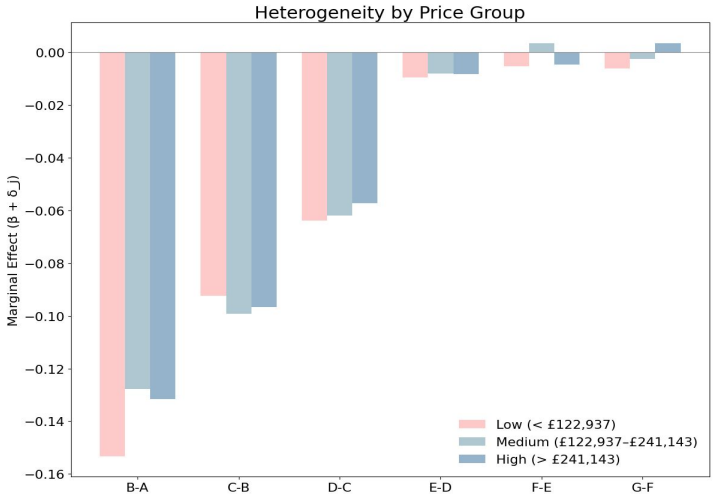
Heterogeneity Analysis

$$StrategicUpgrade_i = \alpha + \beta \cdot DistToThreshold_i + \sum_j \delta_j \cdot DistToThreshold_i \times \mathbf{1}[Interacted_i = j] + \gamma' X_i + \epsilon_i$$

$$Interacted_i = PropertyType_i \text{ or } PriceGroup_i$$



Flats are more likely to be strategically retrofit in band C-B and less in D-C. The other resutls are non-significant at 95% CI.



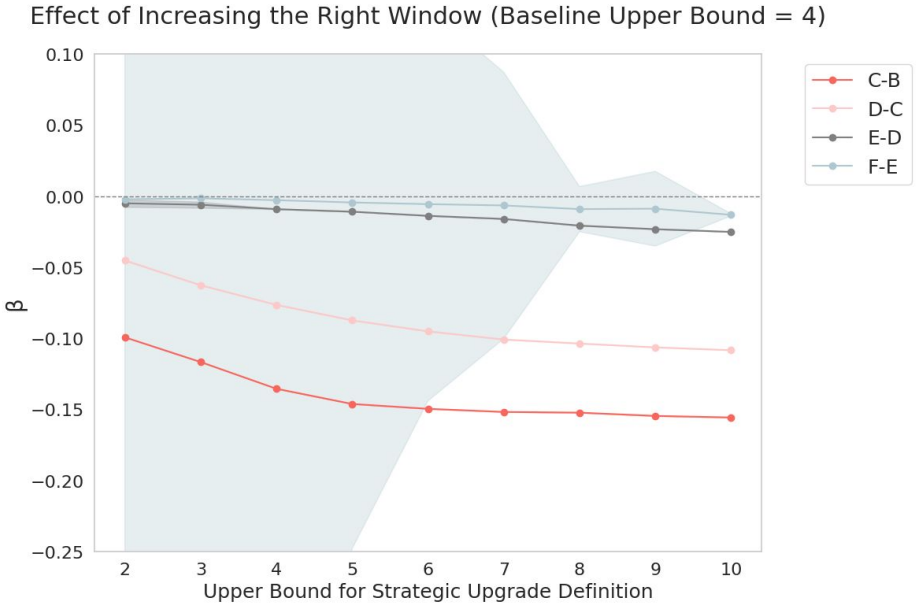
Property prices do not present statistically significnat heterogeneities.

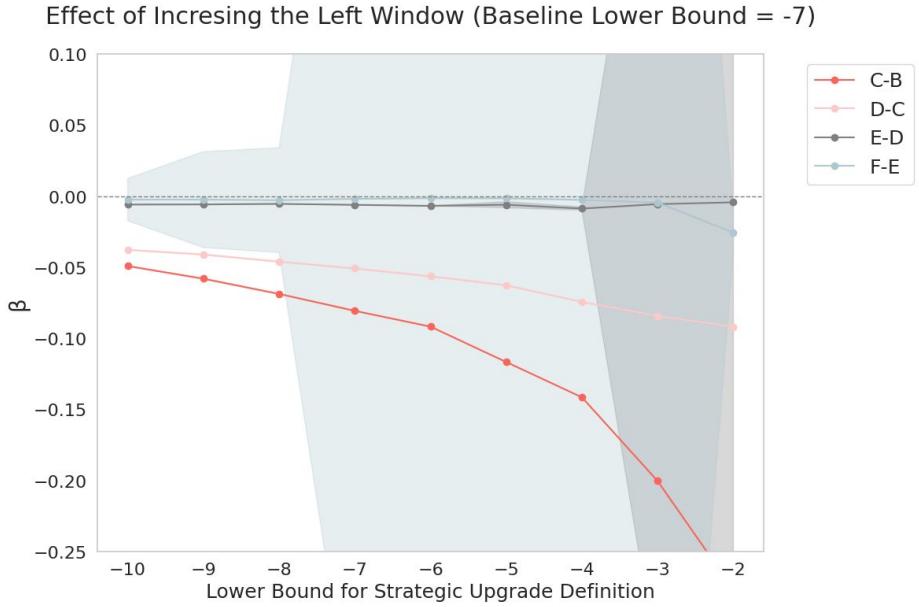
*Price groups defined as tertiles of log_price
** SS indicates statistically significant bars

Sensitivity Analysis

What happens when we widen what counts as a “just above threshold” retrofit?

How far below the next threshold does a property need to start to matter?





Conclusion

Key Findings

Sellers closer to the threshold are more likely to retrofit just to cross the next band ($\beta < 0$)

There is no storng evidence of heterogeneity amount the tested regressors

Widening the «strategic interval» reduces the effect, mosly when shifiting towars properties starting far from the next cutoff

Driver Mechanism

Buyers focus on letter bands hihgligting partial inattention

Sellers target cheap and mimimal upgrades hoping to «fool» the buyers

EPCs do not just inform market partecipans but shape their behaviour, specially closer to cut off points

Policy Implications

Focus on defining a more granular bands to minimize partial inattention

Be aware of superficial compliance as the absence of long-term energy savings and deep retrofit harms optimal environmental outcome

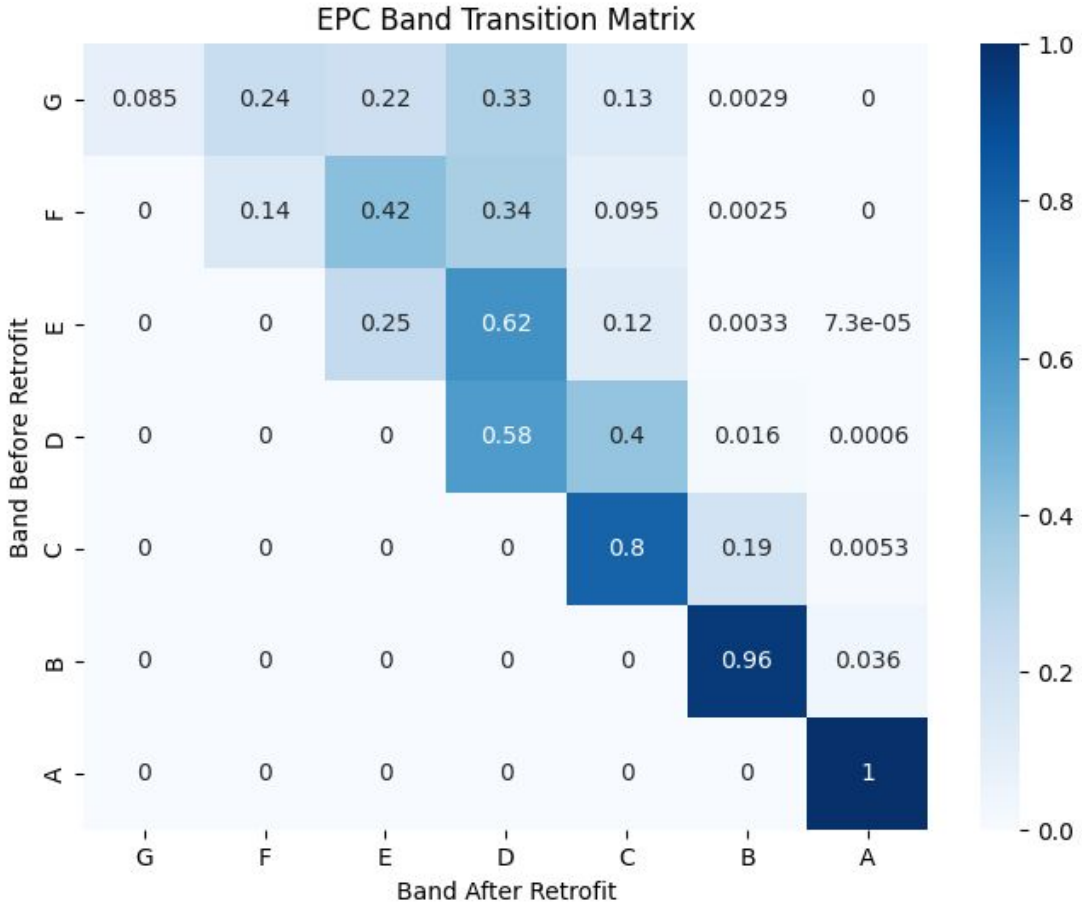
Introduce SAP progress bars or upgrade potential indicators to reduce the market “cutoff obsession” encouraging holistic improvements

ANY QUESTIONS ?

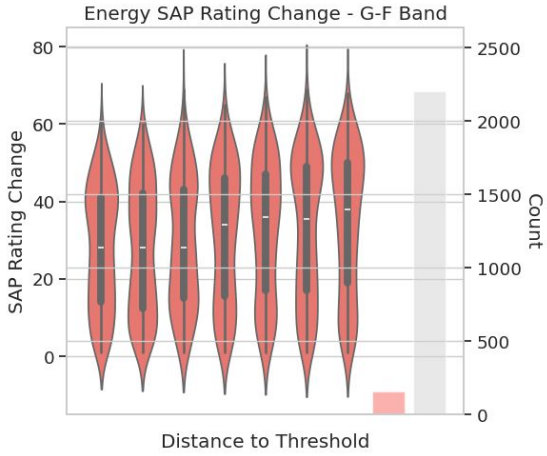
Thank you for your attention. We would appreciate clarifying your doubts and curiosities

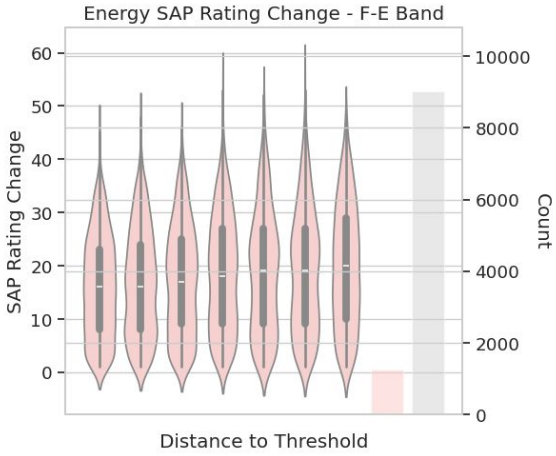
BACK UP SLIDES …

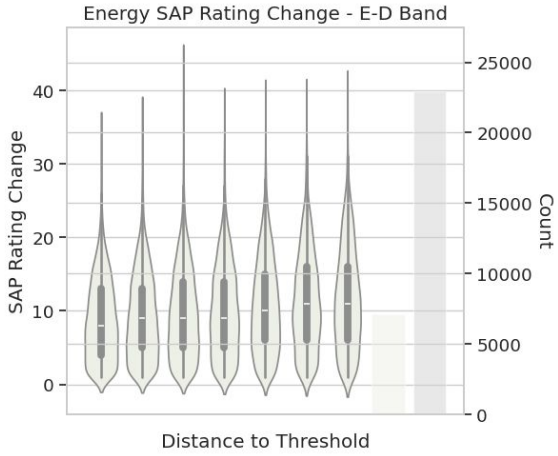
Why G-F and F-E have negligible results...?

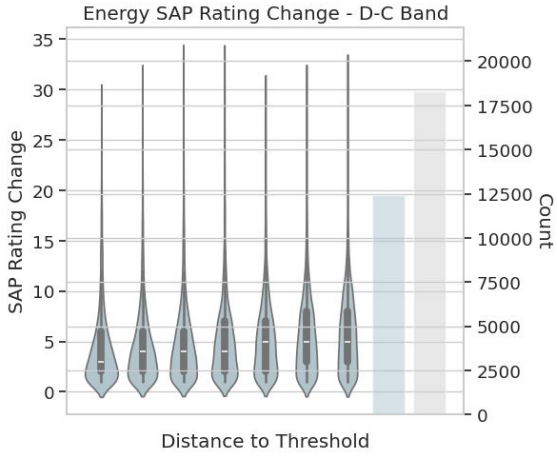


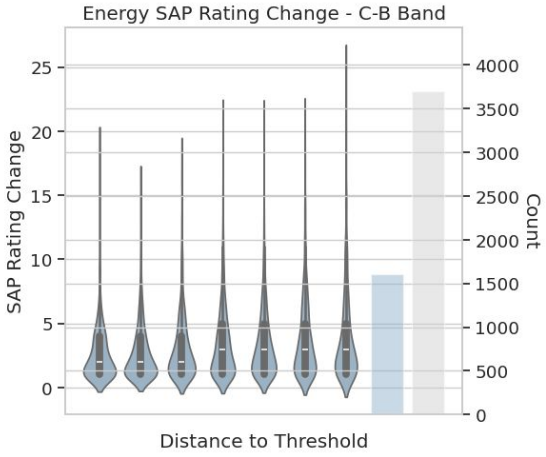
More distributions :)

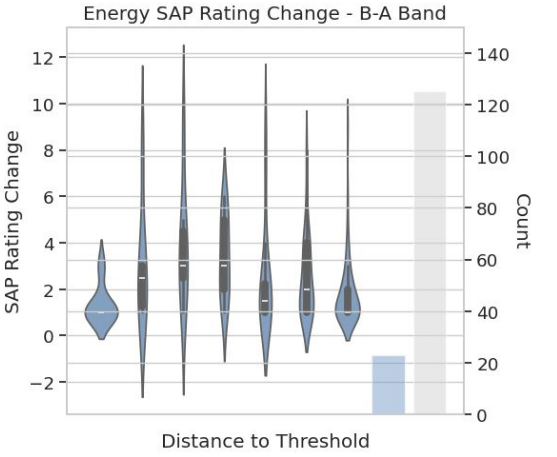












LPM/Logit Base Results

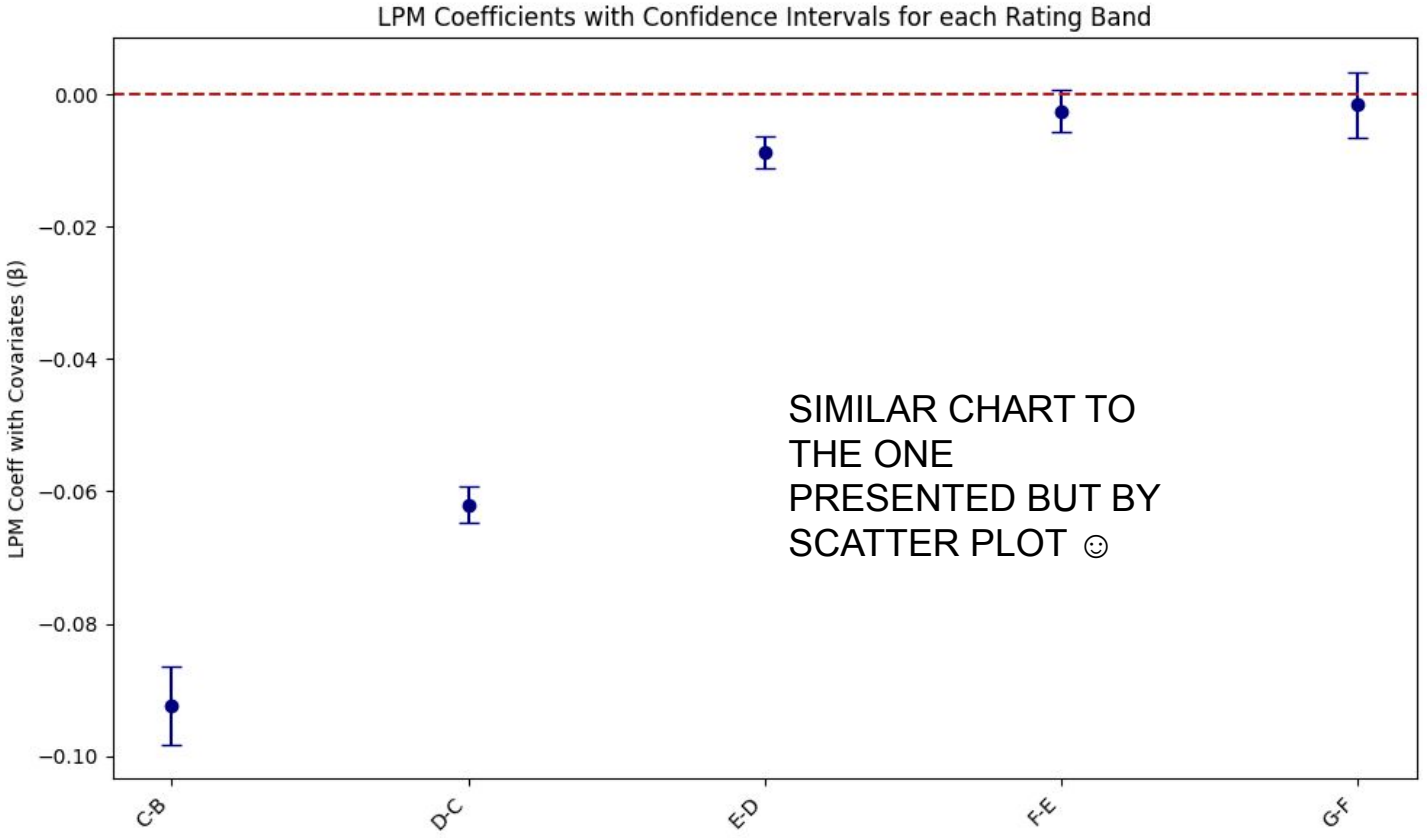
	Band	N_obs	Class_Share	LPM_coef	LPM_pval	Logit_coef (logodds)	Logit_coef (odds)	Logit_pval	LPM_lower_ci	LPM_upper_ci
5	B-A	148	0.155405	-0.136335	2.252289e-18	-1.032883	0.355979	2.509209e-08	-0.163159	-0.109511
4	C-B	5300	0.303208	-0.096475	7.670924e-208	-0.494277	0.610012	2.566629e-166	-0.102350	-0.090601
3	D-C	30677	0.404342	-0.061085	0.000000e+00	-0.261578	0.769836	0.000000e+00	-0.063808	-0.058361
2	E-D	30039	0.237058	-0.008668	2.063676e-12	-0.048160	0.952981	2.183871e-12	-0.011084	-0.006252
1	F-E	10257	0.121381	-0.002284	1.622122e-01	-0.021507	0.978722	1.622509e-01	-0.005487	0.000919
0	G-F	2359	0.066978	-0.001528	5.516726e-01	-0.024513	0.975785	5.515702e-01	-0.006561	0.003505

LPM with Covariates Results

	Band	N_obs	Class_Share	LPM_coef_cov	LPM_pval_cov	LPM_lower_ci_cov	LPM_upper_ci_cov
5	B-A	147	0.149660	-0.144395	4.708053e-16	-0.175215	-0.113575
4	C-B	5255	0.302569	-0.092474	3.166049e-190	-0.098384	-0.086565
3	D-C	30644	0.404484	-0.062024	0.000000e+00	-0.064748	-0.059301
2	E-D	30025	0.237102	-0.008695	1.799099e-12	-0.011112	-0.006278
1	F-E	10244	0.121535	-0.002524	1.237144e-01	-0.005738	0.000690
0	G-F	2356	0.067063	-0.001579	5.394356e-01	-0.006623	0.003465

```
# === LPM ===
formula = """
    strategic_upgrade ~ dist_to_threshold + leasehold +
    total_floor_area + number_habitable_rooms + urban +
    C(region) + sale_year + sale_quarter + C(property_type)
"""
```

LPM with Covariates Results



Het Anal on property type

	Band	N_obs	Class_Share	LPM_coef_cov	LPM_pval_cov	dist_to_threshold:C(property_type)[T.Flat]_coef	dist_to_threshold:C(property_type)[T.Flat]_pval
5	B-A	147	0.149660	-0.112531	4.191119e-05	0.065637	1.785200e-01
4	C-B	5255	0.302569	-0.068805	1.758797e-17	-0.034556	1.054789e-04
3	D-C	30644	0.404484	-0.067478	1.183343e-113	0.027020	3.304629e-10
2	E-D	30025	0.237102	-0.008390	1.238195e-03	0.005143	2.633243e-01
1	F-E	10244	0.121535	-0.003326	2.691888e-01	0.009377	1.017407e-01
0	G-F	2356	0.067063	0.006625	1.680234e-01	-0.001281	8.772397e-01

dist_to_threshold:C(property_type)[T.Semi-detached]_coef	dist_to_threshold:C(property_type)[T.Semi-detached]_pval	dist_to_threshold:C(property_type)[T.Terraced]_coef	dist_to_threshold:C(property_type)[T.Terraced]_pval
-0.054999	0.210103	-0.027802	0.478864
0.004157	0.752775	-0.014687	0.184990
0.000266	0.946897	-0.001236	0.748768
-0.002430	0.473758	-0.000542	0.870650
0.003128	0.468916	-0.003064	0.465886
-0.012658	0.082652	-0.014293	0.027561

Het Anal on log_price

	Band	N_obs	Class_Share	dtt_coef_cov	dtt_pval_cov
5	B-A	147	0.149660	-0.153209	1.146198e-08
4	C-B	5255	0.302569	-0.092509	2.325254e-70
3	D-C	30644	0.404484	-0.063891	9.281777e-155
2	E-D	30025	0.237102	-0.009610	7.218192e-06
1	F-E	10244	0.121535	-0.005259	6.023754e-02
0	G-F	2356	0.067063	-0.006246	1.674930e-01

dist_to_threshold:C(price_group)[T.medium]_coef	dist_to_threshold:C(price_group)[T.medium]_pval	dist_to_threshold:C(price_group)[T.high]_coef	dist_to_threshold:C(price_group)[T.high]_pval
0.025533	0.436380	0.021521	0.548592
-0.006791	0.354977	-0.004098	0.577474
0.001829	0.591841	0.006556	0.053181
0.001558	0.607139	0.001357	0.652608
0.008630	0.031485	0.000564	0.887261
0.003762	0.549531	0.009579	0.133203

Robustness Analysis —— Sorting at the Thresholds

Table 5—Distribution Manipulation Tests for Sorting at the Thresholds

	Final SAP Score	Initial SAP Score	Remove presale investment
	(1)	(2)	(3)
[F–E]			
τ	−0.205***	−0.080***	−0.166***
Robust SE	(0.024)	(0.020)	(0.022)
Effective N	11|12	11|12	11|12
[E–D]			
τ	−0.069***	−0.030	−0.031
Robust SE	(0.028)	(0.030)	(0.032)
Effective N	14|15	14|15	14|15
[D–C]			
τ	0.053	-0.028	−0.003
Robust SE	(0.071)	(0.067)	(0.066)
Effective N	11|12	11|12	11|12

Robustness Analysis —— Sorting at the Thresholds

Table 6—Robustness Analyses for Sorting at the Thresholds

	Donut-hole		IV		Including rating band increases	
	(1)	(2)	(3)	(4)	(5)	(6)
[F–E]						
τ	0.012	0.003	0.033***	0.008***	0.028***	0.005***
Robust SE	(0.002)	(0.002)	(0.004)	(0.001)	(0.004)	(0.002)
Effective N	1,507,810	1,506,677	91,437|189,501	116,728|247,299	114,065|253,167	113,991|252,977
[E–D]						
τ	0.033	0.062	0.019***	0.011***	0.015***	0.008***
Robust SE	(0.014)	(0.021)	(0.001)	(0.001)	(0.002)	(0.001)
Effective N	4,249,542	4,246,691	284,670|554,628	284,484|554,280	408,939|772,189	408,673|771,704
[D–C]						
τ	0.190	0.147	0.008***	0.001***	0.007***	0.002***
Robust SE	(0.021)	(0.023)	(0.001)	(0.000)	(0.001)	(0.000)
Effective N	4,308,980	4,301,817	877,998|984,028	877,370|983,096	903,294|1,026,699	902,667|1,025,756

Robustness Analysis —— Covariate Balance Test

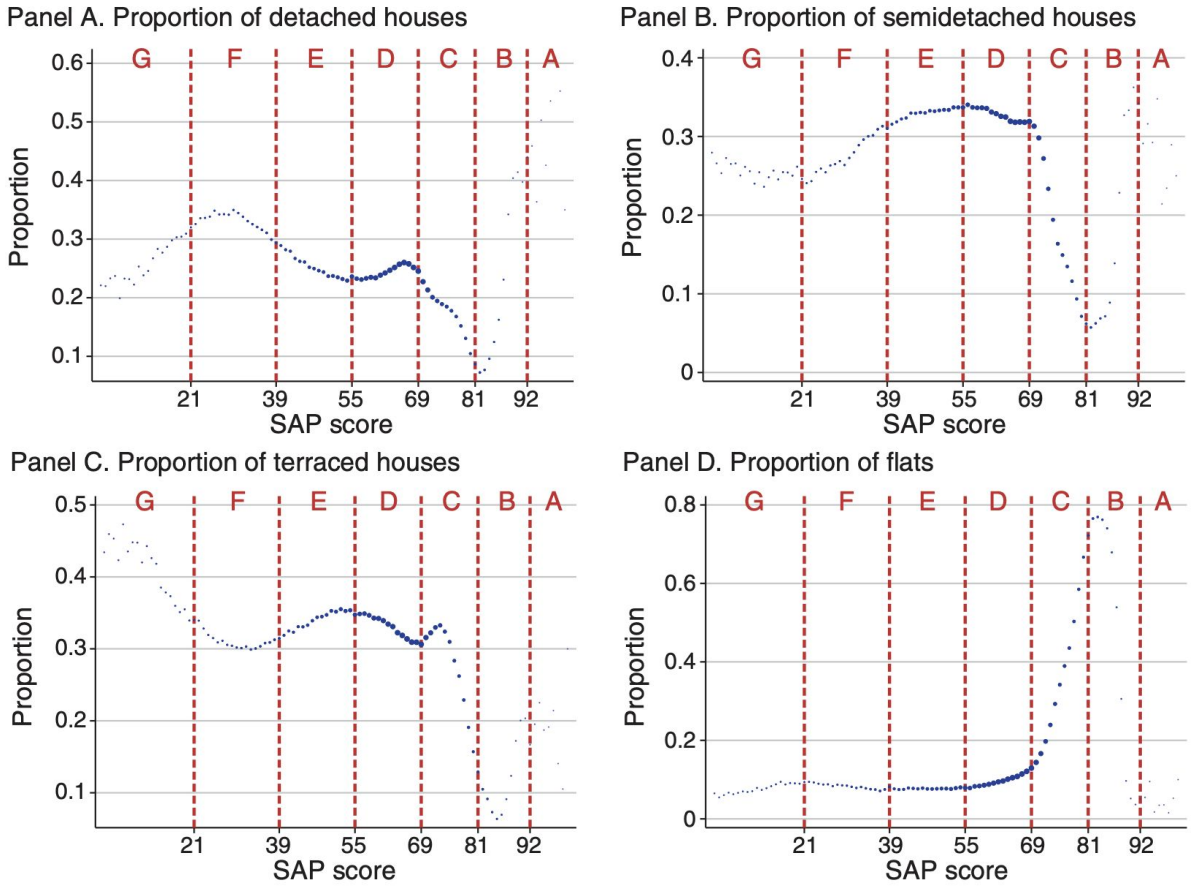


Figure 8. Covariate Balance Plots: Property Characteristics

Robustness Analysis —— Covariate Balance Test

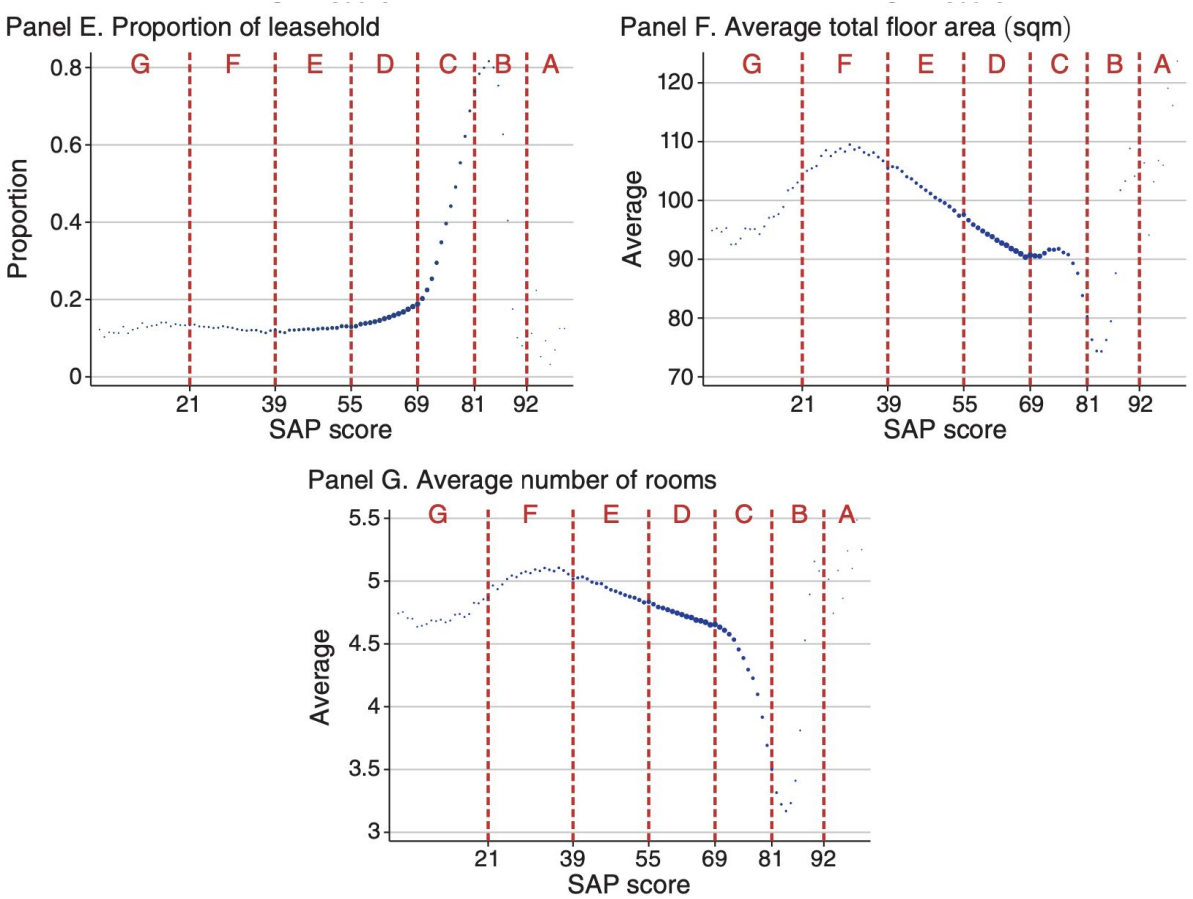


Figure 8. Covariate Balance Plots: Property Characteristics