



Innovation and Productivity in Services: Evidence from Chile

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What do we do?

- We investigate the relationship between innovation inputs, innovation outputs and productivity.
- We analyze the service (whole sector and KIBS) and manufacturing sectors to compare key variables in both:
 - Innovative activity (R&D and innovations)
 - Productivity determinants.
- We also analyze the role of non-technological innovation.

Data

- We use 5th and 6th Chilean Innovation Surveys
- The data has a time span covering the years 2005-2008.
- Unfortunately, level of disaggregation to 1 digit ISIC
- KIBS is defined as sectors K (real state, renting and business activities) and I (transport, storage and communications)

Methodology

- CDM model (Crepon et al 1998), with the specification of Crespi and Zuñiga (2011).
- The model connects innovation investment, innovation performance and productivity.
- This model has 3 stages:
 1. Decision to invest in innovation
The intensity (amount) of expenditure on innovation (innovation expenditure / employment)
 2. A "knowledge production function" that relates the inputs of innovation outcomes (product or process innovation)
 3. A "output production function" in which productivity is modeled as a function of the outcome of innovation and other controls.

Stage 1: investment decision and innovation intensity.

- We use a generalized Tobit
- We modeled as latent variable

$$IE_i^*$$

$$IE_i^* = Z_i' \beta + \varepsilon_i$$

$$ID_i = 1 \text{ if } IE_i^* = W_i' \alpha + e_i > c, \text{ and } 0 \text{ otherwise.}$$

$$IE_i = \begin{pmatrix} IE_i^* = Z_i' \beta + \varepsilon_i & \text{if } ID_i = 1. \\ 0 & \text{if } ID_i = 0. \end{pmatrix}$$

Stage 1: investment decision and innovation intensity.

- Explanatory variables
 - Exporting firm (dummy)
 - Size (log employment)
 - Foreign ownership of the firm (dummy)
 - Patent application at $t-1$ (dummy)
 - Cooperation for innovation (dummy)
 - Public funding for innovation
 - Sources of information (market, scientific and public, dummy)

Stage 2: Knowledge Production Function

- Probit model
- Outcome of innovation: introduced a new product or service / also non-technological innovation

$$P(I_i = 1) = \delta I \hat{E}_i + Y_i' \gamma + \mu_i$$

- Since spending on innovation is endogenous, we use the Tobit predicted value
- Explanatory variables
 - Size
 - Export (dummy)
 - Foreign company (dummy)

Stage 3: Output Production Function

- Assuming a C-D

$$y_i = \alpha_1 k_i + \alpha_2 I_i + v_i$$

- Where y is output per worker (log sales), k is capital per worker, I is the innovation stock per worker.
- We use proxies: new equipment spending fraction of total equipment spending, predicted innovation outcomes (to address endogeneity)

Summary Statistics

	5th Innovation Survey				6th Innovation Survey			
	Manuf	Serv	No KIBS	KIBS	Manuf	Serv	No KIBS	KIBS
Firm Characteristics								
1.- Size (average employment)	142.3	171.3	173.1	183.0	109.9	200.8	210.2	188.8
2.- Skilled labor force (% of total labor force)	1.8%	2.0%	0.9%	3.2%	0.6%	0.8%	0.2%	1.3%
3.- Export propensity	29.7%	2.8%	2.4%	3.6%	25.6%	4.6%	6.4%	1.5%
4.- Propensity to cooperate for R&D	16.9%	14.5%	15.1%	12.9%	7.4%	6.5%	7.2%	5.0%
5.- % that applied to one or more patents	5.7%	3.0%	1.9%	4.0%	1.5%	1.3%	1.8%	0.2%
Inputs								
6.- % of firms that spent in innovation	36.8%	37.3%	34.9%	39.9%	28.3%	28.0%	26.0%	28.5%
7.- Total expenditures on innovation (% of total turnover)	1.4%	2.2%	1.7%	2.8%	2.50%	1.27%	1.13%	1.12%
8.- Total expenditure on R&D (as % of total turnover)	0.5%	1.2%	0.3%	2.2%	0.23%	0.24%	0.13%	0.37%
Technological Innovation								
9.- Firms that introduced a product innovation	21.2%	17.0%	12.5%	21.8%	21.0%	18.5%	15.5%	21.0%
10.- Firms that introduced a process innovation	31.7%	28.2%	28.0%	28.4%	19.6%	16.8%	15.7%	17.6%
11.- Firms that introduced a product or a process innovation	34.3%	31.7%	30.7%	32.8%	27.8%	25.0%	22.7%	26.1%
Non-Technological Innovation								
12.- Firms that introduced a marketing innovation	17.3%	13.0%	10.6%	15.5%	14.3%	7.2%	7.0%	7.4%
13.- Firms that introduces an organizational innovation	29.5%	36.0%	35.2%	36.9%	19.5%	21.3%	19.6%	21.9%
14.- Firms that introduced marketing or organizational innovation	32.7%	37.8%	36.4%	39.3%	22.2%	22.0%	20.1%	22.8%
Public Policy								
15.- Firms that received public financial support	6.8%	4.6%	3.2%	6.1%	5.3%	2.2%	1.7%	2.8%

Tobit model

VARIABLES	(1)	(2)	(3)	(4)
	Manufacturing	Services	Traditional Serv	KIBS
5th and 6th Innovation Surveys 2005-2008				
<i>Selection (prob of spending in innov)</i>				
Exporting	0.0786*** (0.0232)	0.0648** (0.0286)	0.0403 (0.0377)	0.0965** (0.0435)
Foreign	0.0232 (0.0309)	0.0139 (0.0244)	0.0258 (0.0323)	0.000621 (0.0375)
Size	0.0974*** (0.00720)	0.0553*** (0.00925)	0.0565*** (0.00423)	0.0510*** (0.00555)
Patent Protection	0.359*** (0.0526)	0.307*** (0.0528)	0.365*** (0.0790)	0.273*** (0.0714)
<i>Intensity (log amount spend in innov per employee)</i>				
Exporting	0.645*** (0.157)	0.425** (0.200)	0.234 (0.281)	0.548* (0.284)
Foreign	0.318 (0.194)	0.0983 (0.233)	0.443 (0.277)	-0.207 (0.370)
Public financial support	0.276 (0.218)	0.472** (0.225)	0.170 (0.331)	0.814*** (0.289)
Patent Protection	0.258 (0.224)	0.662*** (0.237)	0.504 (0.359)	0.627** (0.319)
Co-operation in R&D	0.533*** (0.139)	0.677*** (0.124)	0.409*** (0.159)	1.019*** (0.197)
Market info sources (INFO1)	-0.0647 (0.174)	0.151 (0.172)	-0.00636 (0.236)	0.199 (0.244)
Scientific sources (INFO2)	-0.000433 (0.102)	-0.120 (0.101)	-0.0459 (0.139)	-0.196 (0.138)
Other spillovers (INFO3)	0.00751 (0.148)	0.00709 (0.128)	-0.145 (0.165)	0.198 (0.186)
Observations	2682	4023	2,421	1,602

Robust standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

Knowledge production function

5th and 6th Innovation Surveys 2005-2008

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Manufacturing		Services		Traditional Serv		KIBS	
<i>Innovation output in product or process</i>								
IE_p (predicted Inn exp per employee)	0.603*** (0.0565)		0.494*** (0.0469)		0.286*** (0.0486)		0.480*** (0.0465)	
Size	0.0753*** (0.00812)	0.0861*** (0.00768)	0.0347*** (0.00411)	0.0453*** (0.00394)	0.0438*** (0.00497)	0.0488*** (0.00493)	0.0318*** (0.00675)	0.0391*** (0.00650)
Export (dummy)	-0.391*** (0.0348)	0.112*** (0.0236)	-0.247*** (0.0207)	0.0677** (0.0299)	-0.0863** (0.0377)	0.0559 (0.0410)	-0.302*** (0.0252)	0.0853* (0.0439)
Foreign Ownership (dummy)	-0.204*** (0.0162)	-0.0105 (0.0300)	-0.0764*** (0.0239)	0.00988 (0.0249)	-0.140*** (0.0323)	0.0142 (0.0337)	0.132*** (0.0439)	0.00594 (0.0371)
Observations	2,688	2,688	4,023	4,023	2,421	2,421	1,602	1,602

Robust standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

Output Production Function

Specification 1: using predicted probability of innovation output

VARIABLES	whitout new equipment				with new equipment			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
5th and 6th Innnovation Surveys 2005-2008								
	Manufacturing	Services	Traditioal Serv	KIBS	Manufacturing	Services	Traditioal Serv	KIBS
<i>log labor productivity (sales per worker)</i>								
TI_p (Technological innovation)	1.337*** (0.190)	0.737*** (0.148)	1.896*** (0.374)	0.570*** (0.185)	1.114*** (0.214)	0.771*** (0.211)	1.057*** (0.308)	0.816*** (0.229)
Size	-0.0123 (0.0329)	-0.321*** (0.0188)	-0.358*** (0.0274)	-0.347*** (0.0248)	0.0432 (0.0448)	-0.198*** (0.0343)	-0.232*** (0.0449)	-0.160*** (0.0426)
New Equipment					0.00149 (0.00173)	0.00164 (0.00182)	0.000513 (0.00231)	0.00257 (0.00200)
Constant	10.14*** (0.0952)	11.00*** (0.129)	12.64*** (0.171)	11.57*** (0.121)	9.915*** (0.139)	10.59*** (0.167)	10.65*** (0.133)	10.38*** (0.180)
Observations	2,688	4,023	2,421	1,602	1,415	1,359	878	518
R-squared	0.041	0.197	0.236	0.137	0.050	0.149	0.188	0.058

Bootstrapped standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

Specification 2: using predicted innovation expenditure per employee

VARIABLES	whitout new equipment				with new equipment			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
5th and 6th Innnovation Surveys 2005-2008								
	Manufacturing	Services	Traditional Serv	KIBS	Manufacturing	Services	Traditional Serv	KIBS
<i>log labor productivity (sales per worker)</i>								
Size	-0.0353 (0.0280)	-0.305*** (0.0149)	-0.288*** (0.0211)	-0.336*** (0.0230)	-0.00471 (0.0366)	-0.181*** (0.0263)	-0.200*** (0.0351)	-0.139*** (0.0397)
IE_p (predicted Inn exp per employee)	0.736*** (0.0548)	0.384*** (0.0449)	0.650*** (0.0915)	0.238*** (0.0589)	0.753*** (0.0731)	0.431*** (0.0697)	0.526*** (0.136)	0.260*** (0.0731)
New Equipment					0.00116 (0.00165)	0.00173 (0.00171)	0.000335 (0.00229)	0.00290 (0.00209)
Constant	7.367*** (0.194)	10.26*** (0.140)	10.86*** (0.296)	11.34*** (0.187)	6.950*** (0.265)	9.058*** (0.283)	10.93*** (0.457)	9.546*** (0.305)
Observations	2,688	4,023	2,421	1,602	1,415	1,359	878	518
R-squared	0.099	0.204	0.247	0.141	0.104	0.157	0.200	0.058

Bootstrapped standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

Extensions

Additionally we investigate the role of:

- Non technological innovation (marketing, organization and management)

Knowledge production function for non-technological Innovation

VARIABLES	(1)	(2)	(3)	(4)
	5th and 6th Innovation Surveys 2005-2008			
	Manufacturing	Services	Traditional Serv	KIBS
<i>Non-technological innovation output</i>				
IE_p (predicted Inn exp per employee)	0.607*** (0.0551)	0.402*** (0.0423)	0.0725** (0.0342)	0.436*** (0.0472)
Size	0.0537*** (0.00730)	0.0342*** (0.00399)	0.0486*** (0.00493)	0.0234*** (0.00653)
Export (dummy)	-0.385*** (0.0323)	-0.182*** (0.0247)	0.0268 (0.0418)	-0.248*** (0.0277)
Foreign Ownership (dummy)	-0.189*** (0.0220)	-0.0879*** (0.0220)	-0.0455 (0.0349)	0.0629 (0.0438)
Observations	2,672	3,983	2,412	1,571

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Productivity and non technological Innovation

Specification 1: using predicted probability of non-tech innovation

whitout new equipment

	(1)	(2)	(3)	(4)
	5th and 6th Innnovation Surveys 2005-2008			
VARIABLES	Manufacturing	Services	Traditional Serv	KIBS
<i>log labor productivity (sales per worker)</i>				
TI_p (non-technological innovation)	1.281***	0.958***	7.989***	0.782***
	(0.176)	(0.177)	(1.062)	(0.199)
Size	0.0186	-0.329***	-0.669***	-0.351***
	(0.0280)	(0.0186)	(0.0575)	(0.0228)
Constant	10.09***	12.90***	10.98***	11.57***
	(0.0915)	(0.121)	(0.115)	(0.110)
Observations	2,672	3,983	2,412	1,571
R-squared	0.038	0.198	0.243	0.141

Bootstrapped standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Conclusions

- We find that the Chilean service sector is as innovative as manufactures.
- In particular we find that KIBS spend more in R&D than manufactures.

Conclusions

- Empirical support for CDM model in services
- We find some evidence in KIBS of a larger role of cooperation as a determinant of innovation activities.
- In services the size of the plants seem to play a smaller role than in manufactures as determinant of innovation activities.

Conclusions

- There are important similarities between manufactures and services that allow us deny strongly that the service sector is less innovative than manufactures.
- It could be good news for developing countries that transit towards a service economy.
- However, there are important differences regarding the determinants of innovation and productivity that need to be explored further.