The Effect of Forward-looking Financial Benefits on PV Adoption Patterns

Justus Böning   Kenneth Bruninx   Marten Ovaere   Guido Pepermans   Erik Delarue[1]

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- Policy makers often opt for **financial benefits as second-best solution** to **incentivize households** to invest in energy-related appliances.

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- How **effective** are **different incentive designs** with future financial benefits?

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- **Control variables** *variation by year and zip*: median income deflated (source: statbel), sociodemographics and building characteristics (source: Walstat/provincies.incijfers)
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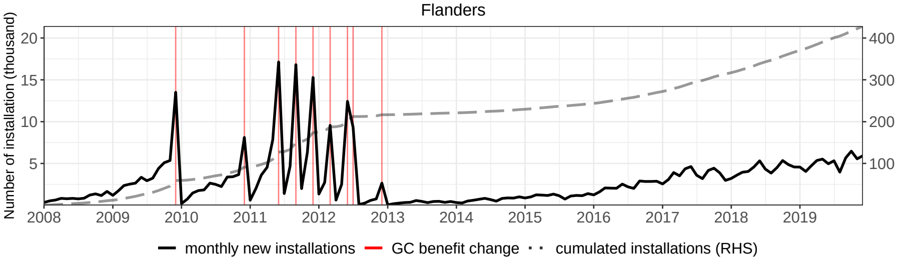

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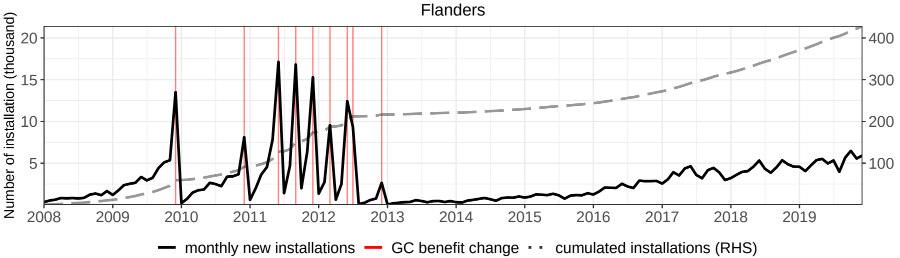

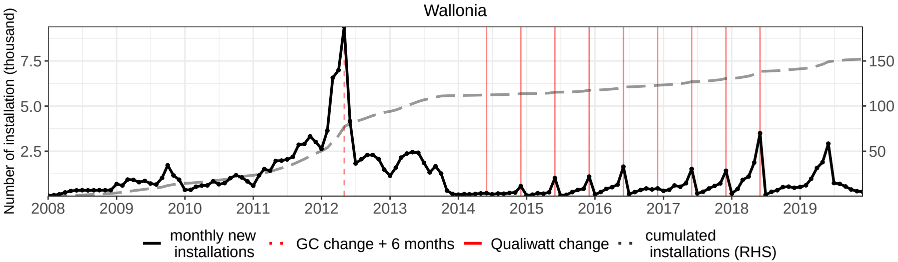

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- **Prosumer tariff in Flanders:** yearly fee per installed capacity for PV-owners, introduced in 2015 only in Flanders, varies by sub-region, **capacity-based cost**.

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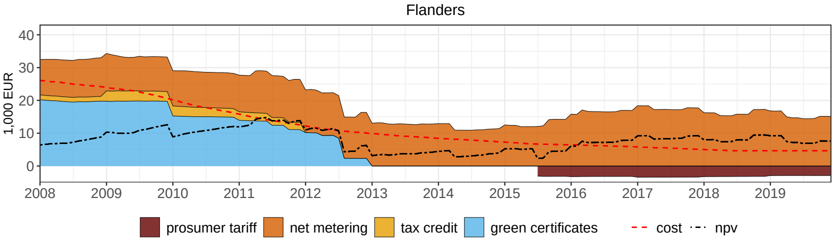

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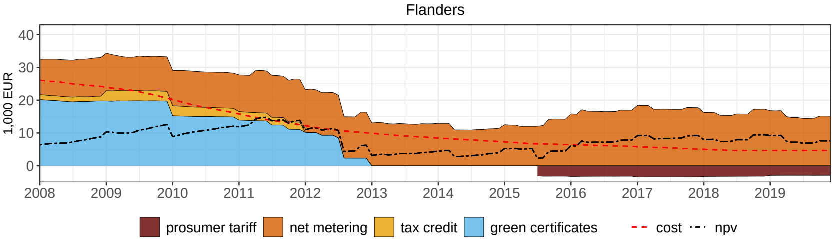

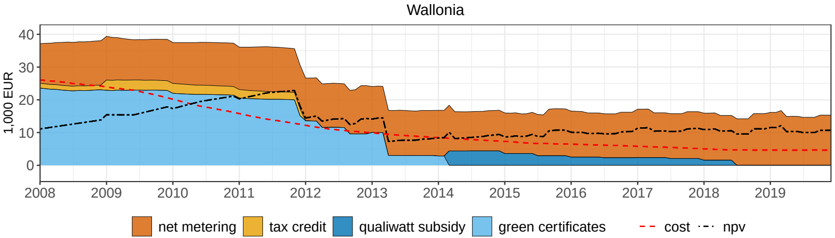

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    As an extension: **instrumental variable (IV)** control function approach (Gillingham and Tsvetanov, 2019). Instrument: network tariff-free regional electricity prices.

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	Aggregate benefits		Sep. benefits	Sep. benefits (IV)
Model:	(1)	(2)	(3)	(4)
net benefits (log)	6.83*** *(0.085)*			
net benefits (thous)		1.05*** *(0.019)*		
GC (thous)			1.34*** *(0.025)*	1.18*** *(0.023)*
net metering (thous)			0.836*** *(0.035)*	0.679*** *(0.041)*
prosumer tariff (thous)			-1.94*** *(0.092)*	-1.20*** *(0.094)*
QW (thous)			1.45*** *(0.042)*	1.25*** *(0.045)*
Zip-, Month-, Year-fixed effects:	Yes	Yes	Yes	Yes
Additional Control Variables:	Yes	Yes	Yes	Yes
Observations	78,048	78,048	78,048	78,048

*Standard-errors in parentheses, Signif. Codes: ***: 0.01, **: 0.05, *: 0.1, observations are at the monthly municipality level. Time span is 2008-2019. Standard-errors for PPMLE (1)-(3) clustered at the municipality-level, for IV estimates (4) bootstrapped. IV estimates contains sub-regional variation in QW and prosumer tariff benefit variables.*

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    - **Declining difference** in coefficients **between cost saving- and capacity-based benefits** suggests importance of **salience as major determinant**.

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net benefits (log)	1.40*** *(0.048)*			
net benefits (thous)		0.344*** *(0.010)*		
GC (thous)			0.390*** *(0.012)*	0.365*** *(0.012)*
net metering (thous)			-0.113*** *(0.022)*	-0.112*** *(0.030)*
prosumer tariff (thous)			-0.310*** *(0.044)*	-0.253*** *(0.047)*
QW (thous)			-0.144*** *(0.027)*	-0.201*** *(0.036)*
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Additional Control Variables:		Yes	Yes	Yes
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- **Cost saving-based** and **capacity-based** benefits affect average capacity size negatively.
- Results suggest **behavior in line with benefit design**: thresholds on compensated capacity reduce average capacity, while absence of thresholds increases capacity.

Conclusion

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- Not all output-based benefit schemes are similarly effective: **less uncertain**, **direct** and **more salient** benefits yield **higher** installation numbers.
- The effect on average capacity also depends on the benefit scheme: **households increase the number of panels if it is compensated**.

Conclusion

Thank you for listening!

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Present Value Equations

$$b^{tc}_{i,s,r,t}(cap) = \sum_{t=1}^{4} \beta^{12t} \ taxcut_t(cap) \tag{3}$$

$$b^{gc}_{i,r,t}(cap) = \beta \cdot \left(1 - (\beta^{gc})^{T^{gc}_{r,t}}\right)\left(1 - \beta^{gc}\right)^{-1} \cdot n^{gc}_{r,t} \cdot p^{gc}_{r,t} \cdot \bar{y}(cap)/12 \tag{4}$$

$$b^{nm}_{i,r,t}(cap) = \beta \cdot \left(1 - (\beta^{nm})^{T^{lt}}\right)\left(1 - \beta^{nm}\right)^{-1} \cdot p^{el}_{s,r,m} \cdot \bar{y}(cap)/12 \tag{5}$$

$$b^{qw}_{i,r,t}(cap) = \beta \cdot \left(1 - (\beta^{qw})^{T^{qw}}\right)\left(1 - \beta^{qw}\right)^{-1} \cdot p^{qw}_{r,m} \cdot \min(cap, 3\text{kW}) \tag{6}$$

$$b^{pr}_{i,r,t}(cap) = \beta \cdot \left(1 - (\beta^{pr})^{T^{lt}}\right)\left(1 - \beta^{pr}\right)^{-1} \cdot p^{pr}_{s,r,m} \cdot AC^{sh} \cdot cap^{p} \tag{7}$$

back

Explanatory Variables - Summary Statistics 2

Variable	Mean	SD	Min	Median	Max	Observations
Benefit Variables						
net benefits (log)	8.48	0.42	7.72	8.32	9.12	70,308
net benefits (thousand)	5.25	2.23	2.25	4.09	9.15	70,308
GC (thousand)	1.95	2.37	0.00	0.00	5.89	70,308
net metering (thousand)	3.38	0.48	2.55	3.31	4.60	70,308
prosumer tariff (thousand)	0.18	0.33	-0.00	0.00	0.86	70,308
Qualiwatt (thousand)	0.11	0.28	0.00	0.00	1.11	70,308
Sociodemographics						
households (log)	8.49	0.86	3.50	8.50	12.37	6,696
net med income per decl. defl. (log)	10.09	0.11	9.72	10.11	10.44	6,516
population density (log)	5.63	1.00	3.18	5.69	8.17	6,696
age:below 18 (sh.)	0.21	0.02	0.10	0.20	0.29	6,696
age:18-49 (sh.)	0.41	0.02	0.24	0.41	0.51	6,694
age:above 64 (sh.)	0.18	0.03	0.10	0.18	0.40	6,694
age:50-64 (sh.)	0.20	0.02	0.13	0.20	0.32	6,696
non-nationals (sh.)	0.06	0.06	0.00	0.04	0.52	6,696
nationals (sh.)	0.94	0.06	0.48	0.96	1.00	6,696
female (sh.)	0.51	0.01	0.40	0.51	0.54	6,696
male (sh.)	0.49	0.01	0.46	0.49	0.60	6,696

Explanatory Variables - Summary Statistics 2

Variable	Mean	SD	Min	Median	Max	Observations
Household Characteristics						
hh single (sh.)	0.24	0.08	0.10	0.22	0.55	6,684
hh single parent (sh.)	0.08	0.03	0.03	0.06	0.18	6,684
hh couple /w children (sh.)	0.36	0.06	0.16	0.37	0.52	6,684
hh couple w/o children (sh.)	0.32	0.08	0.16	0.34	0.51	6,684
Building Characteristics						
house age:until 1981 (sh.)	0.73	0.08	0.46	0.72	0.95	6,696
house age:after 1981 (sh.)	0.27	0.08	0.05	0.28	0.54	6,696
house type:apartments (sh.)	0.12	0.11	0.00	0.09	0.79	6,696
house type:single fam closed (sh.)	0.19	0.13	0.01	0.15	0.71	6,696
house type:single fam semi-detached (sh.)	0.25	0.07	0.03	0.25	0.42	6,696
house type:single fam open (sh.)	0.45	0.19	0.01	0.47	0.85	6,696

back

Dependent Variable: PV installations

Region	zip	Total PV (thous.)	Obs. (thous.)	zerosh. /obs.	PV installations/obs.					mean cap. (KWp)/obs.			
					mean	median	sd	min	max	mean	sd	min	max
Flanders	300	428,175	43,200	0.13	9.91	5.00	16	0	336	4.49	1.25	0.54	10.00
Wallonia	258	152,078	37,152	0.30	4.09	2.00	8	0	278	4.96	1.36	0.75	10.00
Total	558	580,253	80,352	0.21	7.22	3.00	13	0	336	4.68	1.32	0.54	10.00

back

Robustness: Accounting for short-term dynamics

	Number of PV installations			Average new installed capacity		
	Agg. ben.	Sep. ben.	Sep. ben. (IV)	Agg. ben.	Sep. ben.	Sep. ben. (IV)
Model:	(1)	(2)	(3)	(4)	(5)	(6)
net benefits (thous)	1.30***			0.368***		
	(0.018)			(0.012)		
prosumer tariff (thous)		-0.407***	-0.665***		-0.312***	-0.251***
		(0.089)	(0.077)		(0.049)	(0.052)
GC (thous)		1.30***	1.26***		0.429***	0.406***
		(0.027)	(0.024)		(0.015)	(0.015)
net metering (thous)		0.066	0.796***		-0.164***	-0.157***
		(0.044)	(0.056)		(0.027)	(0.042)
QW (thous)		0.724***	0.910***		-0.151***	-0.186***
		(0.047)	(0.046)		(0.030)	(0.042)
Controls, time-&zip-fixed effects:	Yes	Yes	Yes	Yes	Yes	Yes
Observations	67,775	67,775	67,775	67,775	67,775	67,775

back

Robustness: Different discount rates

	Standard PPMLE				IV Controlfunction			
	0% DR	3% DR (base-line)	7% DR	15% DR	0% DR	3% DR (base-line)	7% DR	15% DR
Model:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
prosumer tariff (thous)	-0.943***	-1.64***	-2.85***	-5.93***	-0.551***	-1.01***	-1.77***	-3.58***
	(0.056)	(0.077)	(0.114)	(0.211)	(0.055)	(0.079)	(0.119)	(0.218)
GC (thous)	1.04***	1.34***	1.78***	2.73***	0.935***	1.18***	1.52***	2.23***
	(0.020)	(0.025)	(0.032)	(0.051)	(0.018)	(0.023)	(0.029)	(0.044)
net metering (thous)	0.583***	0.836***	1.26***	2.37***	0.441***	0.679***	1.07***	2.01***
	(0.027)	(0.035)	(0.049)	(0.082)	(0.030)	(0.041)	(0.059)	(0.103)
QW (thous)	1.17***	1.45***	1.81***	2.47***	0.961***	1.25***	1.59***	2.15***
	(0.038)	(0.042)	(0.048)	(0.060)	(0.040)	(0.045)	(0.052)	(0.066)
Controls, time-&zip-fixed effects:	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations:	78,048	78,048	78,048	78,048	78,048	78,048	78,048	78,048

back