The Risks of Innovation: Are Innovating Firms Less Likely to Die?

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11th Comparative Analysis of Enterprise Data & COST Conference (CAED 2012)

26-28 April 2012, Nuremberg, Germany

Motivation and Preview of Findings

- Firm survival: key element of industrial evolution (Caves, 1998; Tybout, 2000)
- 'Being innovative': feature of superior firms but has risks (e.g., high sunk development costs)

  >>> We study the relationship between product innovation and plant survival for Chilean plants between 1996 and 2003
  >>> Focusing on how RISK mediates that relationship

- Main findings
  - Product innovation is beneficial for the survival of Chilean plants
  - But the effects are heterogeneous: only multi-product plants and plants engaging in 'cautious' innovation benefit

Contributions

- We add to the literature on firm survival and firm characteristics (e.g., Disney, Haskel and Heden 2003; Esteve-Perez, Llopis and Llopis 2004; Manjon-Antolin and Arauzo-Carod, 2008) by:

  - Using a novel measure of product innovation that is objective, plant-level and time-varying
  - Capturing incremental new-to-the-plant innovations which can be crucial in an emerging economy context
  - Examining the role of risk as a determinant of innovation-survival link
  - Using a more rigorous identification of the effects that accounts for unobserved firm heterogeneity

Data and Some Statistics

- Unique dataset on Chilean manufacturing plants and their products collected by the Chilean Statistical Institute for period 1996-2003 (ENIA)
  - Allows us to identify plants part of multi-plant firms
  - Combined with older versions of ENIA follows plants since 1979
- Product innovation: dummy = 1 for plant in year *t* selling a 7-digit ISIC product it never sold prior to *t-1*
- Average share of plants introducing new products is 13.4%
  - Lowest for food, beverage, and tobacco industries
  - Highest for basic metals and wood industries
- Average yearly exit rate is above 9%
- 8% of plants are part of a multi-plant firm
- 51% of plants are multi-product

Examples of 7-Digit ISIC Products

4-digit-ISIC	Industry Description	7-digit ISIC	Product Description
3117	Manufacture of bakery products	3117101	Bread of any kind, size and quality (except for sweet bread)
		3117402	Mixed dough (for different types of cakes)
		3117201	Cookies, with and without sugar and filled
		3117301	Noodles, pasta including macaroni
3311	Sawmills, planing and other wood mills	3311997	Saw log and/or shaped log
		3311119	Log produced in all types
		3311302	Wooden boards for prefabricated houses
		3311306	Wooden doors with or without glass

Model Specification (1)

- 'Hazard' model to estimate probability that a plant exits at *t* conditional on having survived until *t-1*

- Cox proportional hazard model
  - Baseline hazard depending only on time duration is multiplied by an exponential function of plant characteristics
  - Allows to estimate the effects of plant characteristics without making assumptions on distribution of baseline hazard function
  - Assumes that the impact of any characteristic on a plant's survival probability is independent of plant age
    - *We will check the validity of this assumption*

Model Specification (2)

Our benchmark empirical specification is a conditional hazard function:

$$\lambda_i^1(t) = \lambda_0(t) e^{(\beta Innovation_{it} + \gamma X_{it} + I_t + I_r + I_j)}$$

To explore differences across multi- and single-product plants our main empirical specification is another conditional hazard function:

$$\lambda_i^2(t) = \lambda_0(t) e^{(\beta^1 Innovation_{it} * Multi + \beta^2 Innovation_{it} * Single + \gamma X_{it} + I_t + I_r + I_j)}$$

Rich set of plant controls in X addresses possibility that unobservables determine product innovation and survival

Benchmark Results

	Cox Proportional Hazard Regression				
	(1)	(2)	(3)	(4)	(5)
Product Innovation	-0.152**	-0.158**	-0.143**	-0.153**	-0.151**
	(0.065)	(0.065)	(0.066)	(0.067)	(0.067)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
4-Digit Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes	Yes	Yes
Observations	21381	21381	21281	20497	20497

Col. (1) only as specified while Cols (2-4) add progressively controls [(2) multi-plant firm dummy, (3) size, capital intensity, (4) labor productivity]

Col. (5) adds interactions with plant age of multi-plant firm dummy, capital intensity, productivity whose effects are not independent of age

Robust standard errors clustered at the plant level

Product innovation has a positive effect on plant survival

Main Results

	Cox Proportional Hazard Regression				
	(1)	(2)	(3)	(4)	(5)
Product Innovation * Multi-Product Plants	-0.216***	-0.212***	-0.219***	-0.209***	-0.205***
	(0.079)	(0.079)	(0.079)	(0.080)	(0.080)
Product Innovation * Single-Product Plants	0.296**	0.303**	0.319***	0.235*	0.234*
	(0.121)	(0.120)	(0.121)	(0.130)	(0.130)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
4-Digit Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes	Yes	Yes
P-Value for Difference in Product Innovation Coefficients	0.00	0.00	0.00	0.00	0.00
Observations	21381	21381	21281	20497	20497

Cols. (1–5) equivalent to previous

Robust standard errors clustered at the plant level

Multi-product plants that innovate exhibit higher survival whereas single-product plants that innovate exhibit lower survival, relative to non-innovating plants

Robustness (1)

	Cox Proportional Hazard Regression						
	Single Plants Only	Excluding Plants with Less than 15 Employee	Innovation at 6-digit Level	Additional Industry Controls	Additional Plant Controls	Allow unique baseline hazard by 4-digit	Allow unique baseline hazard for each year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Product Innovation * Multi-Product Plants	-0.188**	-0.246**		-0.204**	-0.207***	-0.166**	-0.210***
	(0.080)	(0.101)		(0.080)	(0.079)	(0.079)	(0.080)
Product Innovation * Single-Product Plants	0.270**	0.215		0.235*	0.242*	0.145	0.228*
	(0.130)	(0.163)		(0.131)	(0.130)	(0.139)	(0.132)
Product Innovation 6-digit * Multi-Product Plants			-0.225**				
			(0.089)				
Product Innovation 6-digit * Single-Product Plants			0.271*				
			(0.144)				
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4-Digit Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
P-Value for Difference in Product Innovation Coefficients	0.00	0.01	0.00	0.00	0.00	0.05	0.00
Observations	19073	12433	20497	20488	20496	20497	20497

Robustness (2)

	OLS - Linear Probability Model		Weibull		Complementary Log-Log	
	Simple	Plant Fixed-Effects IV Regression	Simple	Frailty - Assuming Gamma Distribution	Simple	Frailty - Assuming Normal Distribution
	(8)	(9)	(10)	(11)	(12)	(13)
Product Innovation * Multi-Product Plants	-0.011*	-0.303*	-0.188**	-0.345***	-0.137*	-0.151*
	(0.006)	(0.158)	(0.079)	(0.131)	(0.083)	(0.090)
Product Innovation * Single-Product Plants	0.051***	0.938*	0.255*	0.119	0.480***	0.503***
	(0.019)	(0.556)	(0.131)	(0.204)	(0.143)	(0.160)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
4-Digit Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
P-Value for Difference in Product Innovation Coefficients	0.00	0.04	0.00	0.00	0.04	0.00
Observations	20497	20564	20497	20497	20332	20497

Defining cautious innovators

- Risk of introducing a new product higher if the product is of substantial importance for a plant's overall revenues
  - Cautious: introduce new products on a small scale
- Risks of engaging in product innovation are higher if the plant introduces new products but stops manufacturing old products
  - Cautious: introduce new products but keep old products
- A plant follows a more risky innovation strategy if it introduces new products in a completely new industry in which it has less technical and market knowledge
  - Cautious: introduce new products in a known industry

Risk and Innovation

	Cox Proportional Hazard Regression		
	(1)	(2)	(3)
Product Innovation Less than 50% Revenues	-0.238***		
	(0.082)		
Product Innovation More than 50% Revenues	0.020		
	(0.105)		
Product Innovation without Product Dropping		-0.615***	
		(0.120)	
Product Innovation with Product Dropping		0.134*	
		(0.078)	
Product Innovation in an Old 4-digit Industry			-0.207**
			(0.092)
Product Innovation in a New 4-digit Industry			-0.098
			(0.091)
Year Fixed Effects	Yes	Yes	Yes
4-Digit Industry Fixed Effects	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes
P-Value for Difference in Product Innovation Coefficients	0.04	0.00	0.38
Observations	20497	20497	20497

Product innovation has a positive effect on plant survival only for cautious innovators

Conclusion

- Innovation is powerful for plant survival …
- … but only under certain circumstances:
  + multi-product plants, risk-mitigating innovators
  - single-product plants and plants engaged in risky product innovations are at greater risk of exit than non-innovators
- Exit risks explain plants' under-investment in innovation (in addition to the traditional rationales of a lack of appropriation of all benefits)
- Policies to help plants reduce the risks of innovation while keeping the right incentives are appropriate