Do Entrants Increase Incumbents’ R&D Activity?
- Escaping the Lock-In & Spurring Technological Change towards Sustainability -
- The Case of the Automotive Industry-

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1. Objective
2. Theoretical Framework
3. Hypotheses
4. Methodology
5. Preliminary Results
6. Future Focus
What drives and what hampers the transition of industries towards sustainability?
How to escape from seemingly locked-in technologies?
How to transit from niche to mass market adoption?
→ Entry dynamics?

Research Questions
Do competitive forces imposed by entry spur

1) technological change?
   → by promoting incumbents’ R&D activity towards new trajectories

2) structural change?
   → by encouraging a heterogeneous response of leading and following incumbents

3) If yes, which entry characteristics are relevant to achieve these effects?
   → number of entrants, R&D activity, technological expertise?
**Entrants**
- new niche markets: new key players introduce DT
- flexible, innovative, no sunk costs
- DT destroy incumbents’ knowledge stock, reduce entry barriers, facilitate entry
→ **high incentives to foster disruptive technologies**

**Incumbents**
- compete on incremental innovations, mature technology
- fixed routines & consistent decision behavior → constrains response to changing environment
- DT cannibalizes profit from existing products
- markets for DT: small, slow market adoption, uncertain long-term profit
→ **low incentives to foster disruptive technologies**

Schumpeter (1911/1934; 1942); Malerba et al. (2007); OECD (2011); Storey/Green (2010); Audretsch/Acs (1991); Tushman/Anderson (1986); Utterback (1994); Nelson/Winter (1982); Teece et al. (1997); Geroski (1995); Henderson/Clark (1990) Christensen (1997); Chandy/Tellis (2000); Gort/Klepper (1982)
→ importance of complementary forces, different **strength** and **challenges**
   (Hockerts/Wüstenhagen, 2010)

**Entrants**
- market barriers
- fail to reach market penetration, target niche markets
- spur incumbents’ R&D: (1) market presence (2) once they become challenging competitor

**Incumbents**
- intentions in favor of dominant design
- once motivated: stronger innovative power → large & in-depth R&D
- mass market adoption: stronger influential power, incremental innovation, scale economies

→ **industry’s transition towards sustainability**

- research focus: domestic effects, quantitative entry
  (Aghion et al., 2009; Iacovone et al., 2011; Czarnitzki et al., 2008, 2011)
→ **still outstanding:**
  macro effects of qualitative entry on incumbents’ R&D activity on product level
Market structure
- oligopoly structure, increasing concentration, leading incumbents, high entry barriers (van den Hoed 2007; Barkenbus 2009; Wang/Kimble 2010)
- environmental problems & regulatory forces open up entry opportunities (Pilkington/Dyerson, 2006; Wesseling et al., 2013)

Alternative Technical Vehicles (ATV)
- disrupting technology (Christensen, 1997)
- provide opportunities for escaping locked-in technology (Cowan/Hultén, 1996)

Ongoing transition (Wesseling et al., 2013)
- incumbents’ BEV patent share increased, their proportion on total BEV patenting decreased
- 5 start-up out of the 11 greatest patent holders (‘03/’06 - ‘07/’10)
  → incumbents seem to struggle to keep up with the rate of technological development
<table>
<thead>
<tr>
<th>Hypotheses</th>
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<tbody>
<tr>
<td><strong>Technological Change:</strong></td>
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<tr>
<td>Quantitative Entry Forces</td>
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<tr>
<td><strong>H1 [2]:</strong></td>
<td>The number of ATV entrants has a positive [weakly/negative] effect on leading [follower] incumbents’ ATV patent activity</td>
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<tr>
<td>Qualitative Entry Forces</td>
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<tr>
<td><strong>H3 [4]:</strong></td>
<td>Entrants’ aggregated ATV patents have a positive [weakly/negative] effect on leading [follower] incumbents’ ATV patent activity</td>
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<td><strong>Structural Change:</strong></td>
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<td><strong>H5:</strong></td>
<td>Heterogeneous responses of incumbent leaders and incumbents followers</td>
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<tr>
<td><strong>Entry Characteristics:</strong></td>
<td></td>
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<tr>
<td><strong>H6:</strong></td>
<td>Effect of entrants with high expertise is stronger than effect of entrants with low expertise</td>
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</table>
country \( i = 1, \ldots, h, c, \ldots, m \)

incumbent: 15 largest OEMs (International Organization of Motor Vehicles)

**quantitative effect:**
yearly sum of 1st ATV patent filings

**qualitative effect:**
yearly sum of all operating entrants’ patents

founding year: very first patent filing; entrant: \( \leq 7 \) years on the market

**Incumbents’ productivity in ATV patenting**

\[
\text{IProd}_{iy} = \frac{\sum_{t=t_{y}}^{t_{y-4}} P_t / 5}{\max \sum_{t=t_{y-4}}^{t_{y}} P_t / 5}
\]

**Entrants’ technological relevance**

\[
\text{ETR}_{iy} = \frac{\sum_{t=t_{0}}^{t_{w=3}} \sum_{w=1}^{w=t_{0}+w} C_{t,t+w}}{\max \sum_{t=t_{0}}^{t_{w=3}} \sum_{w=1}^{w=t_{0}+w} C_{t,t+w}}
\]
Distribution of main Variables

Quantitative Effect:
- # of entrants (newly founded & lateral)

Incumbents’ Response:
- follower incumbents’ patents
- leading incumbents’ patents

Qualitative Effect:
- newly founded follower entrants’ patents
- newly founded leading entrants’ patents
<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
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<tr>
<td>IP&lt;sub&gt;t, i, Inc&lt;/sub&gt;</td>
<td>yearly # incumbents’ individual ATV patents</td>
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<tr>
<td>NE&lt;sub&gt;t-x, i&lt;/sub&gt;</td>
<td>yearly # entrants (newly founded &amp; lateral)</td>
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<tr>
<td>EP&lt;sub&gt;t-x, i, E&lt;/sub&gt;</td>
<td>yearly # newly founded entrants’ aggregated ATV patents</td>
</tr>
<tr>
<td>A&lt;sub&gt;t, Inc&lt;/sub&gt;</td>
<td>Age (from founding year(1&lt;sup&gt;st&lt;/sup&gt; patent filing) until t)</td>
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<tr>
<td>E&lt;sub&gt;t, Inc&lt;/sub&gt;</td>
<td>Experience in ATV research (from 1&lt;sup&gt;st&lt;/sup&gt; ATV patent filing until t)</td>
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<tr>
<td>IP&lt;sub&gt;t-1, Inc&lt;/sub&gt;</td>
<td>External Factors</td>
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- PATSTAT patent data base: version 2012, > 80 national patent offices
- time period: 1977-2008
- negative binominal regression model for over-dispersed count data, fixed effects
$$ IP_{t,i,\text{Inc}} = \beta_0 + \sum_{x=1}^{n} \beta_{1x} \text{NE}_{t-x,i=hc} + \sum_{x=1}^{n} \beta_{2x} \sum_{oc}^{m} \text{NE}_{t-x,oc} $$

**quantitative effect**

**leading entrants**

$$ + \sum_{x=1}^{n} \beta_{4x} \sum_{l=1}^{a} \text{EP}_{t-x,i=hc,l} + \sum_{x=1}^{n} \beta_{5x} \sum_{oc}^{m} \sum_{l=1}^{a} \text{EP}_{t-x,oc,l} $$

**follower entrants**

$$ + \sum_{x=1}^{n} \beta_{7x} \sum_{f=1}^{b} \text{EP}_{t-x,i=hc,f} + \sum_{x=1}^{n} \beta_{8x} \sum_{oc}^{m} \sum_{f=1}^{b} \text{EP}_{t-x,oc,f} $$

$$ + \beta_{10} A_{t,L} + \beta_{11} E_{t,L} + \beta_{17} IP_{t-1,i,L} + \varepsilon_{t,i,L} $$

where $t=1977,...,2008$; $i=1,...,hc, oc,...,m$; Inc= L, F; Entrants: leader $l=1,...,a$; follower $f=1,...,b$; lag years $x=1, ..., n$

-> Endogeneity: lag years, incumbents: application dates & entrants: publication dates
<table>
<thead>
<tr>
<th>Incumbents’ ATV Patents</th>
<th>Following Incumbent</th>
<th>Leading Incumbent</th>
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<tr>
<td></td>
<td>Quantitative Effect</td>
<td>Qualitative Effect</td>
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<tr>
<td><strong># Entrants HC</strong></td>
<td>.0030 (.0054)</td>
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<td><strong># Entrants OC</strong></td>
<td>.0050*** (.0013)</td>
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<td><strong>leading Entrants’ Patents HC</strong></td>
<td>- .0299** (.0137)</td>
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<td><strong>leading Entrants’ Patents OC</strong></td>
<td>.0030 (.0066)</td>
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<td><strong>follower Entrants’ Patents HC</strong></td>
<td>.0286** (.0136)</td>
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<td><strong>ATV Experience</strong></td>
<td>- .0439** (.0219)</td>
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<td><strong>Age</strong></td>
<td>.0246*** (0079)</td>
<td>.0299*** (0096)</td>
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<td>.0637*** (.0128)</td>
<td>.0734*** (.0129)</td>
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<td><strong>Constant</strong></td>
<td>- 2.8954*** (.3867)</td>
<td>-2.5725*** (.3455)</td>
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<td><strong>Observations</strong></td>
<td>591</td>
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Note: Standard errors in parentheses; *, **, *** indicate significance at the 90%, 95%, 99% level.
• control for incumbents’ size, international orientation, patent propensity

• test robustness of results for different measures of: entrants’ expertise & incumbents’ productivity

• split entrant variable ‘other countries’ into: incumbents’ relevant & irrelevant export countries

• consider exits, sailing ship invention of incumbents, technological-opportunities as a driver to innovate, OEM entrants vs. component entrants

• correlation of autoregressive term with ATV demand & R&D subsidies

• do incumbents file only defensive patents to block other firms?

• incumbents do not undertake in-house R&D, purchase patents or obtain patents by M&A  
  → change in patent ownership available on the patent’s electronic register
Thank you for your attention!

Comments & Questions are welcome.

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Aghion et al. (2009): **foreign entry**, incumbents across industries, UK
→ positive effect on incumbents’ productivity growth & patenting, only for technological advanced industries

Iacovone et al. (2011): effects of **foreign entry** on domestic incumbents, before/after China’s entry into the WTO (2001)
→ induces productive incumbents to innovate more and less productive to innovate less
→ competition pressure reinforces difference of strong and weak performing firms → spurs a positive selection

Czarnitzki et al. (2008, 2011): CIS data base
→ incumbent leaders show higher R&D intensity than average firms, only **entry threat**
→ average firm shows a lower R&D intensity, only if entry threat compared to when there is none

**Contribution to the literature:**
→ international entrants: most incumbents, industries at the technological frontier, global markets
→ same technological trajectories
→ distinguish between quantitative & qualitative entry
→ firm level empirical evidence for heterogeneous response of incumbents
Sustainable Entrepreneurship

Figure 1: SuE Publications between 1999 & 2010
Hence, if entry is crucial to spark the sustainable transition of the automotive industry & escape lock-in, it is highly important also from a political point of view to maintain a sufficient entrepreneurship friendly environment in order to allow for the competitive forces to contribute to the sustainable structural change dynamic.

Therefore, this case study tries to contribute to disentangle the competitive forces of entry imposed on incumbents.

- It seeks to gain more insight on whether it is rather the quantitative pure presence or rather the qualitative component of entry in terms of their expertise that causes the incumbents to react and to eventually spark this structural change process in the automotive industry.
\[ IPS_{t,i,Inc} = \beta_0 + \sum_{x=1}^{n} \beta_{1x} NE_{t-x,i=hc} + \sum_{x=1}^{n} \beta_{2x} \sum_{rc}^{3} NE_{t-x,rc} + \sum_{x=1}^{n} \beta_{3x} \sum_{ic}^{m} NE_{t-x,ic} \]

\[ + \sum_{x=1}^{n} \beta_{4x} \sum_{l=1}^{a} EP_{t-x,i=hc,l} + \sum_{x=1}^{n} \beta_{5x} \sum_{l=1}^{a} \sum_{rc}^{3} EP_{t-x,rc,l} + \sum_{x=1}^{n} \beta_{6x} \sum_{l=1}^{a} \sum_{ic}^{3} EP_{t-x,ic,l} \]

\[ + \sum_{x=1}^{n} \beta_{7x} \sum_{f=1}^{b} EP_{t-x,i=hc,f} + \sum_{x=1}^{n} \beta_{8x} \sum_{f=1}^{b} \sum_{rc}^{3} EP_{t-x,rc,f} + \sum_{x=1}^{n} \beta_{9x} \sum_{f=1}^{b} \sum_{ic}^{3} EP_{t-x,ic,f} \]

\[ + \beta_{10} A_{t,L} + \beta_{11} S_{t,L} + \beta_{12} G_{t,L} + \beta_{13} E_{t,L} + \beta_{14} D_{t,L} + \beta_{15} I_{t,L} + \beta_{16} C_{L} + \beta_{17} IP_{t-1,i,L} + \varepsilon_{t,i,L} \]

where \( t = 1977, \ldots, 2009 \); \( i = 1, \ldots, hc, rc, ic, \ldots, m \); \( Inc = F \) or \( L \)

→ Endogeneity: lag years, incumbents: application dates, entrants: publication dates
• increasing number of entrants pursue innovation of sustainable manner (Hockerts et al. 2008; Schaltegger/Wagner, 2011; Kardos, 2012)

• important from a policy perspective (Hockerts/Wüstenhagen, 2010)