Learning Before and After the Global Crisis:
Firm-level Innovation in Latin America

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Motivation

- Strong theoretical literature that **"opportunity cost"** should incentivize learning during economic downturns (Aghion & Saint-Paul, 1998; Blackburn & Galindev, 2003).

- How does the business-cycle and demand-side shocks impact within-firm activities, specifically profitability and innovation activities? Limited evidence, with exceptions: Wälde and Woitek (2004, on G7 economies) and Lee (2016, Korea).

Related Literature:

- Financial and banking crises on firms' activities and firm responses (Archibugi et al. 2013; Kroszner et al. 2007; Bassetto et al. 2015; Fort et al. 2013; Foster et al.2016)

- Innovation decisions and outcomes (Griffith et al. 2006; Hall, 2011)

Aim

1. To assess if innovation investment results in heterogenous innovation outcomes across the business cycle; &

2. To examine if the profitability outcomes of firm-level innovation differs over the business cycle.

The Model Assumptions

1. That individuals are identical in their preferences in consumption and time allocation, firms are heterogeneous. Both are indexed by $j \in [0, J]$ so that each individual owns a firm in the economy.

2. Technological progress in the economy occurs through both external and internal learning (Baily et al. 2001; Bilbiie et al. 2012; Haltiwanger, 2012; Blackburn & Galindev, 2003; Blackburn & Varvarigos, 2008; and Galindev, 2008)

The Model

The output produced in each period t, Y_t, consists of a continuum basket of differentiated goods in $[0, M_t]$, where M_t is the aggregate variety available.

Let q_i denotes the quantity of variety i, so:

$$Y_t = \left\{ \int_0^{M_t} [q_{i,t}]^{(\theta-1)/\theta} di \right\}^{\theta/(\theta-1)}, \tag{1}$$

where $\theta > 1$ is the elasticity of substitution across the different varieties.

The Model

The cost function for each variety i produced by firm j is represented by:

$$C^j_{i,t}(q^j_{i,t}) = F^j_{i,t} + c^j_{i,t} q^j_{i,t}, \tag{2}$$

- $F^j_{i,t}$ is the fixed cost and $c^j_{i,t}$ is the marginal cost of production.
- The fixed cost component and the associated probability of innovation success is assumed to be common across all varieties.

The Model

A firm j producing variety i will engage in process innovation iff:

$$pr^j_{process}[F^j_{L,t} + \phi(g^{z,j}_t)] \geq (1 - pr^j_{process})[F^j_{H,t} + \phi(g^{z,j}_t)] \tag{3}$$

Taking the optimized marginal cost as given, firms choose the price of a variety i that maximizes variable profits given by:

$$\pi^j_{i,t} = [p^j_{i,t} - c^j_{i,t}]q^j_{i,t}(p^j_{i,t}) \tag{4}$$

In each period t, the firm decides whether to introduce a specific variety i (product innovation):

$$\Pr(\pi^j_{i,t} \geq 0 | F^j_{i,t}, c^j_{i,t}) E(\pi^j_{i,t} | \pi^j_{i,t} \geq 0; F^j_{i,t}, c^j_{i,t}) \geq 0 \tag{5}$$

Propositions

- **Proposition 1**: *The threshold probability of product innovation (above which firms would engage in innovation) is lower, the higher the success probability of process innovation of a firm.*

- **Proposition 2**: *The expected profits and product innovation of a typical firm is strictly pro-cyclical to preference shock if the costs associated with product and process innovation are independent of its knowledge stock growth.*

  However, this can also be anti-cyclical if the marginal product of learning is greater than the marginal product of production.

Empirical Strategy

$$PdctInnov_{c,jt} = \alpha_0 + \alpha_1 PcessInnov_{c,jt} + \alpha_2 Z_{c,jt-1} + \sum_{l=1}^{L} \psi_{l,c} X_{l,c,jt} + \sum_{m=1}^{n-1} \lambda_{m,c} \Xi_{m,c,jt} + \mu_j + \varepsilon_{c,jt}, \quad (6)$$

$$\pi_{c,jt} = \beta_0 + \beta_1 PdctInnov_{c,jt} + \sum_{k=1}^{K} \psi_k \Upsilon_{k,c,jt} + \sum_{m=1}^{n-1} \lambda_m \Xi_{m,c,jt} + \mu_j + v_{c,jt}. \quad (7)$$

Data

Table: Countries, Years and Observations

	2006	2010	2017
Argentina	180	180	180
Bolivia	82	82	82
El Salvador	66	66	66
Honduras	28	28	28
Nicaragua	47	47	47
Peru	148	148	148
Uruguay	61	61	61
Total	612	612	612

Data

Table: Variable Definitions

Variable	Definition
Product	(0/1) if firm introduced a process innovation
Process	(0/1) if firm introduced a product innovation
Profit	Log revenues minus cost (US$)
Labour Productivity	Log sales per worker (US$)
Innovation Efficiency $(2004-2006)$	Predictions from a Heckman equation
Innovation Efficiency $(2008-2010)$	Predictions from a Heckman equation

Results: Innovation Pre-Downturn (2004-2006)

	Dependent Variable: **Product Innovation**				
	Model 1	Model 2	Model 3	Model 4	Model 5
Innovation Efficiency	0.040*	0.069*	0.009*	0.042*	0.039*
	(0.017)	(0.032)	(0.004)	(0.017)	(0.018)
Process	1.511***	2.598***	0.471***	1.529***	1.531***
	(0.164)	(0.294)	(0.049)	(0.161)	(0.164)
Investment	-0.127***	-0.222***	-0.036***	-0.133***	-0.125***
	(0.017)	(0.031)	(0.005)	(0.017)	(0.018)
Foreign Technology	0.893**	1.531**	0.208***		0.897**
	(0.283)	(0.512)	(0.063)		(0.296)
R-squared			0.485		
Chi-Squared	210	168		202	225
Observations	549	549	549	549	549

Notes: Models 1, 4 & 5 are Probit regressions, Model 2 is from a Logit regression and Model 3 is from an linear probability model. All regressions include industry and country fixed effects and robust standard errors are in parentheses.

Results: Innovation Post-Downturn (2015-2017)

	Dependent Variable: **Product Innovation**				
	Model 1	Model 2	Model 3	Model 4	Model 5
Innovation Efficiency	0.050*	0.086*	0.019*	0.051*	0.052*
	(0.023)	(0.039)	(0.008)	(0.022)	(0.023)
Process	0.661***	1.106***	0.225***	0.673***	0.690***
	(0.126)	(0.213)	(0.041)	(0.124)	(0.129)
Investment	-0.007	-0.014	-0.003	-0.005	-0.010
	(0.018)	(0.030)	(0.006)	(0.017)	(0.018)
Foreign Technology	0.184	0.271	0.038		0.101
	(0.243)	(0.419)	(0.065)		(0.248)
R-squared			0.119		
Chi-Squared	62	57		49	68
Observations	512	512	512	512	512

Notes: Models 1, 4 & 5 are Probit regressions, Model 2 is from a Logit regression and Model 3 is from an linear probability model. All regressions include industry and country fixed effects and robust standard errors are in parentheses.

Results: Profit Pre-Downturn (2004-2006)

	Dependent Variable: **Profit**				
	Model 1	Model 2	Model 3	Model 4	Model 5
Product	3.645***	3.657***	3.626***	3.649***	3.684***
	(0.475)	(0.477)	(0.467)	(0.473)	(0.475)
Capital	0.907***	0.906***	0.907***	0.907***	0.905***
	(0.091)	(0.091)	(0.091)	(0.091)	(0.091)
Material	-0.861***	-0.860***	-0.863***	-0.861***	-0.859***
	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)
Labour Productivity	0.439***	0.440***	0.440***	0.439***	0.440***
	(0.055)	(0.055)	(0.055)	(0.055)	(0.055)
R-Squared	0.648	0.648	0.649	0.648	0.647
First Stage F-Test	426.874	426.459	426.520	425.078	423.076
Industry FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Observations	519	519	519	519	519

Notes: Differences in the models are based on the approach to predicting product innovation. All regressions include industry and country fixed effects and robust standard errors are in parentheses.

Results: Profit Post-Downturn (2015-2017)

	Dependent Variable: **Profit**				
	Model 1	Model 2	Model 3	Model 4	Model 5
Product	0.591	0.591	0.580	0.682	0.549
	(0.535)	(0.535)	(0.533)	(0.539)	(0.535)
Capital	0.559***	0.558***	0.559***	0.557***	0.556***
	(0.121)	(0.121)	(0.121)	(0.129)	(0.119)
Material	-1.161***	-1.162***	-1.160***	-1.171***	-1.158***
	(0.053)	(0.053)	(0.053)	(0.054)	(0.053)
Labour Productivity	1.155***	1.156***	1.150***	1.157***	1.153***
	(0.103)	(0.103)	(0.103)	(0.103)	(0.103)
R-Squared	0.670	0.670	0.669	0.668	0.670
First Stage F-Test	697.197	690.912	691.447	470.177	778.072
Industry FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Observations	489	489	489	489	489

Notes: Differences in the models are based on the approach to predicting product innovation. All regressions include industry and country fixed effects and robust standard errors are in parentheses.

Robustness Checks Pre-Downturn (2004-2006)

	Dependent Variable: **Product Innovation**				
	Model 1	Model 2	Model 3	Model 4	Model 5
Non-Exporters					
Innovation Efficiency	0.047*	0.080*	0.009*	0.049**	0.047*
	(0.019)	(0.034)	(0.004)	(0.018)	(0.019)
Process	1.673***	2.917***	0.506***	1.702***	1.714***
	(0.209)	(0.386)	(0.058)	(0.206)	(0.213)
Non-ISO9000					
Innovation Efficiency	0.032*	0.054	0.008*	0.036*	0.032
	(0.016)	(0.029)	(0.004)	(0.016)	(0.017)
Process	1.472***	2.526***	0.465***	1.510***	1.515***
	(0.157)	(0.280)	(0.048)	(0.155)	(0.158)

Notes: Models 1, 4 & 5 are Probit regressions, Model 2 is from a Logit regression and Model 3 is from an linear probability model. All regressions include industry and country fixed effects and robust standard errors are in parentheses.

Robustness Checks Post-Downturn (2015-2017)

	Dependent Variable: **Product Innovation**				
	Model 1	Model 2	Model 3	Model 4	Model 5
Non-Exporters					
Innovation Efficiency	0.054*	0.092*	0.020**	0.052*	0.056*
	(0.022)	(0.038)	(0.008)	(0.021)	(0.022)
Process	0.627***	1.039***	0.213***	0.651***	0.634***
	(0.139)	(0.234)	(0.046)	(0.137)	(0.141)
Non-ISO9000					
Innovation Efficiency	0.132*	0.228**	0.042*	0.130*	0.136*
	(0.054)	(0.088)	(0.017)	(0.053)	(0.057)
Process	0.665***	1.107***	0.229***	0.711***	0.703***
	(0.125)	(0.211)	(0.042)	(0.123)	(0.127)

Notes: Models 1, 4 & 5 are Probit regressions, Model 2 is from a Logit regression and Model 3 is from an linear probability model. All regressions include industry and country fixed effects and robust standard errors are in parentheses.

Robustness Checks Pre-Downturn (2004-2006)

	Dependent Variable: **Profit**				
	Model 1	Model 2	Model 3	Model 4	Model 5
Non-Exporters					
Product	3.209***	3.195***	3.234***	3.259***	3.281***
	(0.526)	(0.527)	(0.510)	(0.526)	(0.517)
Non-ISO9000					
Product	4.283***	4.258***	4.272***	4.268***	3.798***
	(0.604)	(0.606)	(0.604)	(0.603)	(0.609)

Notes: Differences in the models are based on the approach to predicting product innovation. All regressions include industry and country fixed effects and robust standard errors are in parentheses.

Robustness Checks Post-Downturn (2015-2017)

	Dependent Variable: **Profit**				
	Model 1	Model 2	Model 3	Model 4	Model 5
Non-Exporters					
Product	-0.133	-0.112	-0.116	0.427	-0.279
	(0.764)	(0.766)	(0.763)	(0.820)	(0.744)
Non-ISO9000					
Product	2.944	2.776	2.726	1.731	1.930
	(1.602)	(1.586)	(1.645)	(1.449)	(1.488)

Notes: Differences in the models are based on the approach to predicting product innovation. All regressions include industry and country fixed effects and robust standard errors are in parentheses.

Summary

We contribute to the literature by developing and testing a theoretical framework of the differentiated effects of innovation on profitability pre and post economic crises.

We show:

1. Sample firms are relatively innovation-efficient to realize innovation.
2. Profitability outcomes varies over the business cycle.
3. Benefit of innovation may be stronger during a crisis compared to other periods.

Thank you!