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iDiv German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig

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Renewable energy policies in federal government systems

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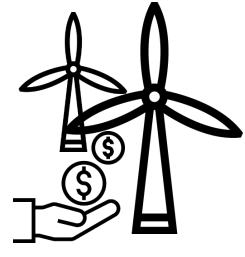

FSR Climate Annual Conference 2020

Motivation and research question

Renewable energy (RE) support policies

- Most common instruments to decarbonize power sector (Meckling et al., 2017).

→ Closely approximate to social optimum (Abrell et al., 2019).

- Often implemented in multi-level governance systems

→ All EU countries use several RE support instruments & are characterized by overlapping national and lower-level RE policies (del Río & Mir-Artigues, 2014).

→ Complexity from overlapping policies and opposing objectives

Recent shifts from price (e.g. feed-in tariff) to quantity instruments (e.g. auction systems) to support RE (REN21, 2019).

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Recent shifts from price (e.g. feed-in tariff) to quantity instruments (e.g. auction systems) to support RE (REN21, 2019).

Research question

How does the instrument choice of the upper-level government (price vs. quantity) affect the incentives for lower-level governments to support RE?

Literature contributions

- Public goods provision in federal systems (Myers, 1990; Caplan et al., 2000)

→ We study incentives through policies instead of direct provision

- Pollution control in multi-level governance systems (Williams III, 2012; Coria et al., 2018)

→ Instead we focus on impure public good like RE

- RE support policies (Ambec & Crampes, 2019; Abrell et al., 2019)

→ Additionally, we consider overlapping policies

- RE support in multi-level systems (Meier & Lehmann, 2019)

→ We focus on policy differentiation on federal level and case of n states

Structure of the presentation

Introduction

Model

Theoretical results

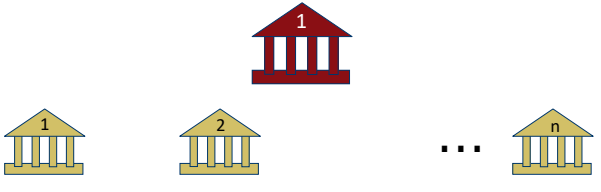
Empirical application

Discussion and conclusion

Players, policies and structure

We extend Williams III (2012) model on pollution control in federal systems to RE.

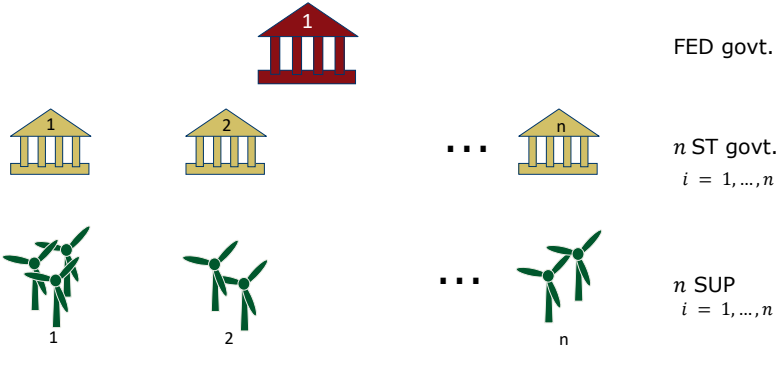
- One federation with n states



Players, policies and structure

We extend Williams III (2012) model on pollution control in federal systems to RE.

- One federation with n states
- In each state a representative, competitive supplier or RE capacity



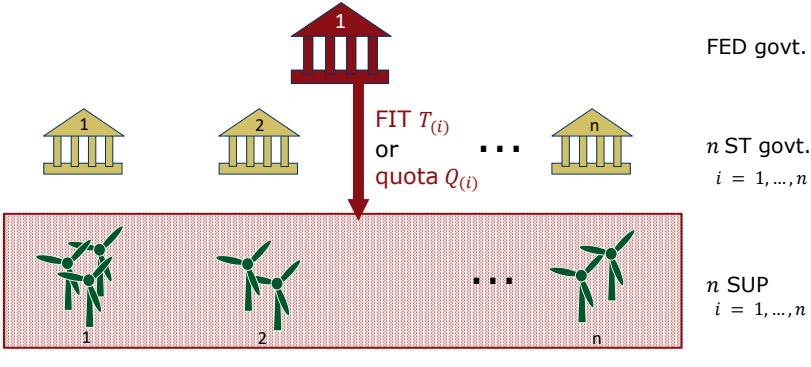
Players, policies and structure

Federal government supports RE by

- (State-specific) **feed-in tariff** (FIT), $T_{(i)}$, paid per unit of RE capacity

or

- (State-specific) **quota**, $Q_{(i)}$, and corresp. uniform quota price $P_{(i)}$.

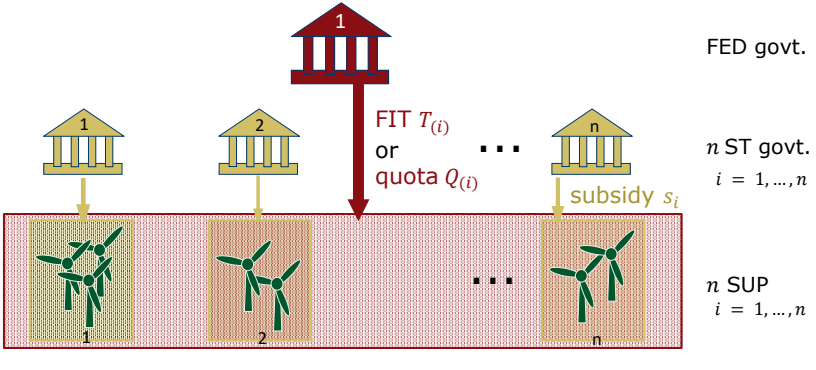


Players, policies and structure

State governments support RE by

→ **Subsidy** s_i paid per unit of RE capacity.

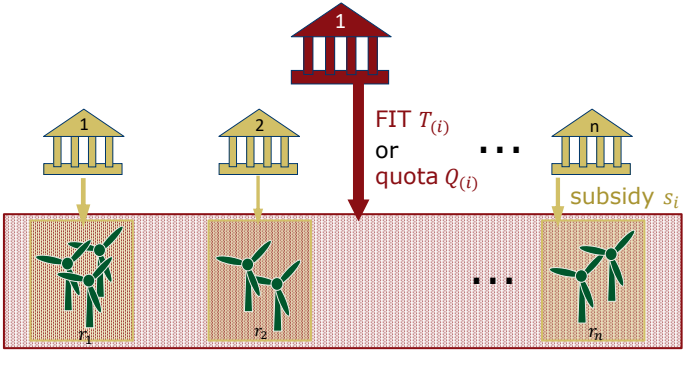
→ May account also for non-financial RE support



Players, policies and structure

RE suppliers receive combined support $\{T_{(i)}, P_{(i)}\} + s_i$

$\rightarrow$ Deploy RE capacity r_i, with $R := \sum_i r_i$

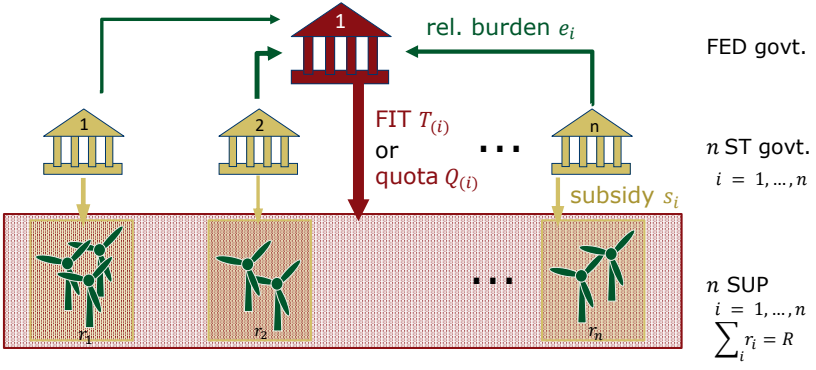


Players, policies and structure

State governments incur

- **Relative burden** of financing federal RE support $e_i \in [0, 1]$ with $\sum_i e_i = 1$

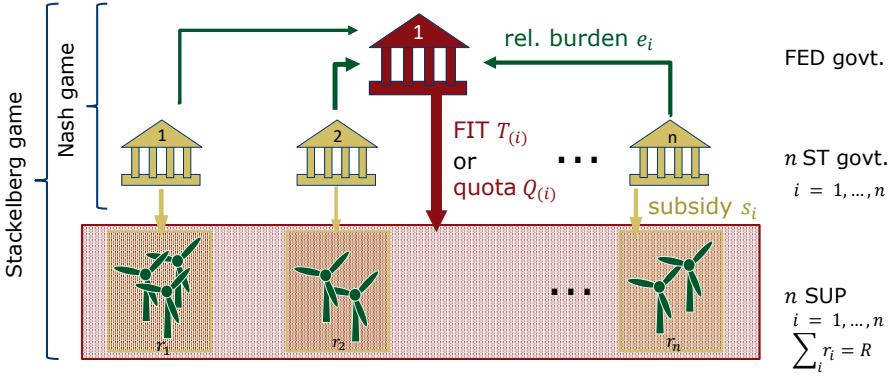
→ Considered as an exogenous model parameter



Players, policies and structure

Two-stage game structure

1. **Federal** and all **state governments** choose level of RE support simultaneously
2. After RE support is announced, suppliers choose state-specific RE deployment r_i



Costs and benefit assumptions

Deploying RE capacity in a state causes convex local costs, $C_i(r_i)$

$\rightarrow \frac{\partial C_i(r_i)}{\partial r_i} > 0, \frac{\partial^2 C_i(r_i)}{\partial r_i^2} = b \geq 0$

and concave local and national (*spillover*) benefits $B_i(r_i, R) \Rightarrow$ **impure public good**

$\rightarrow \frac{\partial B_i(r_i,R)}{\partial r_i} > 0, \frac{\partial B_i(r_i,R)}{\partial R} > 0, \quad \frac{\partial^2 B_i(r_i,R)}{\partial r_i^2} \leq 0, \frac{\partial^2 B_i(r_i,R)}{\partial R^2} \leq 0$

A state's marg. benefit from RE deployment weakly decreases in national capacity (e.g. due to merit-order effect)

$\rightarrow \frac{\partial^2 B_i(r_i,R)}{\partial R \partial r_i} \leq 0$

Formal decision problem under nationwide FIT

For combined support by a **FIT** and state subsidies the decision problem reads:

$$\max_{T} \Pi^{FED} = \sum_{i=1}^{n} \left[-C_i(r_i) + B_i(r_i, R) \right], \tag{1}$$

$$\forall i: \ \max_{s_i} \Pi_i^{ST} = -C_i(r_i) + B_i(r_i, R) - e_i \sum_{j=1}^{n} T\, r_j + T\, r_i, \tag{2}$$

$$\text{s.t. } \forall i: \ \max_{r_i} \Pi_i^{SUP} = -C_i(r_i) + (s_i + T)\, r_i. \tag{3}$$

Nationwide FIT and state subsidies

Policy support in Nash equilibrium

- The federal government's nationwide FIT exactly corresponds to the sum of marginal national benefits (and does not depend on the local benefits):

$$\widetilde{T} = \sum_{j=1}^{n} \frac{\partial B_j}{\partial R}. \tag{4}$$

- A state's subsidy equals its marginal benefits minus its marginal burden:

$$\widetilde{s_i} = \frac{\partial B_i}{\partial r_i} + \frac{\partial B_i}{\partial R} - e_i \sum_{j=1}^{n} \frac{\partial B_j}{\partial R}. \tag{5}$$

Efficiency of combined support

Proposition 1.

Under a nationwide **FIT** *a state decreases its subsidy in response to an increase in its relative burden. The combined support is too low in state i if the states burden share exceeds it's share of marginal benefits from nationwide deployment (and vice versa)*

$$\forall i: \ \widetilde{T} + \widetilde{s}_i \gtreqless \Psi_i^* \iff e_i \lesseqgtr \frac{\frac{\partial B_i}{\partial R}}{\sum_{j=1}^{n} \frac{\partial B_j}{\partial R}}. \tag{6}$$

Here, Ψ_i^* is the optimal level of RE support and given as (proof in paper):

$$\forall i: \ \Psi_i^* := \frac{\partial B_i}{\partial r_i} + \sum_{j=1}^{n} \frac{\partial B_j}{\partial R}. \tag{7}$$

Formal decision problem under nationwide quota

For combined support by a **quota** and state subsidies the decision problem reads:

$$\max_{Q} \Pi^{FED} = \sum_{i=1}^{n} \left[-C_i(r_i) + B_i(r_i, R) \right], \tag{8}$$

$$\forall i: \ \max_{s_i} \Pi_i^{ST} = -C_i(r_i) + B_i(r_i, R) - e_i \sum_{j=1}^{n} P\, r_j + P\, r_i, \tag{9}$$

$$\text{s.t. } \forall i: \ \max_{r_i} \Pi_i^{SUP} = -C_i(r_i) + (s_i + P)\, r_i, \tag{10}$$

$$R = Q. \tag{11}$$

Nationwide quota and state subsidies

Policy support in Nash equilibrium

- The federal government sets the nationwide quota so that the quota price equals the sum of marginal benefits of national RE (similar to FIT):

$$\overline{P} = \sum_{j=1}^{n} \frac{\partial B_j}{\partial R} \tag{12}$$

- A state's subsidy is determined by the marginal local benefits and by the effect of the state's RE capacity on the marginal national benefits received by all states:

$$\forall i : \overline{s_i} = \frac{\partial B_i}{\partial r_i} + [r_i - e_i Q] \sum_{j=1}^{n} \frac{\partial^2 B_j}{\partial R \partial r_i}. \tag{13}$$

Efficiency of combined support

Proposition 2.

Under a nationwide **quota** *a state increases its subsidy in response to an increase in its relative burden. The combined support through auction and subsidy in a state is inefficiently high if the relative burden share of the state exceeds its capacity share*

$$\forall i: \ \overline{P} + \overline{s_i} \gtreqless \Psi_i^* \iff e_i \gtreqless \frac{r_i}{Q}. \tag{14}$$

Efficiency of combined support

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→ **Opposing effects** on states' subsidies and thus total support

Empirical application for German onshore wind

Context

- The 16 German states have played an active role in the energy transition (Schönberger & Reiche, 2016)
- Switch from FIT (1991-2014) to discriminatory price auctions (2017-)
- The federal RE policy is financed by a surcharge on the electricity price

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Calibration

- Relative burden e_i is approximated using state-specific power demand data from Kunz et al. (2017)
- State's average wind capacity available for generation, r_i, is specified by combining RE capacity data (Kunz et al., 2017) with state-specific full load hours (Koch et al., 2016)

Empirical application for Germany

Table: Incentive changes for state support after switch from FIT to nationwide auctions in Germany. Illustrative colors, states sorted North to South.

State	Relative burden, e_i	Capacity share, $\frac{r_i}{R}$	Incentive for subsidies
SH	0.024	0.197	↓
MV	0.013	0.057	↘
HH	0.032	0.003	↑
HB	0.004	0.001	↗
BB	0.022	0.121	↘
BE	0.037	0.003	↑
NI	0.092	0.249	↘
NRW	0.200	0.086	↗
ST	0.020	0.102	↘
SN	0.042	0.026	↗
TH	0.021	0.029	→
HE	0.064	0.018	↗
RP	0.068	0.062	→
SL	0.015	0.005	↗
BY	0.182	0.026	↑
BW	0.165	0.014	↑

Discussion

Critical model assumptions

- Nash game between governments

→ All governments can adjust equally well

- Exogenous distribution of relative burden e_i

→ Reasonable when federal policy financed by consumption surcharge or from federal budget

Empirical analysis

- Divergence from institutional setting, assumption $R = Q$

Conclusion and outlook

- Incentives for state subsidies depend on the federal instrument choice (**price** vs. **quantity**) and their **burden**.
- A high state burden to finance the federal policy incentivizes lower state subsidies under price and higher state subsidies under quantity instrument.

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- Switch from FIT to quota may reduce transmission stress in Germany.

Conclusion and outlook

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- A high state burden to finance the federal policy incentivizes lower state subsidies under price and higher state subsidies under quantity instrument.
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Outlook

- Findings might **generalize** to other impure public goods (transport, communication).
- Different policy mixes; decision sequence; uncertainty
- More nuanced empirical analysis

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Thank you!

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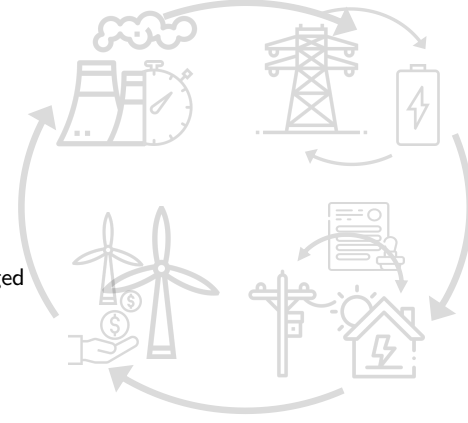

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