GSBC - EIC | The Economics of Innovative Change

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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Objective

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, Incumbents & Disruptive Technologies (DT)

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); Malerbaet 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)

Entrants' Indirect Contribution to the Technological Change

→ 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

spur incumbents

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

Choice of Automotive Industry

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

Hypotheses

Technological Change:

Quantitative Entry Forces

H1 [2]:
The **number of ATV entrants** has a positive [weakly/negative] effect
on leading [follower] incumbents' ATV patent activity

Qualitative Entry Forces

H3 [4]:
Entrants' aggregated **ATV patents** have a positive [weakly/negative] effect
on leading [follower] incumbents' ATV patent activity

Structural Change:

H5: Heterogeneous responses of incumbent leaders and incumbents followers

Entry Characteristics:

H6: Effect of entrants with high expertise is stronger than effect of entrants with low expertise

Methodology: Separations

country i = 1,…hc, oc,…, m
incumbent: 15 largest OEMs (International Organization of Motor Vehicles)

quantitative effect:
yearly sum of 1st ATV patent filings → # of newly founded & lateral entrants

qualitative effect:
yearly sum of all operating entrants' patents → yearly R&D of newly founded entrants
founding year: very first patent filing; entrant: <=7 years on the market

Incumbents' productivity in ATV patenting

$$IProd_{t_y} = \sum_{t=t_{y-4}}^{t=t_y} P_t/5 \Big/ max \sum_{t=t_{y-4}}^{t=t_y} P_t/5$$

→ incumbent leader (20%) & follower (80%)

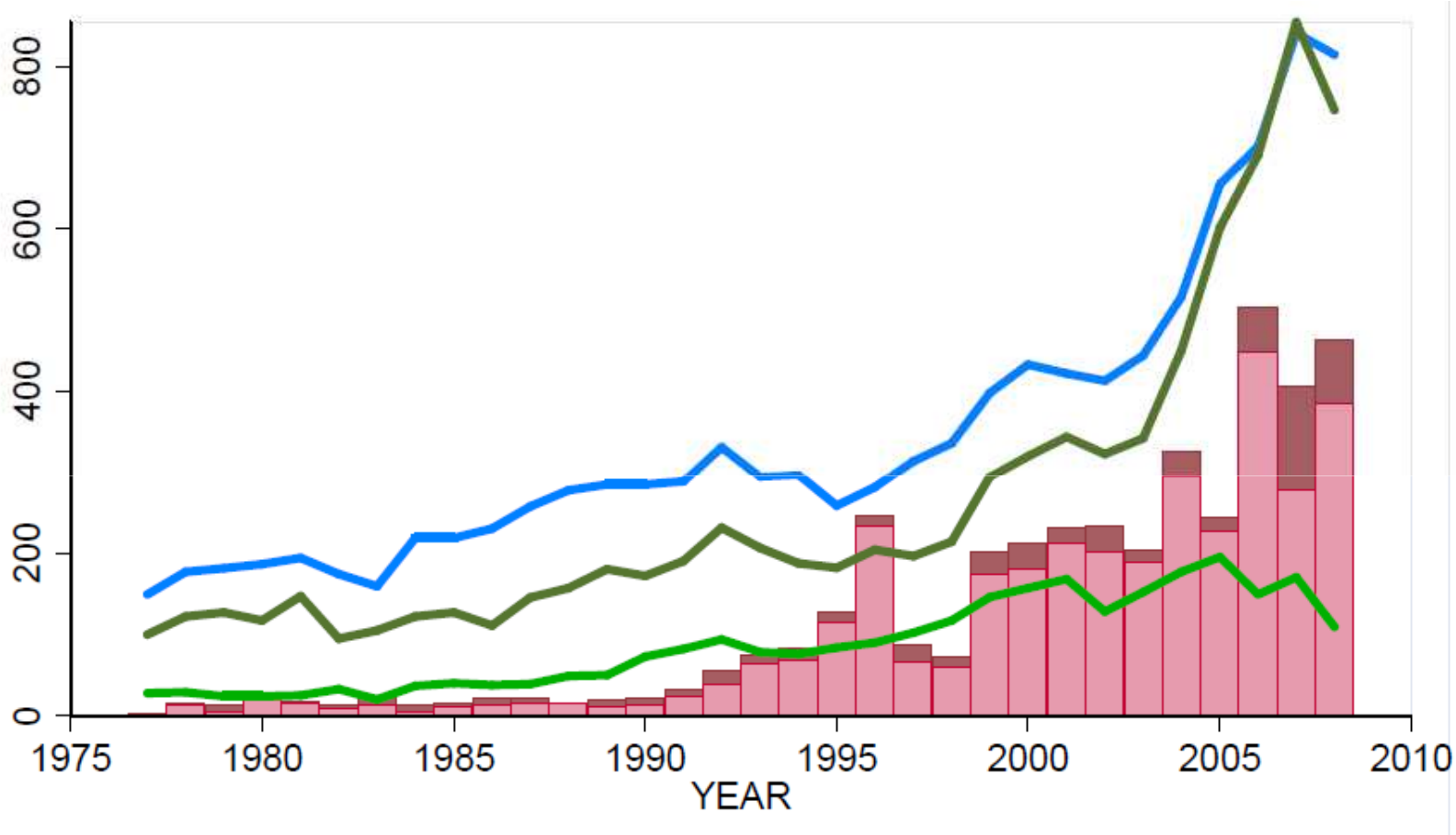
C: # citation
w: citation window
P: # patents

Entrants' technological relevance

$$ETR_{t_y} = \sum_{t=t_0}^{t=t_y} \sum_{w=1}^{w=3} C_{t,t+w} \Big/ max \sum_{t=t_0}^{t=t_y} \sum_{w=1}^{w=3} C_{t,t+w}$$

→ entrant leader (10%) & follower (90%)

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

Methodology: Variables & Data

$IP_{t, i, Inc}$	yearly # incumbents' individual ATV patents
$NE_{t-x, i}$	yearly # entrants (newly founded & lateral)
$EP_{t-x, i, E}$	yearly # newly founded entrants' aggregated ATV patents

$A_{t, Inc}$	Age (from founding year(1st patent filing) until t)
$E_{t, Inc}$	Experience in ATV research (from 1st ATV patent filing until t)
$IP_{t-1, Inc}$	External Factors

- 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

Methodology: Model

home country | other countries

$$IP_{t,i,Inc} = \beta_0 + \sum_{x=1}^{n} \beta_{1x} NE_{t-x,i=hc} + \sum_{x=1}^{n} \beta_{2x} \sum_{oc}^{m} NE_{t-x,oc}$$ **quantitative effect**

leading entrants

$$+ \sum_{x=1}^{n} \beta_{4x} \sum_{l=1}^{a} EP_{t-x,i=hc,l} + \sum_{x=1}^{n} \beta_{5x} \sum_{oc}^{m} \sum_{l=1}^{a} EP_{t-x,oc,l}$$ **qualitative effect**

follower entrants

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

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

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

Incumbents' ATV Patents	Following Incumbent		Leading Incumbent	
	Quantitative Effect	Qualitative Effect	Quantitative Effect	Qualitative Effect
# Entrants HC	.0030 (.0054)		.0067 (0065)	
# Entrants OC	.0050*** (.0013)		- .0037** (.0018)	
leading Entrants' Patents HC		- .0299** (.0137)		.0188* (.0111)
leading Entrants' Patents OC		.0030 (.0066)		.0213*** (.0081)
follower Entrants' Patents HC		.0286** (.0136)		- .0053 (.0120)
follower Entrants' Patents OC		.0031** (.0016)		- .0089*** (.0027)
ATV Experience	- .0439** (.0219)	- .0360 (.0263)	.0900*** (.0315)	.0354 (.0323)
Age	.0246*** (0079)	.0299*** (0096)	- .0164** (.0074)	.0045 (.0084)
ATV Patents t-1	.0637*** (.0128)	.0734*** (.0129)	.0041*** (.0011)	.0053*** (.0014)
Constant	- 2.8954*** (.3867)	-2.5725*** (.3455)	.3999 (.4544)	- .3546 -(.3751)
Observations	591	591	141	139

IV

IV

≤

Note: Standard errors in parentheses; *, **, *** indicate significance at the 90%, 95%, 99% level.

Future Focus

- 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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	noATVp~p	HavE1t..	OCavE1..	LH~7YbfT	LO~7YbfT	FH~7YbfT	FO~7Y
noATVpaten~p	1.0000						
HavE1to7YbfT	0.2420	1.0000					
OCavE1to7Y~T	0.1599	0.1006	1.0000				
LHavEP1to7~T	0.1473	0.8388	0.1085	1.0000			
LOCavE~7YbfT	0.1652	0.1194	0.9433	0.0363	1.0000		
FHavEP1to7~T	0.4136	0.8667	0.2450	0.5770	0.3175	1.0000	
FOCavE~7YbfT	0.1682	0.1895	0.9732	0.2063	0.9094	0.2899	1.0
age	0.0004	0.2963	-0.0249	0.3370	-0.0452	0.1098	0.0
experience	0.1507	0.3279	0.4221	0.3746	0.4033	0.2566	0.4
ATVpatent_1	0.7784	0.2438	0.1575	0.1713	0.1557	0.4046	0.1

Previous Empirical Findings: Heterogeneous Response

Aghion et al. (2009): **foreign entry**, incumbents across industries, UK
→positive effect of 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 innovative 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

JD5 Josi; 23.07.2013

Sustainable Entrepreneurship

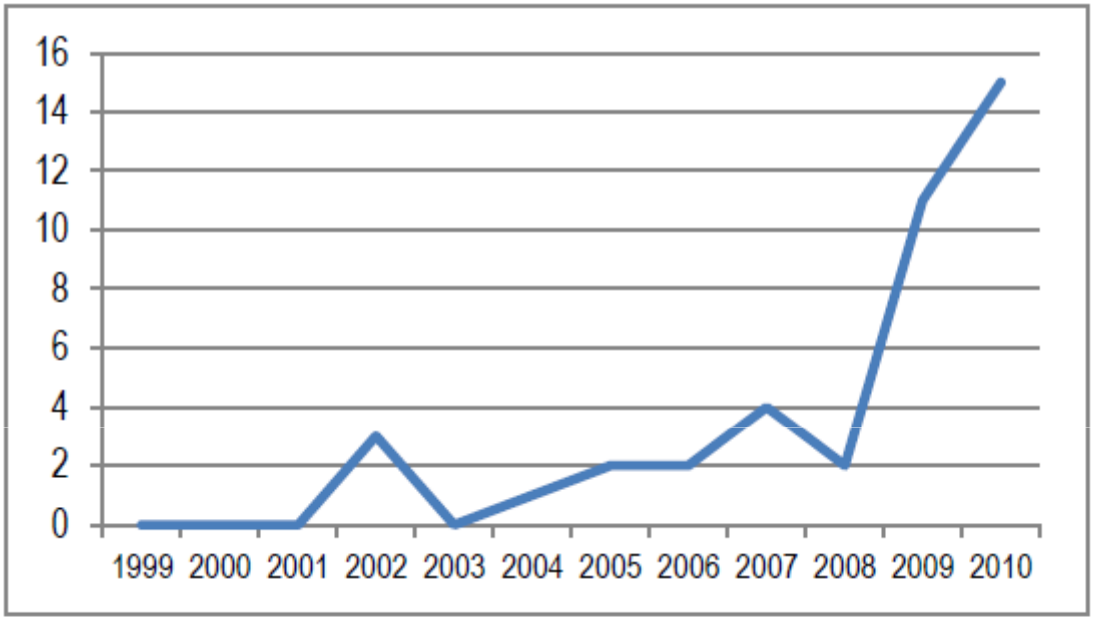


FIGURE 1: SUE PUBLICATIONS BETWEEN 1999 & 2010

•Hence, if entry is crucial to spark the sustainable transition of the automotive industry & escape lock-in →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.

home country | relevant countries | irrelevant countries

$$IPS_{t,i,Inc} = \beta_0 + \sum_{x=1}^{n}\beta_{1x}NE_{t-x,i=hc} + \sum_{x=1}^{n}\beta_{2x}\sum_{rc}^{3}NE_{t-x,rc} + \sum_{x=1}^{n}\beta_{3x}\sum_{ic}^{m}NE_{t-x,ic}$$ **quantity**

leader

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

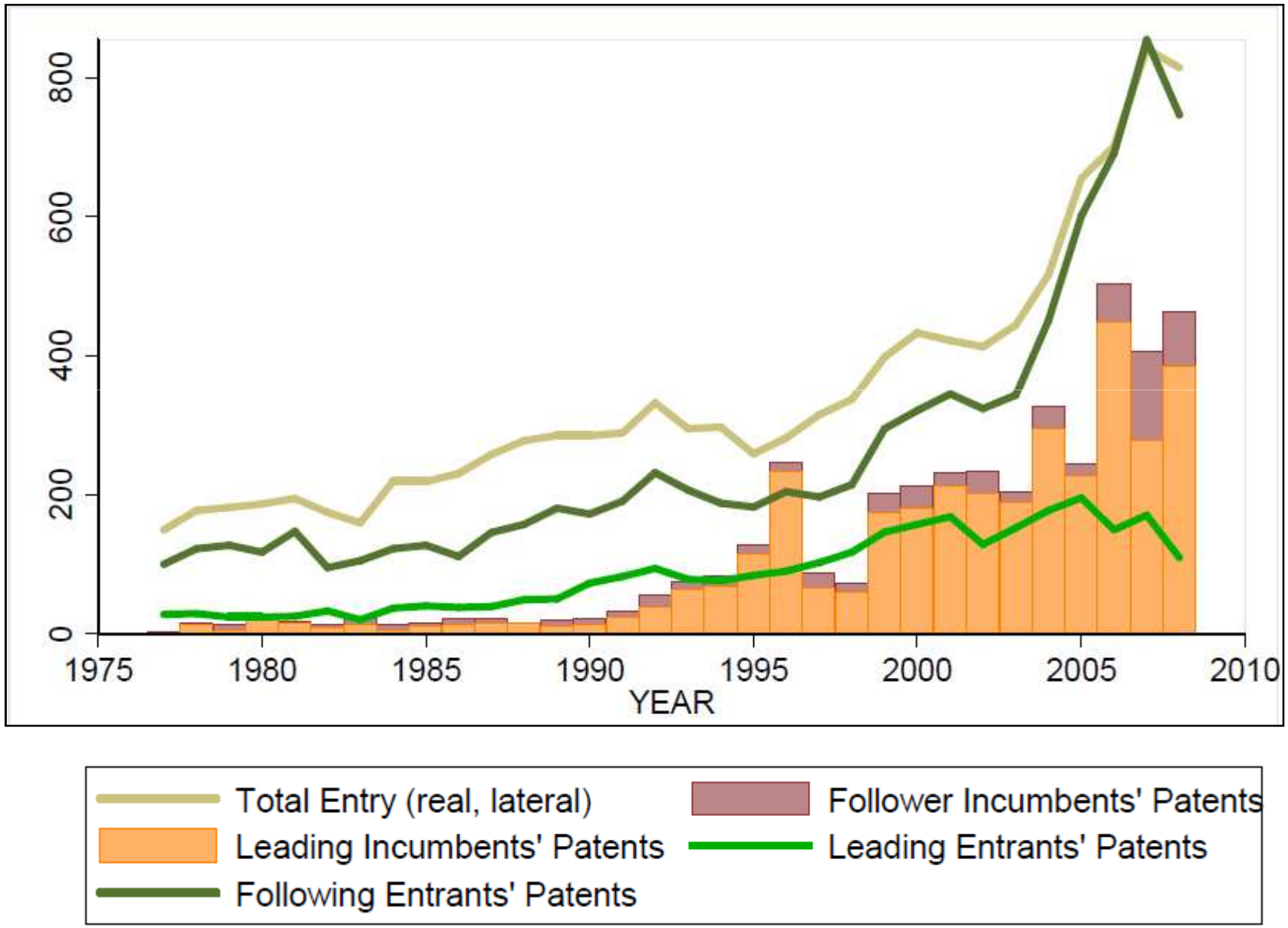
follower

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

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

where t=1977,..., 2009; i=1,...hc, rc, ic,...,m; Inc= F or L

→Endogeneity: lag years, incumbents: application dates, entrants: publication dates


0
200
400
600
800
1975
1980
1985
1990
1995
2000
2005
2010
YEAR
Total Entry (real, lateral)
Leading Incumbents' Patents
Following Entrants' Patents
Follower Incumbents' Patents
Leading Entrants' Patents

Why Entry Dynamics Important for Transition towards Sustainability

- 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)