

TO INNOVATE OR NOT TO INNOVATE

The case of Uruguayan manufacturing firms

Adriana Cassoni[¥]

Magdalena Ramada-Sarasola^Υ

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¥ GEOPS – acassoni@gmail.com

Υ Watson Wyatt – Magdalena.Ramada@watsonwyatt.com



Overall Objective:

¿Are scarce efforts devoted to innovation
one of the underlying causes of
Uruguayan meagre performance in terms
of *per capita* GDP growth?

Answer: no

It is not the lack of efforts devoted to borderline activities but instead:

- The use of a non-optimal input mix not accounting for complementarities: investment too concentrated on innovative inputs + disregard of R&D, especially if innovating in processes
- The still insufficient generation of relevant innovative processes: returns to innovation are a lot higher when the innovation output is restricted to processes

Other Findings:

- Innovative processes are used to cope with economic recessions successfully
- Links with NIS agents are not perceived as inadequate
- Financial aid is not particularly binding
- Differing results on the impact of innovation on productivity LA vs Europe and others maybe due to not accounting for innovation processes and to focusing just on R&D investment

Policy Recommendations:

- Connect specific knowledge centres with productive actors: technical information
 - Develop adequate information channels
 - Focus on strengthening internal efficiency, especially in the case of small size firms
- ? Conditioning financial aid on improving internal production processes)

Other Issues:

- Intensity and Knowledge Production Function different for Products and Processes
- Warning on the use of non-expanded micro-data pooling certainty units with stratified sampling observations (Fazio, Lam & Ritchie, 2008)
- Relevance of including other innovation inputs in the economic analyses
- Work on new indicators that account for processes and for complementarities is needed
- Crucial role of analysing data in depth – subjectivity and design of questionnaires
- Importance of incorporating the economic cycle dimension



Future Research

- Specify Knowledge Production Function so as to analyse different input mixes
- Analyse input-output dynamics of each of the 3 processes separately
- Analyse effects on productivity of each process separately
- Interact variables with business cycle

Specific Goals

- **Characterise innovative behaviour of firms**
 - CDM model: integrated sequential process
 - Propensity/ Intensity/ Input-output/ Productivity
 - Role of NIS agents and access to financial aid
- **Existence of complementarities**
 - Inputs: distributional mechanism *versus* only R&D
 - Output: knowledge production function
- **Role of Processes Innovation**
 - Scale effects *versus* returns to innovation
 - Differing results developed *versus* non-developed countries

/ Results

- **≠ w/r to other Latinamerican studies:**
 - Size of effort: >0 effect on output
 - Output: >0 effects on firm performance (as measured by labour productivity growth)
- Supporting evidence
- Returns to Processes Innovation more important than to Product Innovation
- Processes Innovation as a strategy to face downturn

Defining types of Input & Output

- 9 types of innovation input, grouped in 4:
 - Physical capital, Hardware, Software
 - Training Programmes
 - R&D
 - Engineering & Industrial Design, Consultancy Svs., Technology Transfers
- 4 types of innovation output grouped in 2:
 - Only Processes: Org., Comm., Prod.
 - Products (only and/or with any process)

Distribution of firms by innovation input and output 1998 – 2006

(% firms)

	1998-00	2001-03	2004-06
Total firms	100	100	100
Innov. firms	67	55	49
R&D	55	52	44
K+H+S	86	80	82
EID+TT+CS	48	50	37
TP	69	67	69
Only R&D	2	4	3
Only K+H+S	14	13	17
Only EID+TT+CS	2	2	2
Only TP	3	6	6
All Inputs	25	23	17

Distribution of firms by innovation input and output 1998 – 2006

(% firms)

Inn. firms with output	97	99	98
Production Processes	83	84	71
Organisational Procs.	66	68	43
Commercialisation Procs.	53	55	24
Processes	96	95	89
Products	64	64	57
Products & Prod. Procs.	10	13	5
Prods. & Non-Prod. Procs.	5	2	5
Only Processes	36	36	43
Only Production Procs.	10	7	18
Only Non-Prod. Procs.	8	9	13
Only Products	4	5	11
All Outputs	33	34	11

Innovative firms by size and relevance of the innovation output 1998–2006

(% firms)

Relevance of Output		19 & less	20-49	50-149	150 & more
Firm Only	2000	10	33	34	22
	2003	9	30	24	24
	2006	7	24	38	31
Local Market	2000	8	36	39	17
	2003	11	26	36	27
	2006	8	22	38	32
International Market	2000	6	26	23	45
	2003	3	10	35	52
	2006	5	5	43	46
Total	1998	9	28	39	24
	2003	10	33	34	23
	2006	6	23	40	31

Inputs mix by type of innovation output and firm characteristics

(% firms investing in each input)

	Products				Only Processes			
	R&D	K+H+S	Training	EID+TT+CS	R&D	K+H+S	Training	EID +TT+CS
All Firms								
2000	71	95	80	56	32	83	58	36
2003	69	82	76	61	22	82	58	35
2006	69	90	75	45	14	78	67	31
Exporting Firms								
2000	75	92	81	60	34	81	54	38
2003	74	90	82	63	27	87	65	40
2006	78	92	79	51	16	75	75	36
Non Exporting Firms								
2000	52	100	80	51	31	86	63	33
2003	57	69	57	57	15	76	49	29
2006	51	86	68	32	12	82	59	24
National Ownership								
2000	68	92	78	57	29	82	55	33
2003	66	83	75	61	21	83	55	32
2006	66	90	79	43	13	77	66	29
Non-National Ownership								
2000	46	65	50	27	44	67	67	50
2003	44	56	52	41	25	60	45	35
2006	77	90	67	50	5	57	43	14
Large Firms - 50 & more workers								
2000	78	94	87	60	35	85	63	40
2003	77	88	82	62	28	86	68	42
2006	69	92	79	44	15	79	69	31
Small Firms - 49 & less workers								
2000	61	86	75	51	28	79	49	28
2003	56	73	67	59	15	78	48	28
2006	69	86	69	46	14	75	64	31

Complementarities: Inputs

Innovation Input Concentration Index

- Original aim: 4-equations system
- First step: Herfindhal-type index - IICI $\in [0,1]$
 - 1= concentrated on 1 input
 - Weights: share of expenditure

	Obs.	Mean	Std.Dev.	Min.	Max.
IICI	2314	0,303	0,377	0	1
IICI2	2314	0,326	0,401	0	1

Defining Output: Overall Innovation Output Indicator

- Original aim: value of output for each type
- First step: differentiate according to relevance - firm, local market, international market:
- $OIOI \in [0, \infty]$ Our sample: $OIOI \in [0, 45]$
- Weight: inverse frequency of each category within each type

Weights OIOI: value for each type of output

Products		Organizational Process	
Firm	2,12	Firm	1,68
Local Market	2,89	Local Market	3,12
International Market	5,50	International Market	11,67
Productive Process		Commercialization Process	
Firm	1,73	Firm	1,29
Local Market	3,23	Local Market	5,80
International Market	8,91	International Market	19,40

Descriptive Statistics OIOI

	Obs.	Mean	SD	Min	Max
OIOI All Output	828	7,59	7,04	1,288	45,485
OIOI Only Processes	776	6,10	6,34	1,288	39,985

CDM Model

$$\text{If } g_i^* \geq C_i^* \Rightarrow g_i = \mathbf{X}_{0i} \boldsymbol{\beta}_0; \quad \text{if } g_i^* < C_i^* \Rightarrow g_i = 0 \quad (1)$$

$$\text{If } g_i \neq 0 \Rightarrow k_i = \mathbf{X}_{1i} \boldsymbol{\beta}_1; \quad \text{if } g_i = 0 \Rightarrow k_i = 0 \quad (2)$$

$$\text{If } k_i \neq 0 \Rightarrow t_i = k_i \alpha + \mathbf{X}_{2i} \boldsymbol{\beta}_2; \quad \text{if } k_i = 0 \Rightarrow t_i = 0 \quad (3)$$

$$\ln q_i = \sigma \sum t_i + \mathbf{Z}_i \boldsymbol{\lambda} + \mathbf{X}_{3i} \boldsymbol{\beta}_3 \quad \text{or else:}$$

$$\Delta \ln q_i = \sigma t_i + \boldsymbol{\lambda}' \Delta \ln \mathbf{Z}_i + \boldsymbol{\beta}_3' \Delta \ln \mathbf{X}_{3i} \quad (4)$$

Where: g_i^* is a latent variable denoting firm i 's propensity to innovate; C_i^* is a certain threshold interpretable as a decision criterion to innovate; so that whenever g_i^* exceeds C_i^* it would thus be possible to observe innovative activities performed by firm i , denoted as g_i . The size or intensity of the innovation effort is captured by k_i ; t_i is the innovation output; and q_i is the log of labour productivity, so that $\Delta \ln q_i$ refers to its rate of growth. The vectors \mathbf{X}_{0i} , \mathbf{X}_{1i} and \mathbf{X}_{3i} include firm, sector and macroeconomic characteristics, while factors of production are gathered in vector \mathbf{Z}_i .

Uruguay: Propensity

- Procyclical
- Scale matters
- Skill level – absolute and relative to sector – matters, including having R&D formal unit (if products), high previous labour productivity level
- Capital endowment is not an issue
- Information stemming from firm and specific knowledge agents fosters propensity
- Obstacles stem mainly from the firm

Uruguay: Intensity of Innovation

- Own financing: less intensity if procs./Irrelevant for prods
- More effort the more concentrated the market for procs
- Cycle has no role
- Input mix:
 - The more concentrated the input mix the smaller the effort, especially for procs
 - To spend in R&D lowers the effort for both
 - TP lowers effort if procs & raises effort if prods
 - K+H+S rises effort if prods
 - IICI: - effect on both: diversification raises effort
- Characteristics of production:
 - Scale -
 - Skilled labour +
 - Proximity to sector avg. +
 - Destiny of sales for prods: exports + (competition)

Econometric Results

Variables	Innovation Effort		
	Propensity All firms	OnlyProcs	Product
Size: 20-49	0.13*	-0.12	-1.5***
Size: 50-149	0.27***	-0.76*	-1.6***
Size: 150 & more	0.36***	-0.58	-2.1***
Engineers/Professionals firm	0.24***	0.69*	0.12
Profs/Empl. – Dev.firm/sector	0.56*	-1.3	-2.9***
Formal R&D unit 1 lag	0.13*	-0.09	0.22
% Foreign capital	-0.28**	-0.26	-0.10
Economic group_d	0.02	---	---
Full export	0.29	0.15	1.5***
Export&local market	0.08	---	---
Avg.labour productiv. 1 lag	0.06**	---	---
Machinery/L, 1 lag	---	-0.01	-0.03
K/L, 1 lag	0.00	---	---
Productive capacity - % use	0.11	0.52	-0.62
Expenditure in R&D - Dummy	---	-0.62**	-0.62***
Expenditure in K+H+S - Dummy	---	0.51	0.55**
Expenditure in TP - Dummy	---	-0.68**	0.72***
Expenditure in EID - Dummy	---	0.04	0.09
IICI	---	-2.7***	-1.02***
Obstacles: firm	-0.13*	---	---
Obstacles: macro	-0.01	---	---
Obstacles: market	0.01	---	---
Financing - Own resources only	---	-0.55**	-0.26
Inform. Source: gral knowl.	-0.02	---	---
Inform. Source: specif. knowl.	0.20 ***	---	---
Inform. Source: consultants	-0.01	---	---
Inform. Source: headquarters	0.06	---	---
Inform. Source: related agents	0.10	---	---
Inform. Source: internal	0.17***	---	---
Business cycle sector	1.2*	-1.1	-0.19
Concentration market	-0.01	1.3***	0.16
Uncertainty	-2.9	---	---
Number of Observ.	1388	298	484
PSUs/Strata	672/4	246/4	323/4
Rho	0.27	0.06	0.34
Over-identifying Restrictions	-----	-----	-----

Uruguay: Innovation Output Equations

- 1% increase in effort generates 0.25% increase in relevance of innovation output
- If Prods.: diversification raises relevance
- If Procs.: concentrating in K+H+S lowers relevance
- Technical aspects:
 - Skill matters, scale is positively correlated
 - K intensity enhances process innovation
 - Anticyclical: focus on relevance in recessions

Uruguay: Returns to Innovation

- Higher for procs.: 0.24 vs 0.15 (in line with CDM = 0.1)
- No role of NIS agents on that
- No role of size
- CRS
- Market concentration favours productivity
- Procyclical

Econometric Results

Variables	Innovation Output		Productiv Growth
	OnlyProcs	Product	All firms
In Inn. Expenditure/Sales	0.26 *	0.25 ****	---
In K+H+S & TP/Sales	-0.23 **	---	---
In R&D & EID+TT+CS/ Sales	---	0.04	---
OIOI - All	---	---	0.02 ****
OIOI - Only Processes.	---	---	0.04 ****
Size: 20-49	0.07	0.26	---
Size: 50-149	0.25 *	0.23	---
Size: 150 & more	0.52 ****	0.57 ****	---
Size: 50 & more	---	---	-0.028
Engineers/Professionals firm	0.10	0.22 **	---
Profs/Empl.- Dev.firm/sector	---	---	---
Formal R&D unit 1 lag	0.17	0.13 *	---
Formal R&D in all three periods	0.32	---	---
% Foreign capital	0.11	0.16	---
Avg.labour productiv. 1 lag	---	---	-0.36 ****
Machinery/L, 1 lag	-0.08 **	0.05	---
Capital/Labour - Rate of Growth	---	---	0.14 ****
Labour - Rate of Growth	---	---	-0.0
IICI	---	-0.47 ****	---
Financing - Own resources only	0.24	-0.21	---
Financing - Related agents	0.40	-0.34	---
Financing - Public sector	0.29	0.07	---
Financing - Banks	0.42 *	-0.20	---
Financing - International	1.4	-1.3 ****	---
Linked with NIS	0.18	-0.28 **	0.02
Link for technical assistance	0.04	0.09	---
Link for R&D	0.18	0.08	---
Link for training	-0.05	0.18 **	---
Link for information	-0.05	-0.10	---
Inform. Source: gral knowl.	-0.28 **	-0.09	---
Inform. Source: specif. knowl.	0.02	-0.055	---
Inform. Source: consultants	-0.01	-0.08	---
Inform. Source: headquarters	0.01	-0.06	---
Inform. Source: related agents	0.14	0.02	---
Inform. Source: internal	-0.05	0.23 ****	---
Business cycle sector	-2.7 ***	-2.3 ***	3.9 ****
Concentration market	0.33	-0.15	0.23 ****
Number of Observ.	268	451	1221
PSUs/Strata	220/4	303/4	610
Rho	0.0581	0.0902	0
Over-identifying Restrictions	3.00	11.817	-----