



# Split Incentives in Energy Efficiency

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# Outline

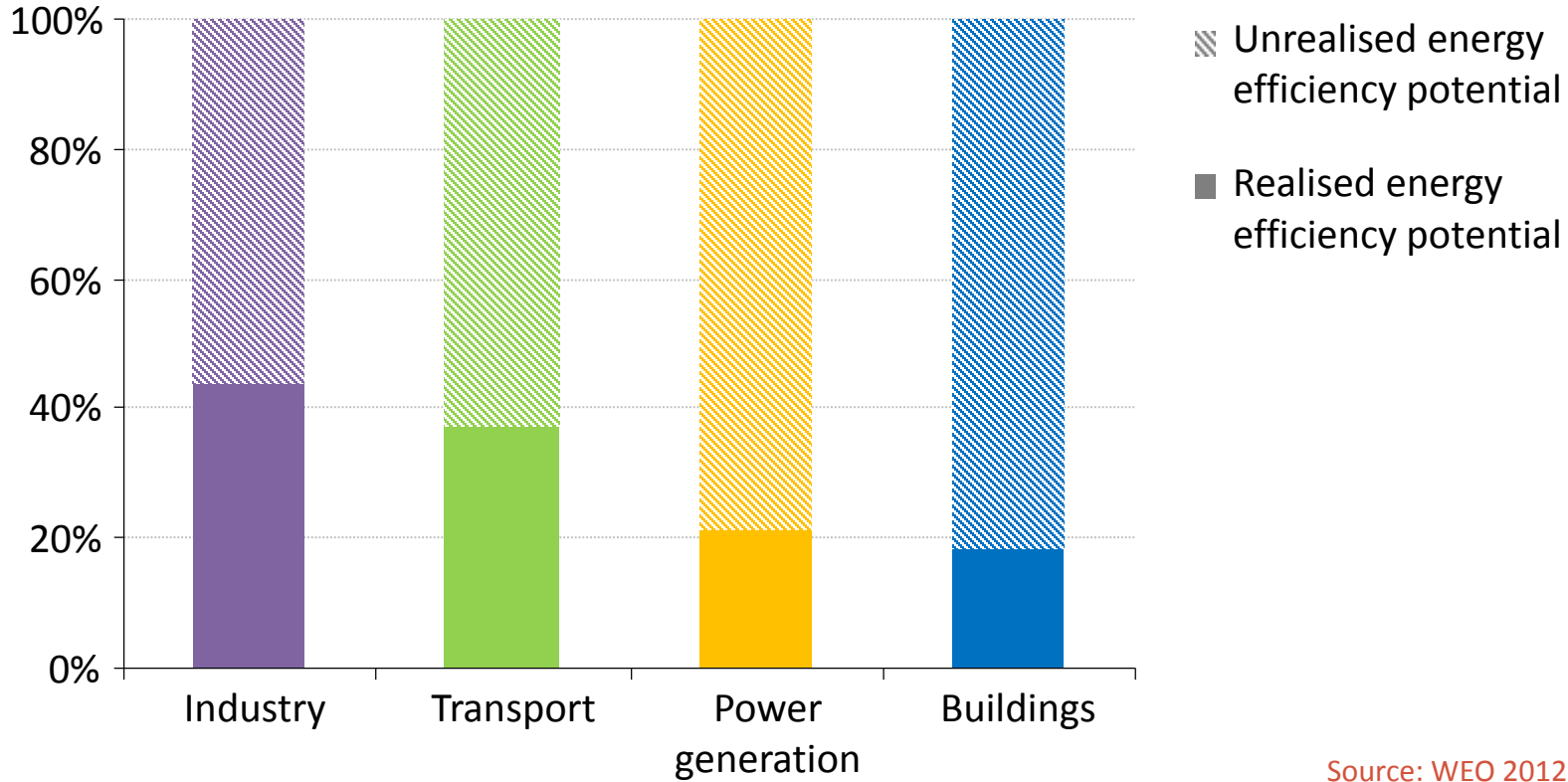
- Energy efficiency and split incentives
- Analysis of the Irish rental sector
  - Data
  - Methodology
  - Results
- Conclusions



# Energy efficiency – unrealised potential



Energy efficiency potential used by sector

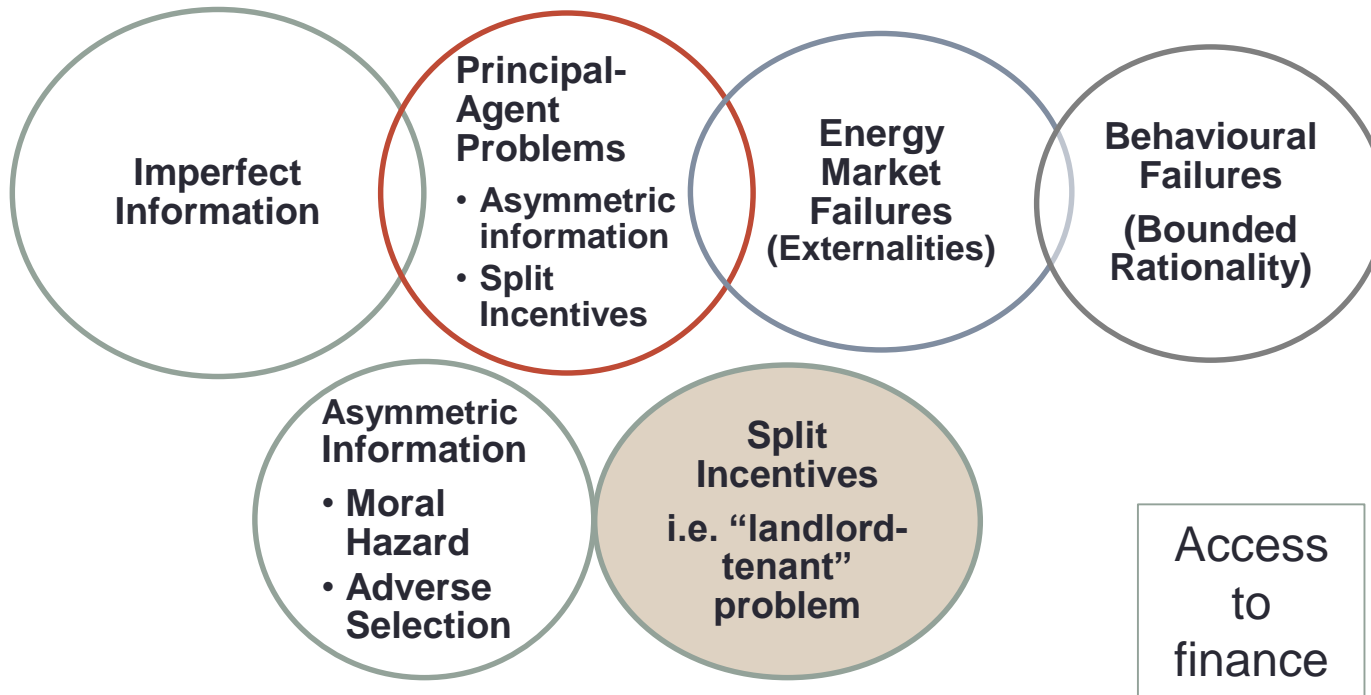


Source: WEO 2012

***Two-thirds of the economic potential to improve energy efficiency remains untapped in the period to 2035***

# The EE challenge – why so much untapped?

## Market failures in energy efficiency



**Prices**  
important for removing certain barriers, e.g. **negative externalities**

- Other market failures, i.e. informational failures and principal-agent problems, can prevent price signal from reaching consumers
- The person experiencing increased prices may not be the one making decisions on energy use (split incentives problem)

# What are Split Incentives?



- Split incentives: when participants in an economic exchange do not share the same goal (Charlier, D. 2014. Split Incentives and Energy Efficiency: Empirical Analysis and Policy Options Document de travail ART-Dev 2014-07. )

$$\text{Total cost} = \underbrace{K(E)}_{\text{Capital costs}} + \underbrace{O(E, PP_E) \times D(r, T)}_{\text{Operating costs}} + \text{other costs}$$

←—————→

Paid by different people

- Split incentives are an important barrier to reducing energy consumption in the residential sector (IEA, 2007).



# Split incentive in residential buildings: Landlord tenant energy use problem

- When the owner and the occupier of a housing unit are different people, a split in incentives occurs.
- Landlord wants to minimize the purchase cost of energy

## *Evidence from research*

- *Mind the Gap* (IEA, 2007): up to 30% energy savings potential untapped
- 2005 Residential Energy Consumption Survey (2005) in the US: renters significantly less likely to have energy-efficient refrigerators, clothes washers and dishwashers than homeowners; controlling for income, demographics, energy prices, weather and other controls
- Gillingham et al. (2012) found that owner-occupiers 20% more likely to insulate and 16% more likely to turn down heating at night.

# Split incentives: Landlord-tenant problem



Are renters less likely to have energy efficient appliances than homeowners?

Energy Star refrigerator	-6.7%
Energy Star dishwasher	-9.5%
Energy Star air conditioner	-0.9%
Energy Star washing machine	-3.3%
Energy efficient lighting	-4.9%

Source: Davis, L. W. (2010) "Evaluating the Slow Adoption of Energy Efficient Investments: are Renters Less Likely to have Energy Efficient Appliances?" *NBER Working Paper No. 16114*.

# Landlord-Tenant Problem – Residential Rental Properties in Ireland



- **Research Questions:**

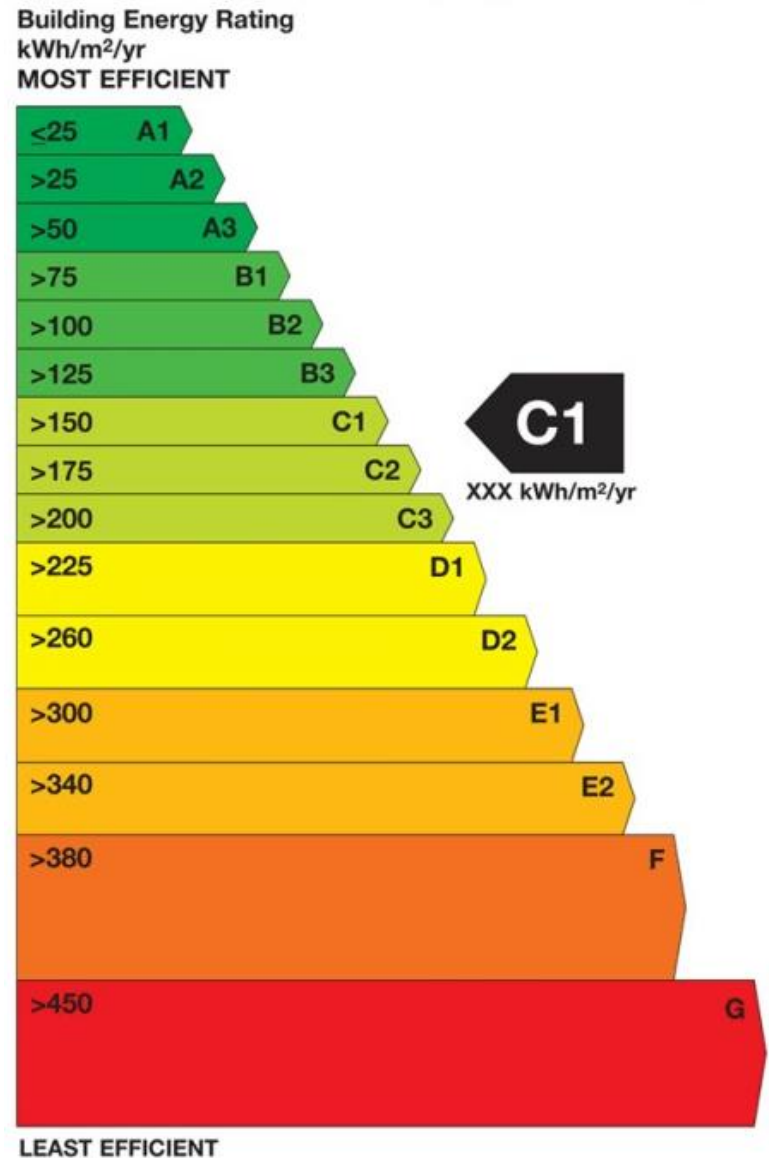
1. Are rental properties less efficient than owner-occupied, even with BER labels?  
*i.e. does the split incentive still exist in the presence of information?*
2. Is this effect different in urban vs rural areas?
3. Do buildings with better energy performance labels command a higher rental premium?



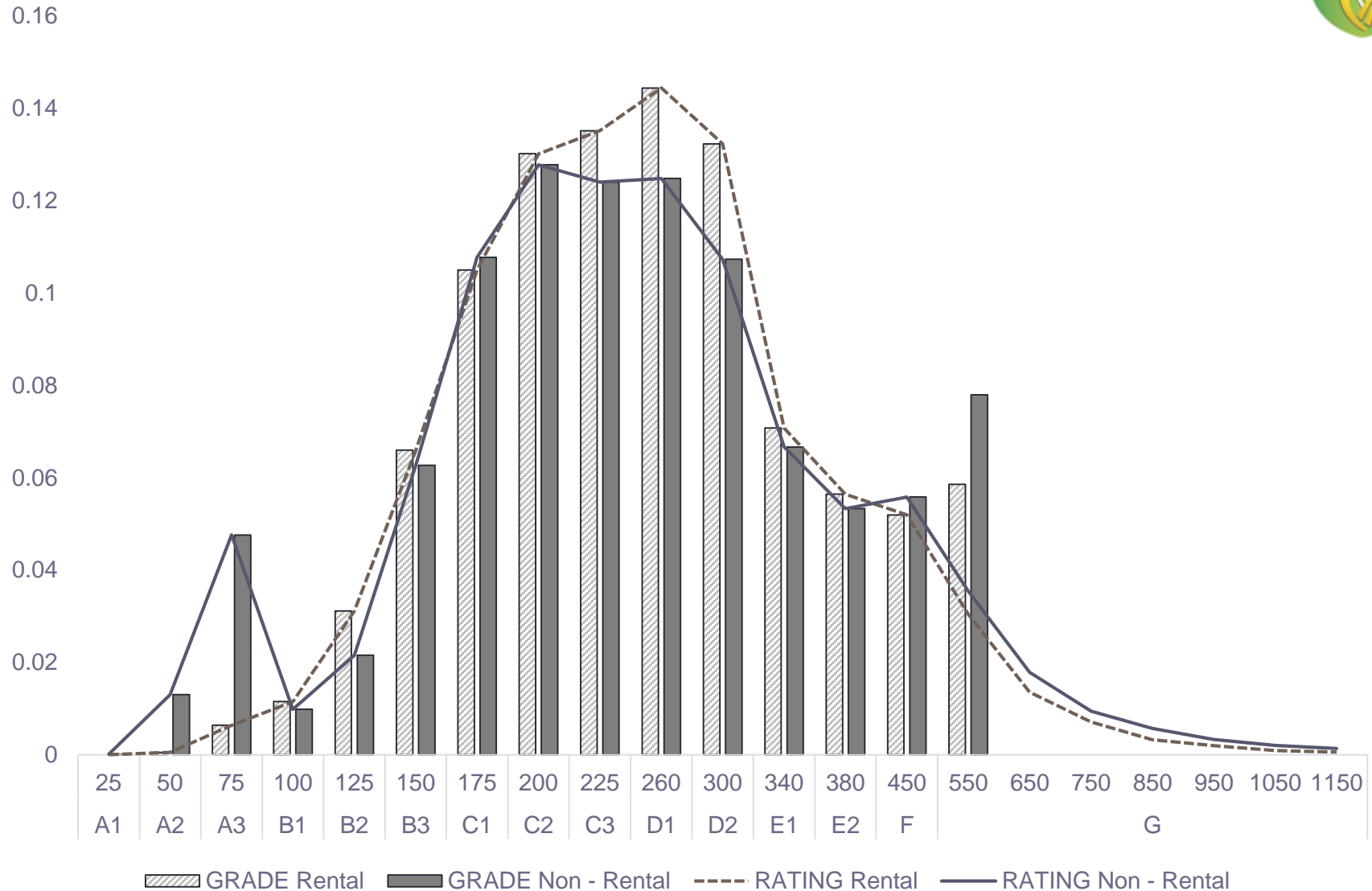


# Data: BER database and rental properties

- BER – Building Energy Rating: An objective measure of the energy used for space, hot water heating, ventilation and lighting.
- 518,759 observations in total
- 54,589 rental BER's
  - 464,170 controls
- Compulsory from 2009 to display BER cert at point of sale or lease
- 2013 – Legislation extended to advertising of rental properties.

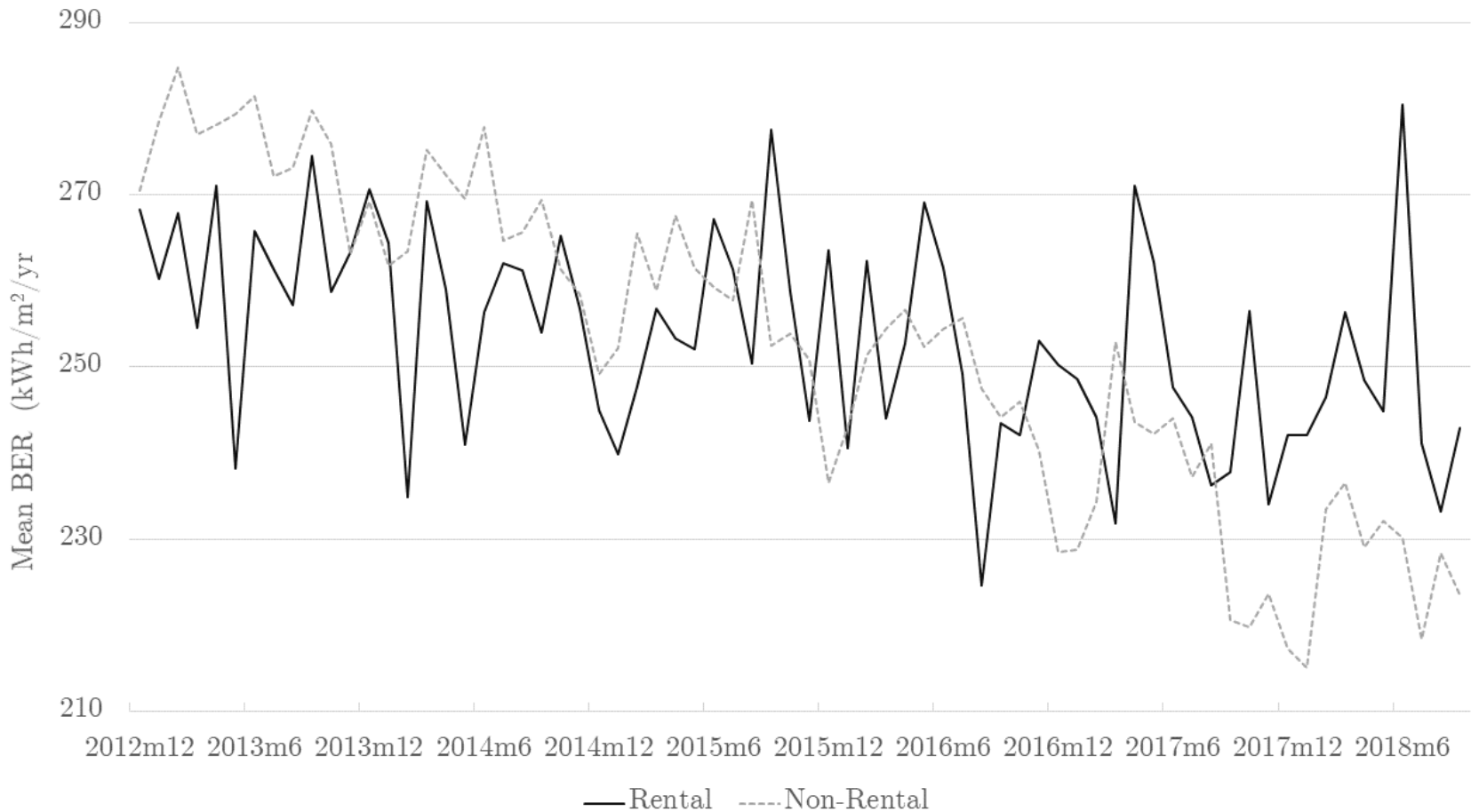


# BER Distribution: Rental vs Non-Rental





# Issuance of BERs: Rental and non-rental



# Summary Statistics



Variable	Full Sample		Rental		Non-rental		
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	
Berrating	251.66	148.96	<b>255.07</b>	120.56	<b>251.26</b>		152.26
Groundfloorarea (m2)	110.53	58.14	91.61	46.33	112.75	***	59.10
Apartment	0.18	0.38	0.44	0.50	0.15	***	0.35
Terracedhouse	0.17	0.37	0.15	0.36	0.17	***	0.38
Semi-detached	0.37	0.48	0.26	0.44	0.38	***	0.49
Detached	0.29	0.45	0.15	0.36	0.30	***	0.46
Rural	0.69	0.46	0.58	0.49	0.70	***	0.46
Inner Dublin city	0.08	0.27	0.16	0.37	0.07	***	0.25
South Dublin City	0.08	0.27	0.09	0.29	0.07	***	0.26
North Dublin City	0.07	0.26	0.07	0.26	0.07		0.26
Waterford city	0.01	0.11	0.01	0.10	0.01	***	0.11
Limerick City	0.02	0.14	0.03	0.17	0.02	***	0.14
Galway City	0.02	0.13	0.03	0.17	0.02	***	0.13
Cork City	0.03	0.18	0.03	0.16	0.04	***	0.19
Age	35.80	33.05	33.77	34.51	36.04	***	32.83
No. Observations	<b>518,759</b>		<b>54,589</b>		<b>464,170</b>		

\*\*\* Statistically different from rental mean at  $p < 0.01$

# Methodology



- Naïve comparison: Rental properties appear to be more efficient.
- Coarsened Exact Matching (CEM)<sup>17, 18</sup> & parametric regression
  - $ATT = E[Y_{1i} - Y_{0i} | D_i = 1] = E[Y_{1i} | D_i = 1] - E[Y_{0i} | D_i = 1]$ <sup>19</sup>
  - We cant observe  $E[Y_{0i} | D_i = 1]$
  - However, we can approximate  $E[Y_{0i} | D_i = 1]$  using  $E[Y_{0i} | D_i = 0]$  which we can observe
- Idea is to match treated (rental) houses to similar control (non-rental).
- Estimate the effect of renting on a property's level of efficiency.
- Can only do so if we are willing to make the CIA
- Conditional Independence Assumption (CIA):  $\{Y_{0i}, Y_{1i}\} \perp D_i | X_i$

<sup>17</sup> Iacus, S. M., King, G., & Porro, G. (2011). Multivariate Matching Methods That Are Monotonic Imbalance Bounding. *Journal of the American Statistical Association*, 106(493), 345–361. <https://doi.org/10.1198/jasa.2011.tm09599>

<sup>18</sup> Iacus, S. M., King, G., & Porro, G. (2012). Causal Inference without Balance Checking : Coarsened Exact Matching, 1–24. *Political Analysis* <https://doi.org/10.1093/pan/mpr013>

<sup>19</sup> Angrist, J. D., & Pischke, J.-S. (2008). *Mostly Harmless Econometrics: An Empiricist's Companion*. Princeton University Press.



# Results: Impact of rental on BER (1)

Dep. Variable: ln(BER)	OLS
Rental	0.0828 *** (0.0017)
Groundfloorarea (m2)	-0.0035 *** (0.0001)
Apartment	<b>(omitted)</b>
Terraced house	-0.0765 *** (0.0024)
Semi-detached	0.0581 *** (0.0026)
Detached	0.27096 *** (0.0047)
Rural	-0.1058 *** (0.0039)
Inner Dublin city	-0.1782 *** (0.0045)
Limerick City	-0.0807 *** (0.0053)
Cork City	-0.1901 *** (0.0050)
Age	0.0087 *** (0.0000)



\*\*\* Statistically significant at  $p < 0.01$



# Results using CEM: BER vs rental for semi-detached properties (1) and location (2)

Dep. Variable: ln(BER)	OLS	CEM1	CEM2	CEM3
<b>Full Sample</b>				
Rental	0.1268 *** (0.0030)	0.0439 *** (0.002)	0.0397 *** (0.0025)	0.0387 *** (0.0026)
<b>Excluding Dublin</b>				
Rental	0.1146 *** (0.0032)	0.0354 *** (0.003)	0.0305 *** (0.0027)	0.0303 ** (0.0027)
<b>Dublin only</b>				
Rental	0.1847 *** (0.0077)	0.0794 *** (0.006)	0.0778 *** (0.0064)	0.0754 *** (0.0069)

\*\*\* Statistically significant at  $p < 0.01$

Semi-detached rental properties consume between 3 – 18% more energy per  $m^2$  than privately owned properties.  
The effect is greater in Dublin.

# Summary statistics: Rental Data (3)



- Data: RTB (Data used by ESRI in their quarterly rent index<sup>12</sup>)

Variable	Full Sample		BER Certified		No BER	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Monthly rent	936.45	500.44	1016.52	526.61	906.19 ***	486.77
ln(Monthly rent)	6.72	0.50	6.80	0.50	6.68 ***	0.50
Number of bedrooms	2.49	1.02	2.58	0.99	2.46 ***	1.03
Sublet	0.00	0.02	0.00	0.02	0.00	0.02
Substantial refurbishment	0.00	0.01	0.00	0.02	0.00 ***	0.01
Detached	0.11	0.32	0.12	0.33	0.11 ***	0.31
Semi-detached	0.24	0.43	0.25	0.43	0.24 ***	0.43
Terraced	0.15	0.36	0.16	0.37	0.14 ***	0.35
Apartment	0.43	0.50	0.44	0.50	0.43 ***	0.50
Flat	0.05	0.22	0.02	0.15	0.06 ***	0.24
Bedsit	0.01	0.11	0.00	0.07	0.02 ***	0.12
Oil	0.28	0.45	0.31	0.46	0.27 ***	0.44
Gas	0.43	0.50	0.53	0.50	0.39 ***	0.49
Cork city council	0.06	0.23	0.05	0.21	0.06 ***	0.24
Dublin city council	0.23	0.42	0.21	0.41	0.24 ***	0.43
Galway city council	0.04	0.20	0.05	0.22	0.04 ***	0.19
Limerick city council	0.03	0.17	0.03	0.16	0.03 ***	0.17
Waterford city council	0.02	0.14	0.02	0.12	0.02 ***	0.14
Town/borough council	0.10	0.31	0.09	0.29	0.11 ***	0.31
County council	0.52	0.50	0.56	0.50	0.50 ***	0.50
Number of observations	292,440		80,208		212,232	

\*\*\* Statistically different from BER certified mean at

$p < 0.01$

<sup>23</sup> RTB. (2017). *The Residential Tenancies Board Rent Index Report - Quarter 2 2017*.



# Results: Rent vs BER



Dep Var: ln(Monthly Rent)	OLS		FE - Unweighted		CEM4	
BER Certified	0.0742 *** (0.0017)		0.0350 *** (0.0013)		0.0359 *** (0.0013)	
Number of Bedrooms	0.1458 *** (0.0013)		0.1572 *** (0.0008)			
Sublet	-0.0560 * (0.0329)		-0.0208 (0.0251)			
Substantial Refurbishment	0.0795 (0.0513)		0.0895 *** (0.0376)			
Detached	<b>0</b> <b>(omitted)</b>		<b>0</b> <b>(omitted)</b>			
Semi-Detached	0.0467 *** (0.0030)		-0.0004 (0.0021)			
Terraced house	0.0655 *** (0.0034)		-0.0126 *** (0.0024)			
Apartment	0.1933 *** (0.0036)		0.0690 *** (0.0024)			
Flat	-0.1358 *** (0.0050)		-0.2473 *** (0.0036)			
Bedsit	-0.3307 *** (0.0072)		-0.4721 *** (0.0058)			
Oil	-0.1954 *** (0.0020)		-0.0638 *** (0.0015)			
Gas	0.1834 *** (0.0016)		0.0589 *** (0.0012)			

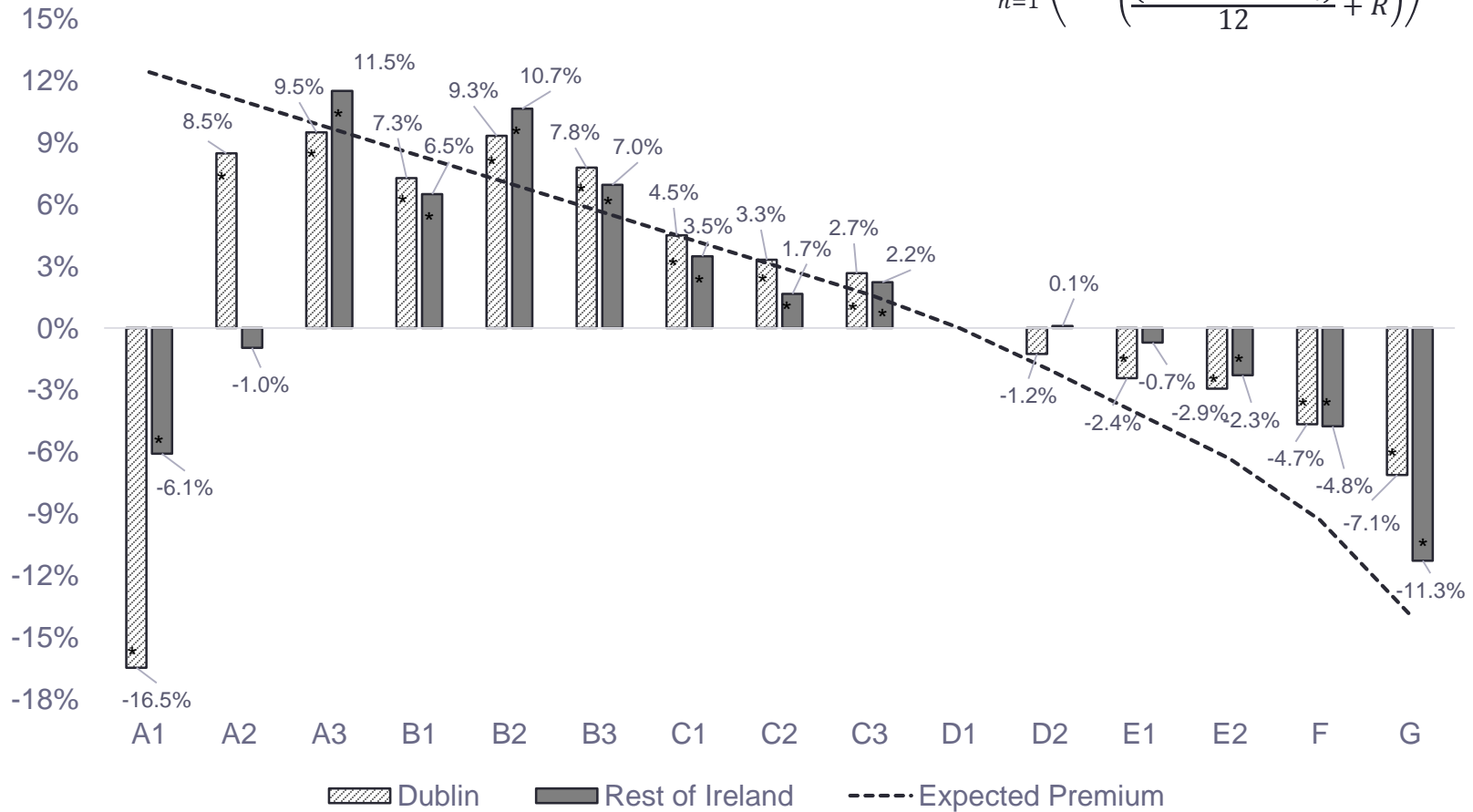
	Dublin	Rest
BER Certified	0.0565 *** (0.0014)	0.0300*** (0.0026)

\*\*\* Statistically significant at  $p < 0.01$

# Results: Premiums: Dublin vs Rest of Ireland



$$Expected\ Premium_g = \sum_{h=1}^h \left( 1 - \frac{\left( \frac{(BER_g(\bar{m}^2)p_h)}{12} + \bar{R} \right)}{\left( \frac{(BER_{D1}(\bar{m}^2)p_h)}{12} + \bar{R} \right)} \right) w_h$$



\* indicates statistical significance at p < 0.05



# Conclusions

- Split incentives exist in residential properties in the Irish rental sector
- Energy performance information is available to Irish renters since 2009 via BER labels.
- We estimate that rental properties have BER labels indicating a consumption of 1-8% more energy per m<sup>2</sup> per year compared with non-rental properties. For semi-detached properties this is higher.
- This effect is higher in Dublin where the rental market is very tight.
- Properties with a BER label command a rent 3-7% higher than those without.

# Takeaway message....

## ...Policy packages needed



**Energy/Carbon prices for least-cost demand/carbon mitigation**



**Complementary policies for Energy Efficiency**

MEPS\*

Labelling

Grants/  
subsidies

Greening  
taxes

Finance

\* = Minimum energy performance standards



# Bibliography

- Brounen, D., & Kok, N. (2011). On the economics of energy labels in the housing market. *Journal of Environmental Economics and Management*, 62(2), 166–179. <https://doi.org/10.1016/j.jeem.2010.11.006>
- Cajias, D., & Piazzolo, M. (2013). Green performs better: energy efficiency and financial return on buildings. *Journal of Corporate Real Estate*, 15(1), 53–72. <https://doi.org/http://dx.doi.org/10.1108/JCRE-12-2012-0031>
- Davis, L. W. (2010), “Evaluating the Slow Adoption of Energy Efficient Investments: are Renters Less Likely to have Energy Efficient Appliances?” *NBER Working Paper No. 16114*.
- IEA (2011), *Energy efficiency and carbon pricing*, Paris.
- IEA (2007), *Mind the Gap- Quantifying Principal-agent Problems in Energy Efficiency*. Paris.
- Gillingham, K., M. Harding, and D. Rapson (2012), Split Incentives in Residential consumption”, *The Energy Journal*, 33:2, 37.
- Hyland, M., Lyons, R. C., & Lyons, S. (2013). The value of domestic building energy efficiency - evidence from Ireland. *Energy Economics*, 40, 943–952. <https://doi.org/10.1016/j.eneco.2013.07.020>
- Jaffe A. B. and R. N. Stavins (1994), “Energy-Efficiency Investments and public policy”, *The Energy Journal* 15(2),
- Murtishaw, S. and J. Sathaye (2006), “Quantifying the Effect of the Principal-Agent Problem on US Residential Energy Use”, Formal Report LBNL-59773 Rev., Lawrence Berkeley National Laboratory, University of California, Berkeley.
- Scott, S. (1997). Household energy efficiency in Ireland: A replication study of ownership of energy saving items. *Energy Economics*, 19(2), 187–208. [https://doi.org/http://dx.doi.org/10.1016/S0140-9883\(96\)01000-6](https://doi.org/http://dx.doi.org/10.1016/S0140-9883(96)01000-6)
- Stanley, S., Lyons, R. C., & Lyons, S. (2016). The price effect of building energy ratings in the Dublin residential market. *Energy Efficiency*, 9(4), 875–885. <https://doi.org/10.1007/s12053-015-9396-5>
- Yamamoto, Y., A. Suzuki, Y. Fuwa and T. Sato (2008), “Decision-making in Electrical Appliance Use in the Home”, *Energy Policy*, Vol. 36, No. 5, pp. 1679-1686.
- Zheng, S., Wu, J., Kahn, M. E., & Deng, Y. (2012). The nascent market for “green” real estate in Beijing. *European Economic Review*, 56(5), 974–984. <https://doi.org/10.1016/j.euroecorev.2012.02.012>



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