The Effect of Future Financial Benefits on PV Adoption - Evidence from Belgium

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

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Overview

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- Policy makers often opt for **incentive schemes** as second-best solution (instead of an emission tax) to **foster energy-related investments of households**.
- Often, these incentives contain **future financial benefits**, i.e. benefits **after the time of investment**.

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Energy-related technology adoption & future benefits, monthly photovoltaic (PV) installations

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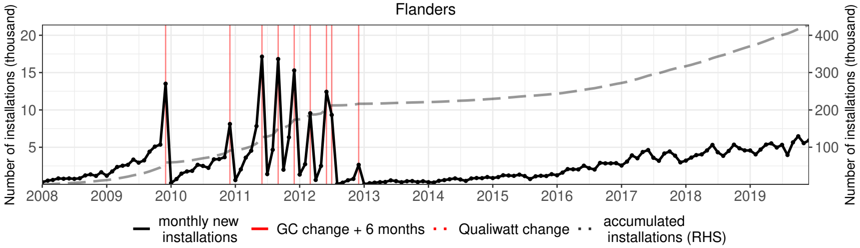

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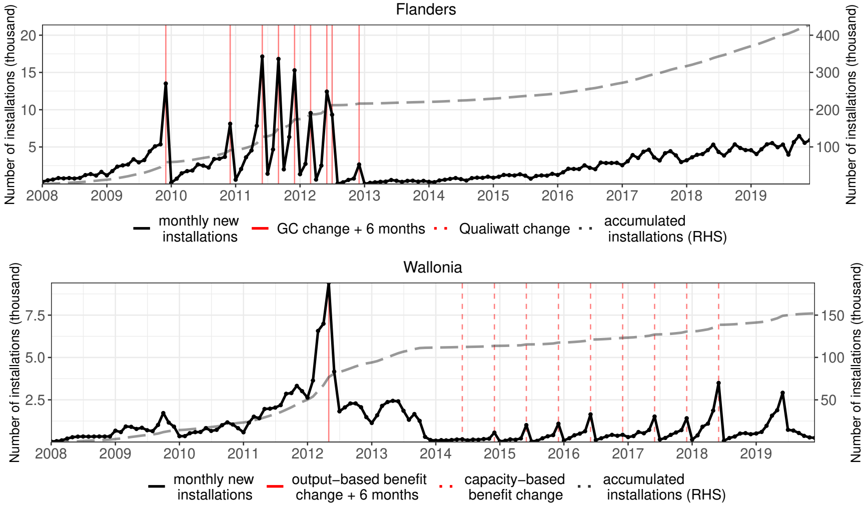

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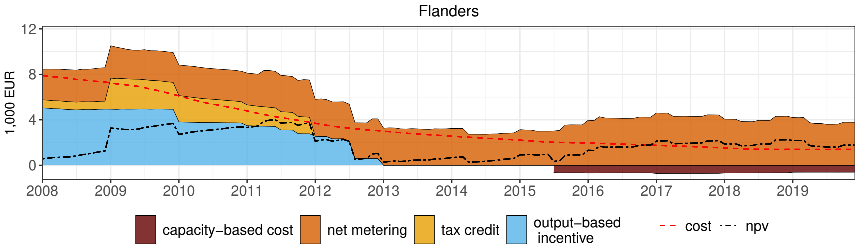

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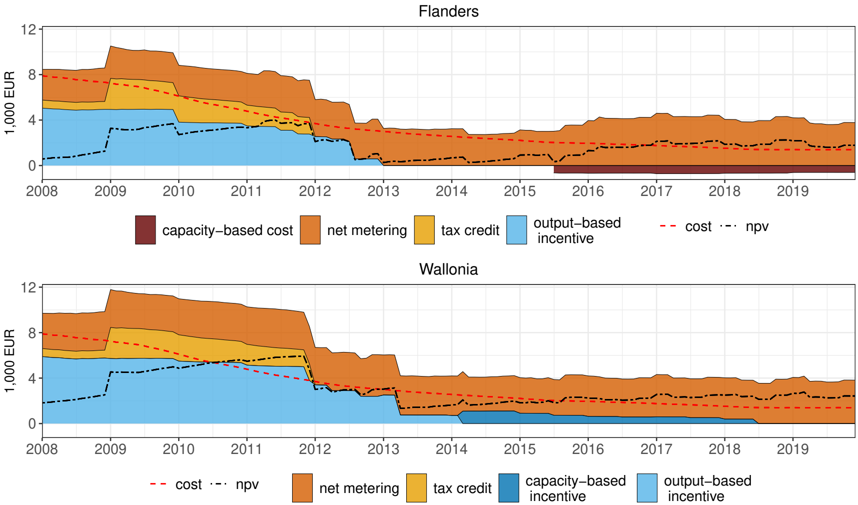

Literature and Research Question

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  - **Cost-efficiency (structural models)**: capacity-based upfront vs. output-based, optimal incentive design.[3]

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- How do **higher future financial benefits** affect **PV adoption patterns** (number and average size) (in a month & municipality) and how **effective** are **different incentive schemes**?

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→ We calculate the present value for the separate incentive schemes in each month of investment and assess their effectiveness in a statistical model.

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$$PV_{it} = \exp[\sum_{j \in J} \beta^j \times b_{rt}^j + \gamma \times \boldsymbol{X_{it}} + \mu_i + \psi_t] \cdot u_{it} \qquad j \in \{yel, nm, cap, capcost\} \tag{2}$$

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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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Results Number of Installations

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Model:	Aggregate benefits (1)	(2)	Sep. benefits (3)	Sep. ben. (IV) (4)
Net benefits (log)	6.83*** *(0.085)*			
Net benefits (thous)		1.05*** *(0.019)*		
Output-based incentive			1.34*** *(0.025)*	1.18*** *(0.023)*
Net metering			0.84*** *(0.035)*	0.68*** *(0.041)*
Capacity-based cost			-1.94*** *(0.092)*	-1.20*** *(0.094)*
Capacity-based incentive			1.45*** *(0.042)*	1.25*** *(0.045)*
Zip-, Month-, Year-fixed eff.:	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, obs. at monthly municipality level. Time span 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 capacity-based incentive/cost.*

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

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	Aggregate benefits		Separate benefits	Separate benefits (IV)
Model:	(2)	(3)	(4)	(5)
Net benefits (log)	1.40*** *(0.048)*			
Net benefits		0.344*** *(0.010)*		
Output-based incentive			0.390*** *(0.012)*	0.365*** *(0.012)*
Net metering			-0.113*** *(0.022)*	-0.112*** *(0.030)*
Capacity-based cost			-0.310*** *(0.044)*	-0.253*** *(0.047)*
Capacity-based incentive			-0.144*** *(0.027)*	-0.201*** *(0.036)*
Zip-, Month-, Year-fixed effects:	Yes	Yes	Yes	Yes
Additional Control Variables:		Yes	Yes	Yes
Observations	78,048	78,048	78,048	78,048

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→ Incentive schemes also affect the size of new installations.

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→ Possibility of improving the modelling of energy related investment decisions and implications for energy system modelling.

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Thank you for listening!

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Present Value Equations

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

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

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

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

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

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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

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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

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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

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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	1.30***			0.368***		
	(0.018)			(0.012)		
Capacity-based cost		-0.407***	-0.665***		-0.312***	-0.251***
		(0.089)	(0.077)		(0.049)	(0.052)
Output-based incentive		1.30***	1.26***		0.429***	0.406***
		(0.027)	(0.024)		(0.015)	(0.015)
Net metering		0.066	0.796***		-0.164***	-0.157***
		(0.044)	(0.056)		(0.027)	(0.042)
Capacity-based incentive		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

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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)
Capacity-based cost	-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)
Output-based incentive	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	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)
Capacity-based incentive	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

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