Industrial Policies and Innovation: Evidence from the Global Automobile Industry

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ASSA 2025
Industrial Policy
Jan, 2025

Introduction

- **Research question:** how industrial policies (IPs) aimed at promoting electric vehicles (EVs), affect green innovation in the automobile sector.
  - IP: (1) State action (2) Shift the composition of economic activity (targeting specific industry)
- We construct a unique database of global IPs and patents for the automobile industry.
- **Key takeaway:**
  - Green transition global automobile industry.
  - More EV IPs are associated with ↑ in the number of EV patents.
  - Firms with more EV experience innovate more rapidly, ⟶ path dependence.

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Measuring IP 1: Using Global Trade Alert Database

- Natural Language Processing techniques to identify IPs (Juhász et al. 2023)
  1. Manually label a training dataset to either IP or non-IP.
  2. Train a supervised ML model and apply it to the entire dataset.

- 3,385 unique automobile IPs.

- Classify IPs into three fuel types based on the six-digit Harmonized System (HS) code of *Affected Products*:
  1. EV: related to electric vehicles, e.g., "electrical", "lithium," and "batteries."
  2. GV: related to internal combustion engine vehicles.
  3. General: related to both, e.g., brakes, safety airbags, and wheels.

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Measuring IP 2: Using Country-by-Model EV Subsidy

- Compile a database of model-level EV subsidies and supply chain data for 13 countries from 2013 to 2020 (account for 95% of global EV sales).
  - E.g. Subsidy for Tesla Model 3 in the US in 2018 *vs* in China in 2020.

- Calculating the total subsidy exposure to firm-level (92 automakers and 45 battery cell suppliers):

$$\ln TotalSubsidy_{it} = \ln\left(\sum_{m} Sales_{imgt} \cdot Subsidy_{imgt}\right),$$

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Measuring Patents: PATSTAT Database

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- Classify fuel type of each patent filing record to *EV/GV/Both* based on International Patent Codes (IPC).
- Aggregate count of patent to country-level data and firm-level data (Aghion et al., 2016).

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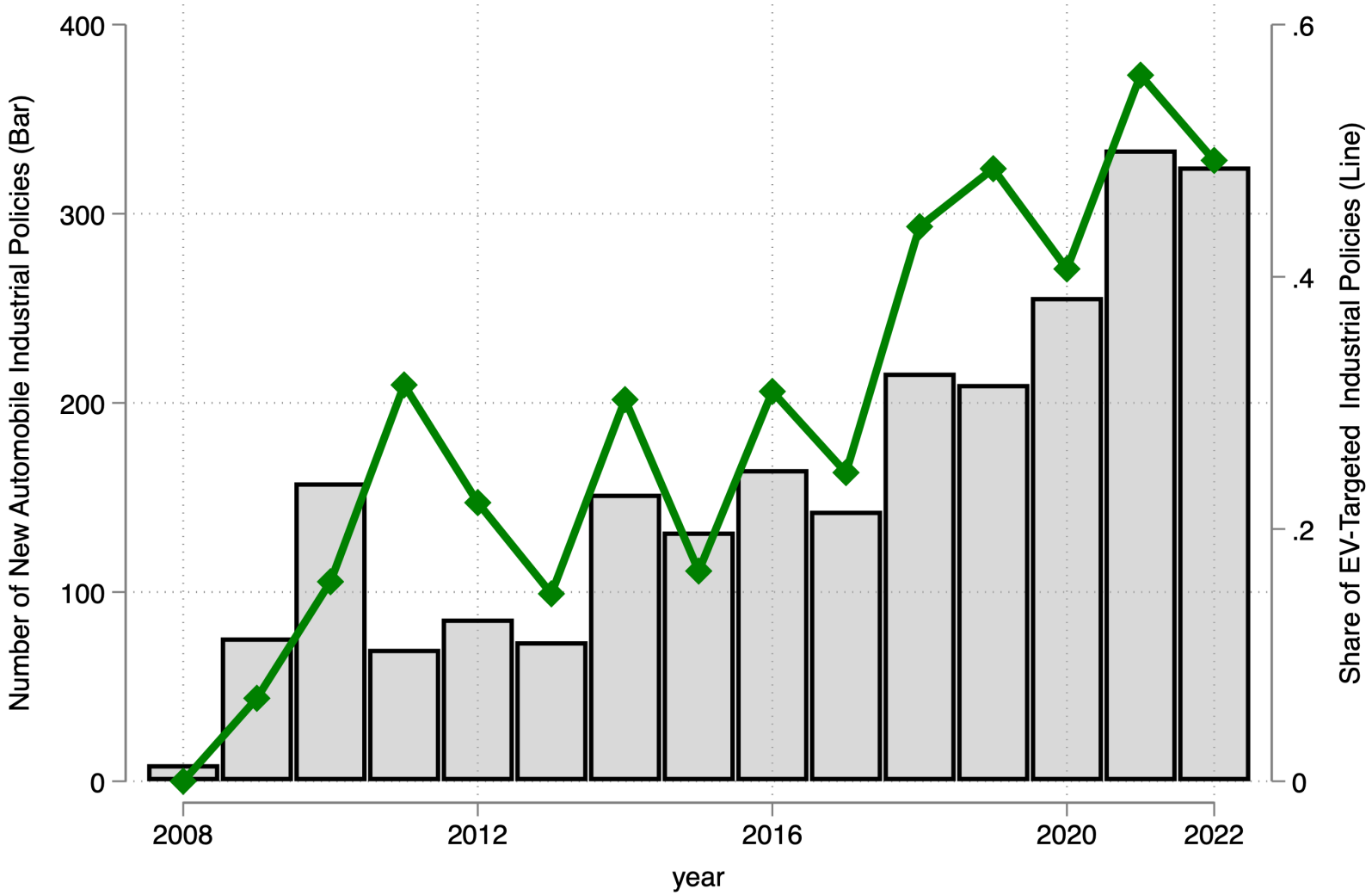
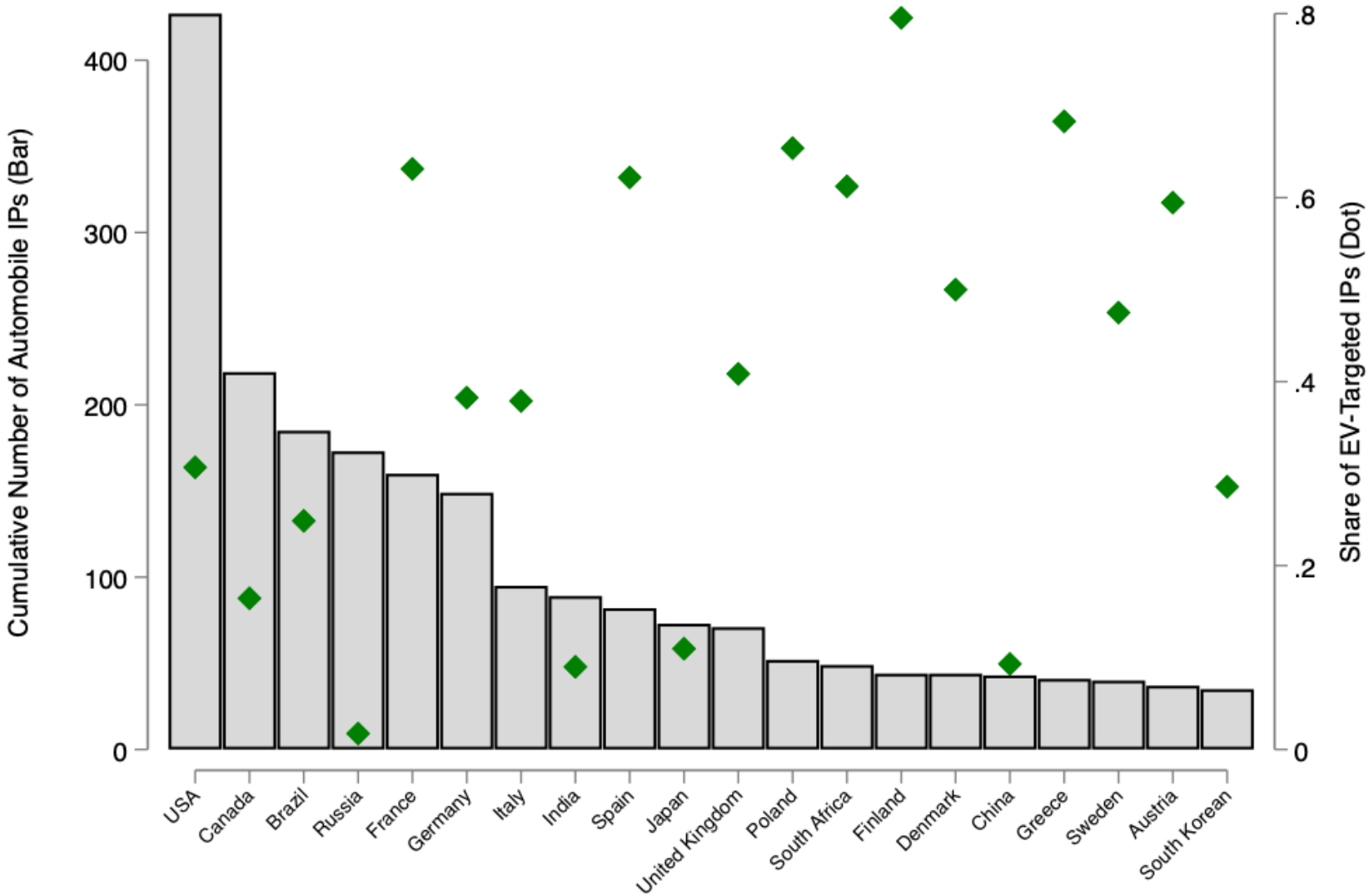
The Number of New IPs in the Automobile Sector

- IPs targeting EVs have surged from almost non-existent in 2008 to 50% of IPs by 2022.

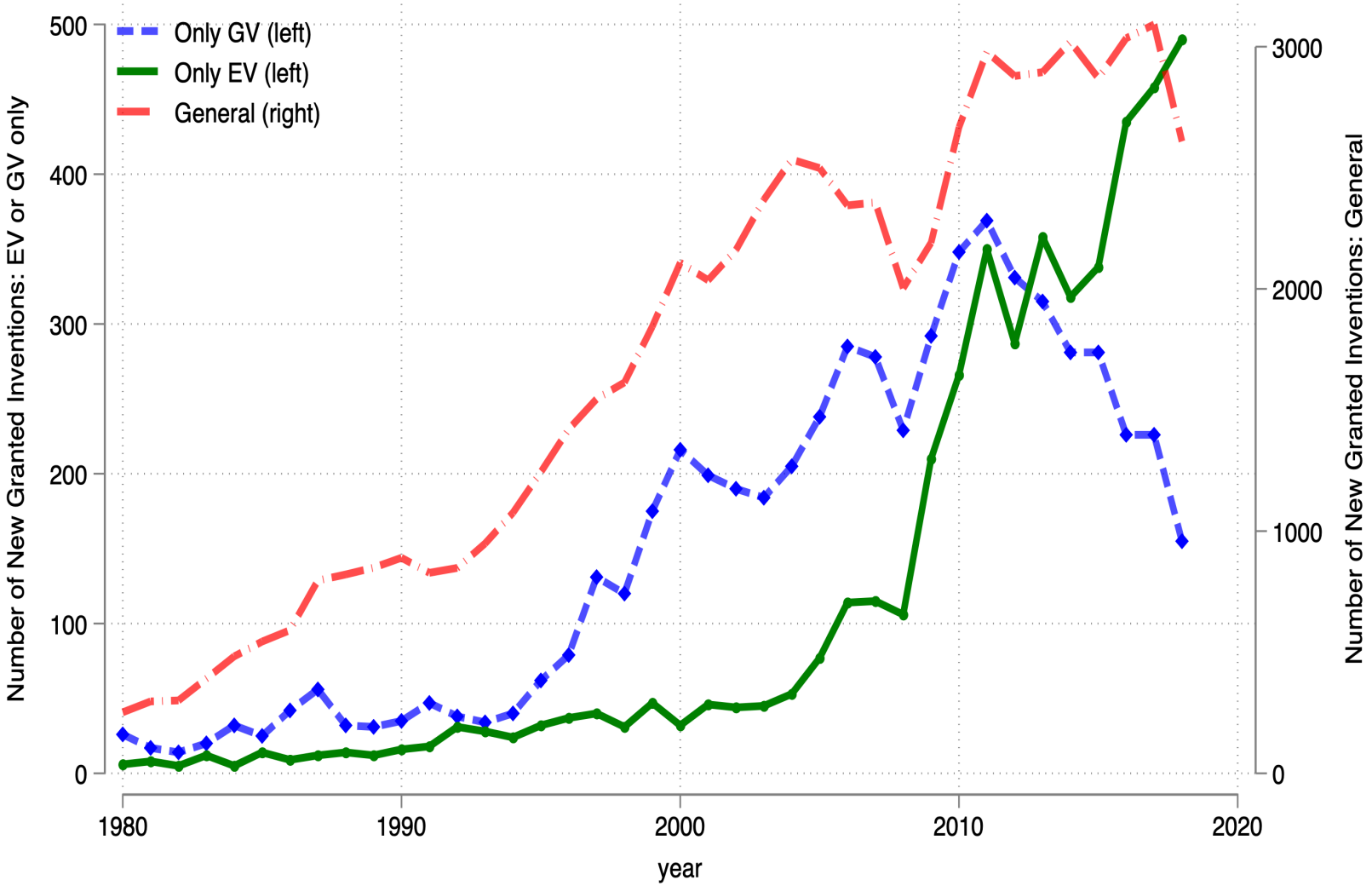


Top 20 Countries in Automobile-Related Industrial Policies



Global Trend of Newly Granted Inventions: 1980-2018

- EV-specific inventions have rapidly increased, surpassing GV inventions by 2020



Regression Analysis and Robustness

- **County-IPC-level analysis**:

$$\ln(Y_{clt}) = \alpha_1 \, IP_{c,k,t-1} + \alpha_2 \, \ln(Cum.\, Patent_{c,l,t-1}) + \mathbf{X}_{clt}\Gamma + \tau_c + \tau_l + \tau_t + u_{clt},$$

  - Y_{clt} count of new EV patent, $IP_{c,k,t-1}$ cumulative of EV IP
  - Poisson pseudo maximum likelihood (PPML) with a rich set of fixed effects
  - Alternative IP or patents measures.
  - Placebo:
    1. Effects of EV IP on GV Patents.
    2. Effects of GV IP on EV Patents.

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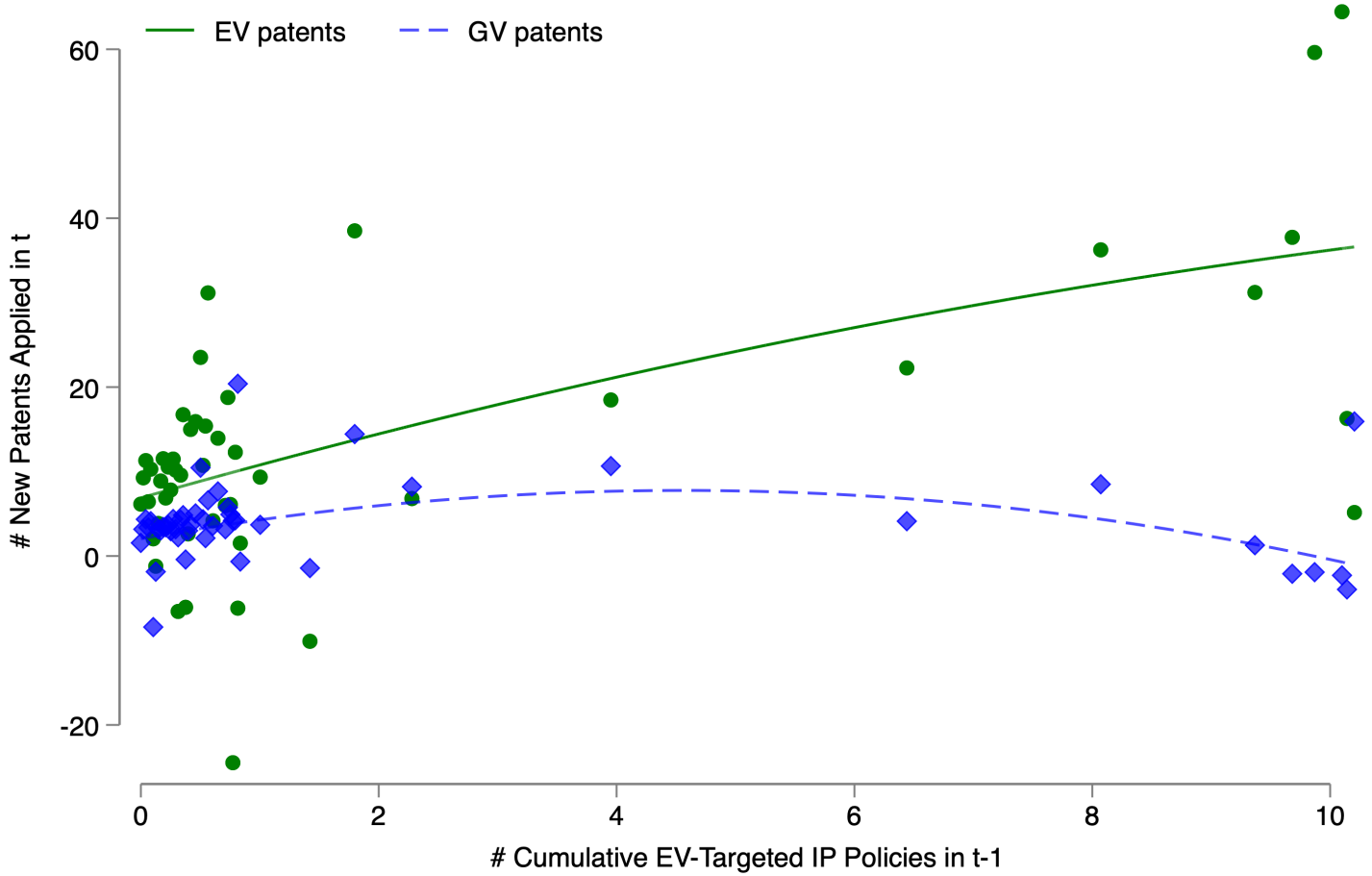
Patents Applied against Cumulative EV IPs: Country-Level

- A one-standard-deviation ↑ in five-year cumulative EV-targeted IPs is associated with a 4% ↑ in new EV patent applications



Regression Analysis and Robustness

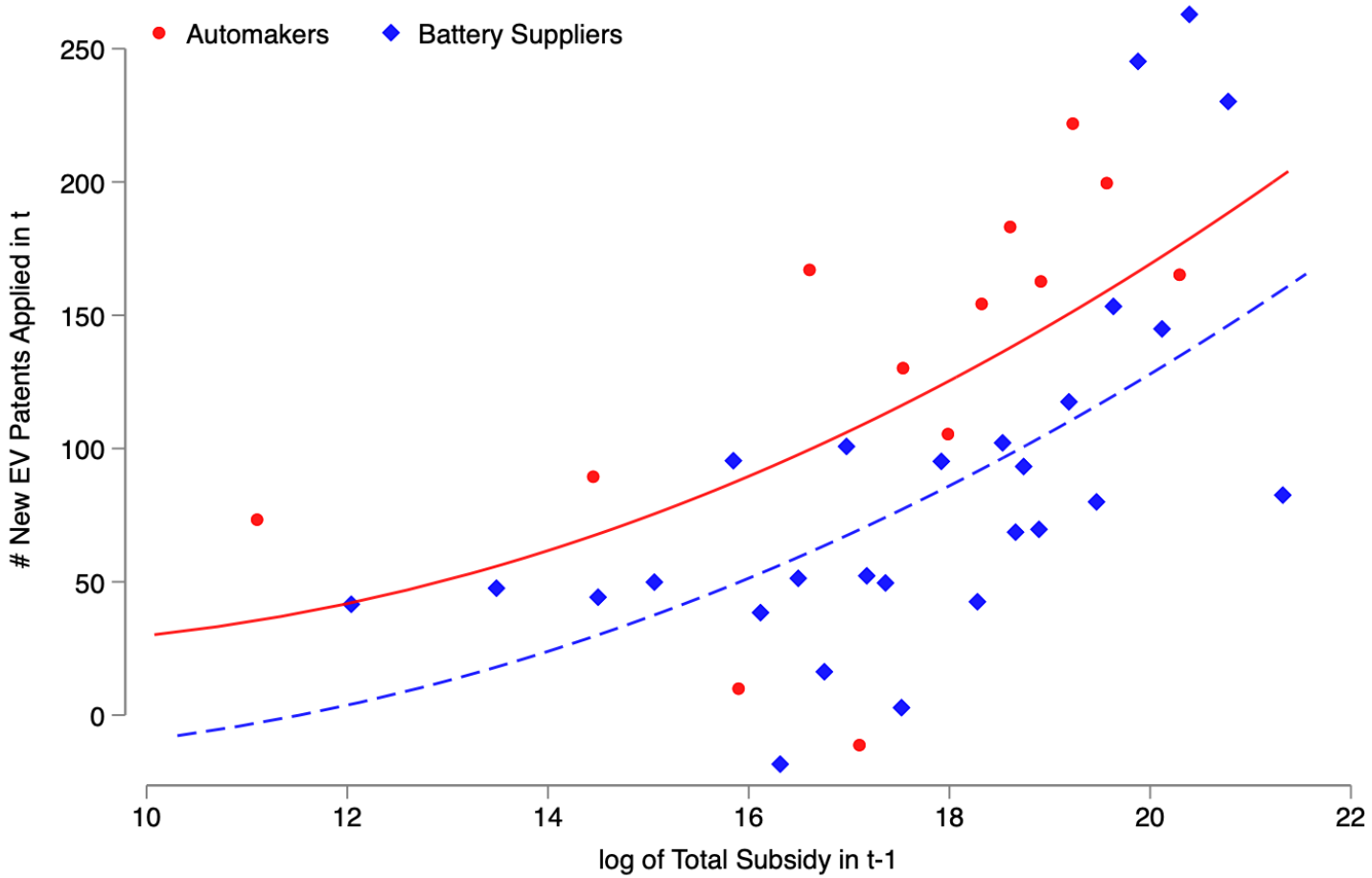
- **Firm level results**

$$\ln(PAT_{it}) = a_1 \ln TotalSubsidy_{i,t-1} + a_2 \ln(Stock^{ev}_{c,t-1}) + a_3 \ln(Stock^{gv}_{c,t-1}) + \tau_i + \tau_t + \varepsilon_{it}$$

  - Using demand-model-simulated sales and incentives as (IO-style) IV
  - Identification: "shift-share" variations,
    1. Simulated sales: pre-determine sales and dealership network, brand loyalty, home bias, etc. $\Longrightarrow$ "Share"
    2. Model-level subsidy: government policies, typically attribute-based $\Longrightarrow$ "Shift"

EV Patents Applied against EV Subsidy Received: Firm-Level

- A 10% ↑ in EV financial incentives received leads to a similar 4% ↑ in EV innovations



Economics of Scale and Path Dependency

- Innovate more in EV technologies if:
  (1) having more EV patents accumulation/stock;

- Country-level Analysis

	(1)
Lag 5-year Cum. EV IP	0.045**
	(0.022)
Lag log(1+Cum. granted P)	0.436***
	(0.037)
Environmental Policy Stringency	0.063*
	(0.033)

Economics of Scale and Path Dependency

- Innovate more in EV technologies if:
  (1) having more EV patents accumulation/stock;
  (2) having less GV patents stock.

- Country-level Analysis

	(1)
Lag 5-year Cum. EV IP	0.045**
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	(0.037)
Environmental Policy Stringency	0.063*
	(0.033)

- Firm-level Analysis

	(1)
Lag ln(1+Total Subsidies)	0.040***
	(0.008)
	[0.014]
Lag Knowledge stock, EV	0.525***
	(0.100)
Lag Knowledge stock, GV	-0.322***
	(0.101)

Takeaways

- We quantitatively study EV-targeted industrial policies and EV technology innovation in the global automobile market.
- We construct a unique database of global IPs and patents.
- **Key findings:**
  - Increasing global trend towards greater usage of EV IPs and more EV patents.
  - More EV IPs are associated with $\uparrow$ in the number of EV patents.
  - Firms with more EV experience innovate more rapidly, $\longrightarrow$ path dependence.

THANKS!

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