

Management Quality as an Input for Innovation

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1. MOTIVATION

- The idea that technological progress is driven by the effort in the accumulation of knowledge is the central insight of the endogenous growth literature.
- Large literature on estimating *knowledge production functions* exploring the relationship between Patents and R&D expenditures. Also, in the innovation literature – R&D, innovation, productivity (Crepon, Dougnet and Mairesse, 1998).
- Standard static specification (Hausman, Hall, and Griliches 1984, Blundell, Griffith and Van Reenen 1995) derived from a Cobb-Douglas technology production function:

$$P_{it} = R \& D_{it}^{\beta} \alpha_i$$

1. MOTIVATION

This paper has two objectives, particularly with regards to management practices:

1. *How important is management as an input in the knowledge function.* R&D a very incomplete measure of innovative effort, especially in poor countries.
Data driven?

Historical accounts of the role of building managerial and organizational practices in the process of technological catch up – Japan, Italy, Korea, Singapore – suggest management as key input in the knowledge production function (hobday, Bell,..).

1. MOTIVATION

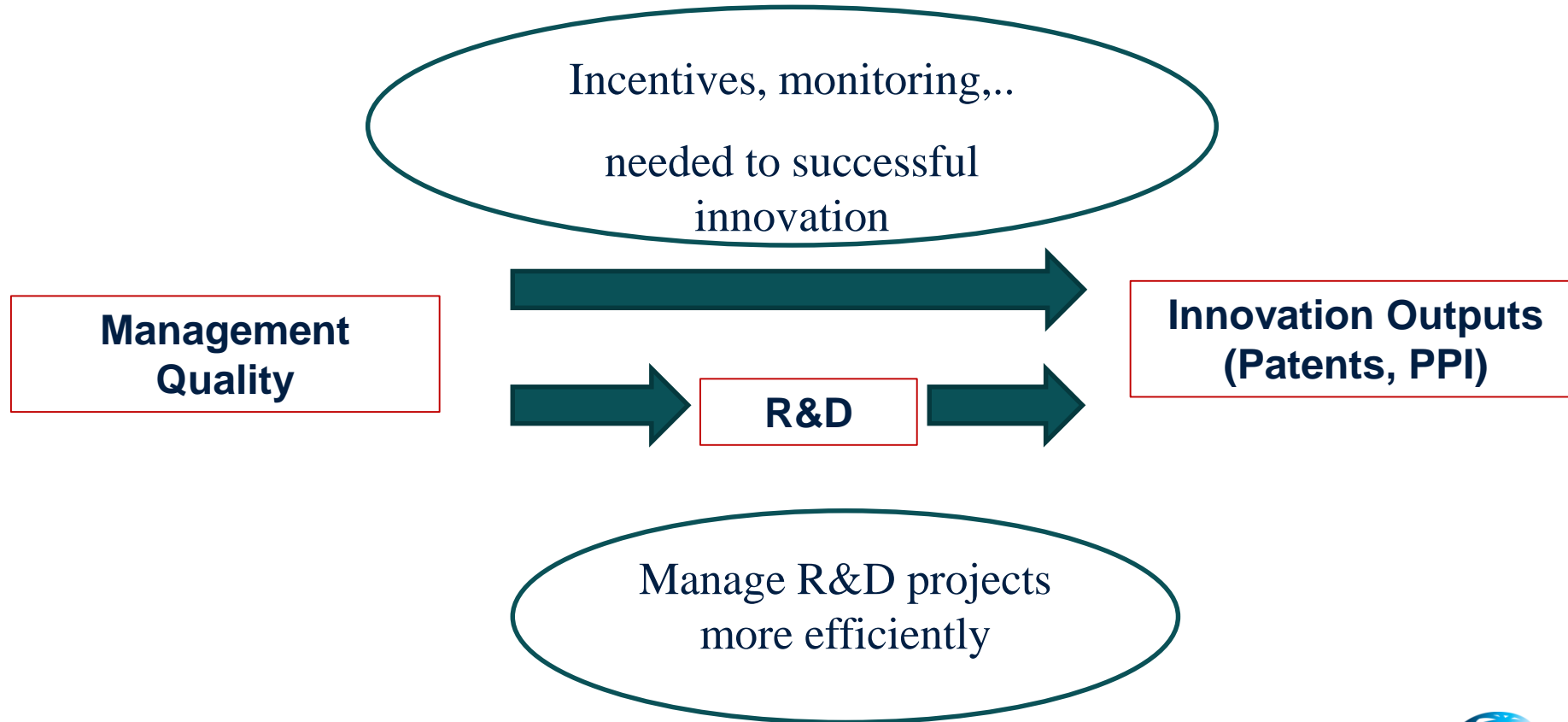
2. *To extent knowledge production function* in two dimensions:

- Patents a very incomplete measure of knowledge production: we add process and product innovation (PPI) as more relevant for developing countries.
- Broader set of countries in the three income regions – high, middle and low income countries.

We use two different datasets – Enterprise Survey (ES) and WMS/ORBIS

2 ROLES OF MANAGEMENT QUALITY IN CREATING KNOWLEDGE

Testing the direct and indirect role of managerial practices in generating innovation



3. METHODOLOGY: AN AUGMENTED KNOWLEDGE PRODUCTION FUNCTION

- We use a standard knowledge production function with management quality (MQ) as an additional factor:

$$K_{it} = \exp(\beta \ln R \& D_{it} + \delta_2 \ln MQ_{it}) \alpha_i + \varepsilon_{it}$$

K_{it} – patent applications, decision to apply to patent, decision to introduce product and process innovation.

- Determinants of R&D:

$$R \& D_{it} = MQ_{it}^{\beta} \alpha_i$$

4. DATA: WMS MERGED WITH BVD ORBIS

- *BvD Orbis*: Includes companies' financial accounts, credit scores, directorships, ownership structures, **patents**. Mostly Europe and upper middle income.
- *World Management Survey*. The World Management Survey (WMS)
- Four broad areas: operational management techniques, systematic performance monitoring, appropriate target setting, and talent management.
- We match the WMS with 20 countries in the BvD Orbis sample.
- Bias towards larger, MNEs and in higher income countries

4. DATA: WB ENTERPRISE SURVEY

World Bank Enterprise Survey

- ES includes : firm characteristics, access to finance, annual sales, costs of inputs/labor, workforce composition and other business climate and performance measures.
- Balance sheet and information regarding investment climate.
- The innovation module differentiates between two types of technological innovation outcomes, **product and process (PPI)**.
- Also includes reduced version of MOPS to medium and large firms (above 50 workers) and firms in the manufacturing sector.

$$\widetilde{m}_i = \frac{1}{4} (m_{operations} + m_{monitoring} + m_{targets} + m_{incentives})$$

- 43 low, medium and high income countries from Africa, South Asia, Europe and Central Asia and Middle East and North Africa.

4. DATA: TWO MAJOR LIMITATIONS OF DATA, SO ONLY A FIRST STEP

1. Only a cross section of each sample so we cannot study dynamics. Important since while some works suggest investment and knowledge generation occur contemporaneously (Hall, Griliches and Hausman 1986); although others find substantial lags (Blundell, Griffith and Windmeijer 2002, Lederman et al. 2010).
2. No robust instruments that would fully mitigate endogeneity concerns.

This said:

- Much of the analysis done to date for the advanced countries began in a similar position (Bound et. al 1984, Pakes and Griliches 1980,
- The few dynamic studies which could potentially exploit lagged correlates (Hausman, Hall and Griliches 1984, 1986; Blundell, Griffith and Windmeijer 2002, Blundell, Griffith and Van Reenen 1995) suggest cross-section tells a qualitatively similar story: that R&D is a statistically important correlate of patenting.

4. DATA: SUMMARY

Dataset loss of a significant number of observations, but include 43 countries ES and 20 countries WMS/ORBIS

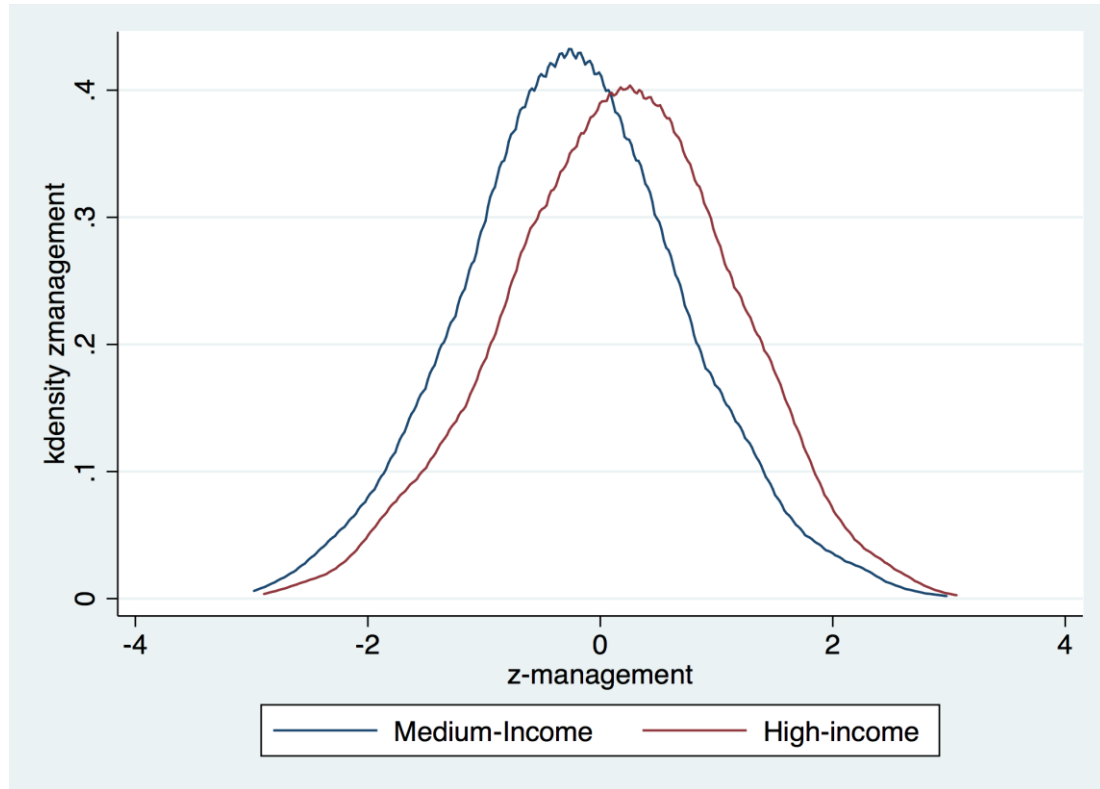
	ES	WMS/ORBIS
Observations	10,212	1,055
Size (employment)	180.64	938
Age	20.47	48
Exporter	38.93%	94%
Foreign owned	8.93%	47%
Management score	-0.0015	0.1891
R&D	26.94%	54.69%
IPP or Patenting	50.41%	23.89%
Product	32.20%	
Process	35.00%	

4. DATA. VARIABLES

- Explain R&D and Innovation knowledge function with almost identical specification

	WMS/ORBIS	ES
R&D effort	Standardized R&D per worker expenditure. Dummy if firm performs R&D	Standardized R&D per worker expenditure. Dummy if firm performs R&D
Management quality	Management z score	Management z score
Size	Log of employment	Log of employment
Exporter	Dummy if exporter	Dummy if exporter
Skills of the labor force	% workforce with college degree (log)	% workers in shop floor with STEM skills
Foreign ownership	Part of a MNE	At least 25% foreign owned
Labor disputes	% of union members	Index 0 to 4 if labor regulations a problem
Financial/revenue constraint	Profit margin	Share of working capital self-funded
Trust in contractual environment		Index 0 to 4 whether informal sector is an obstacle (proxy for tax code enforcement)

4. DATA. MANAGEMENT QUALITY – HIGHER VARIANCE ON ES DATA

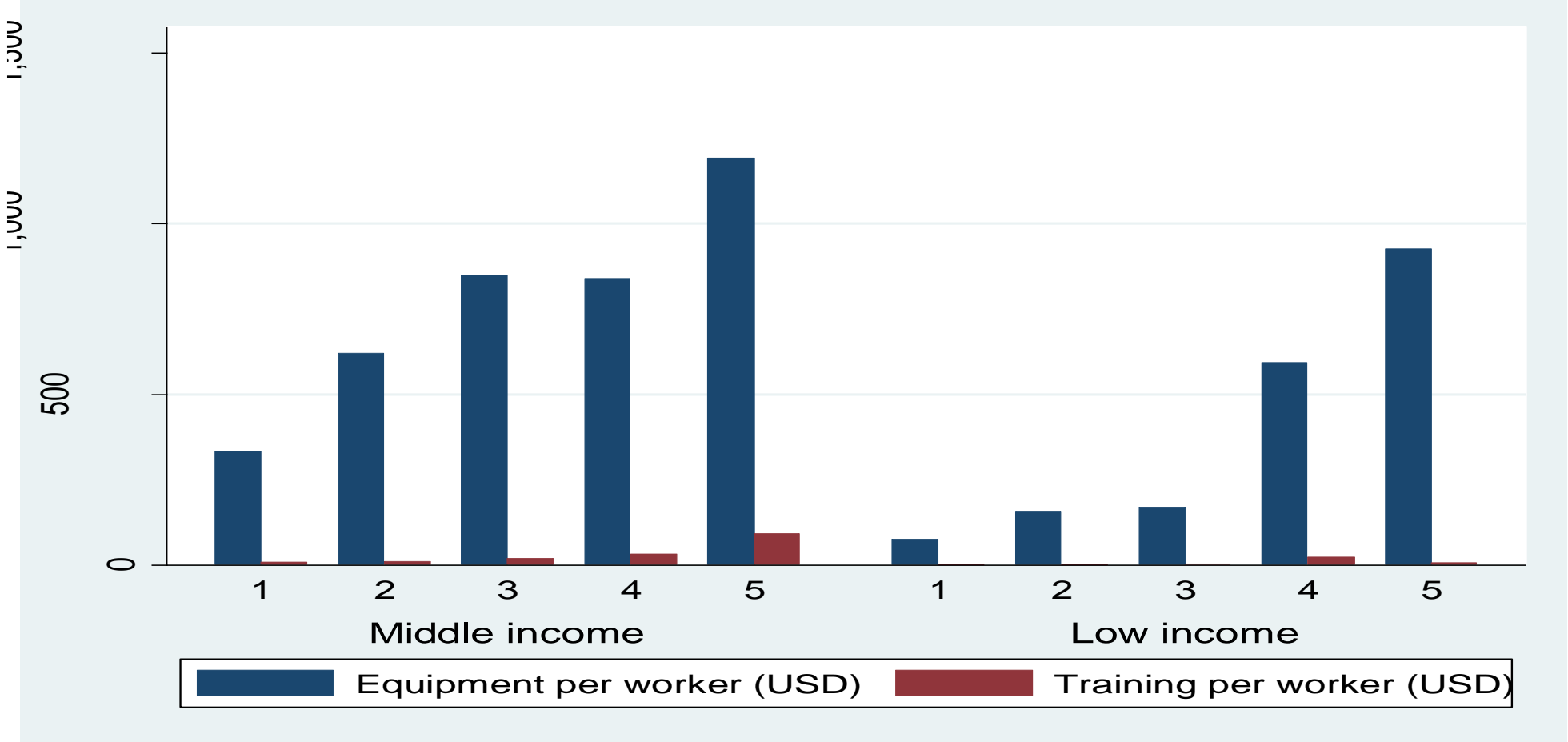


WMS/ORBIS

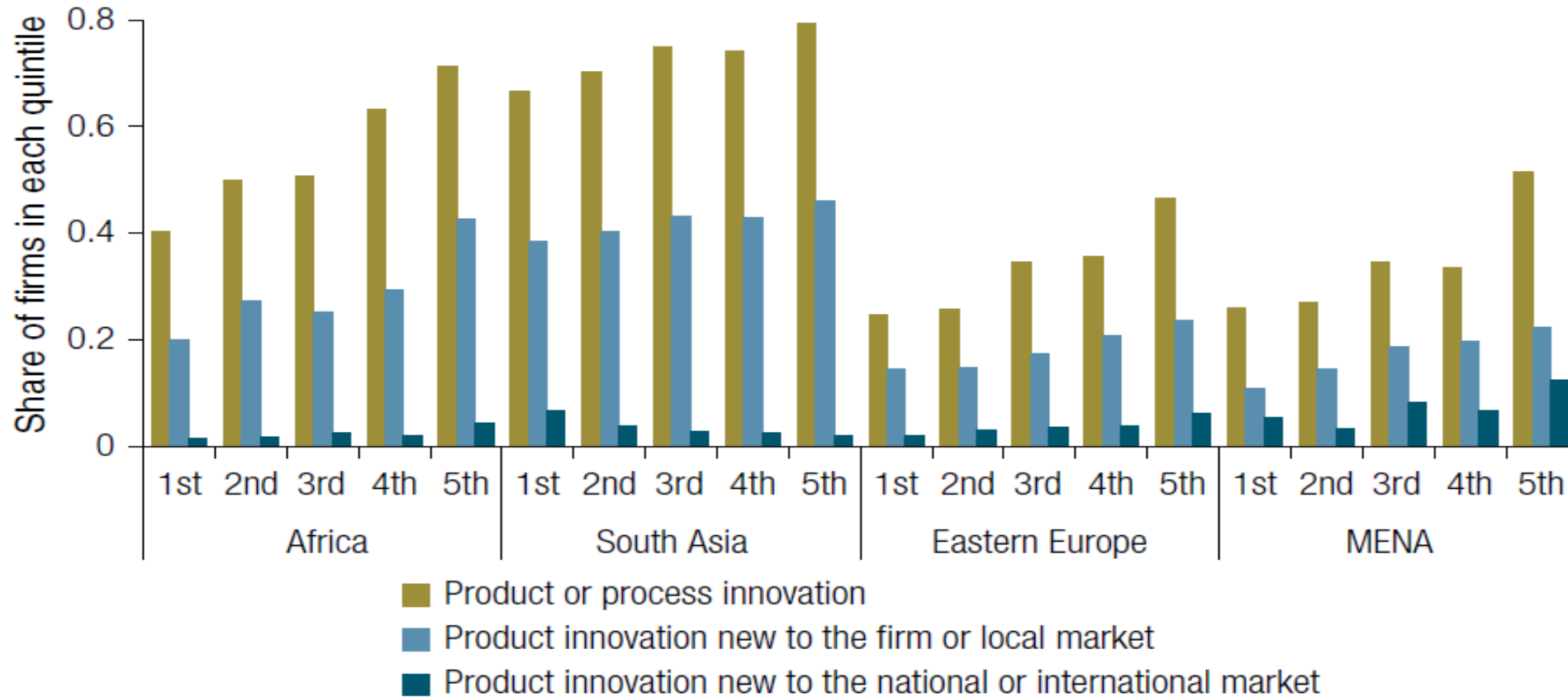


ES

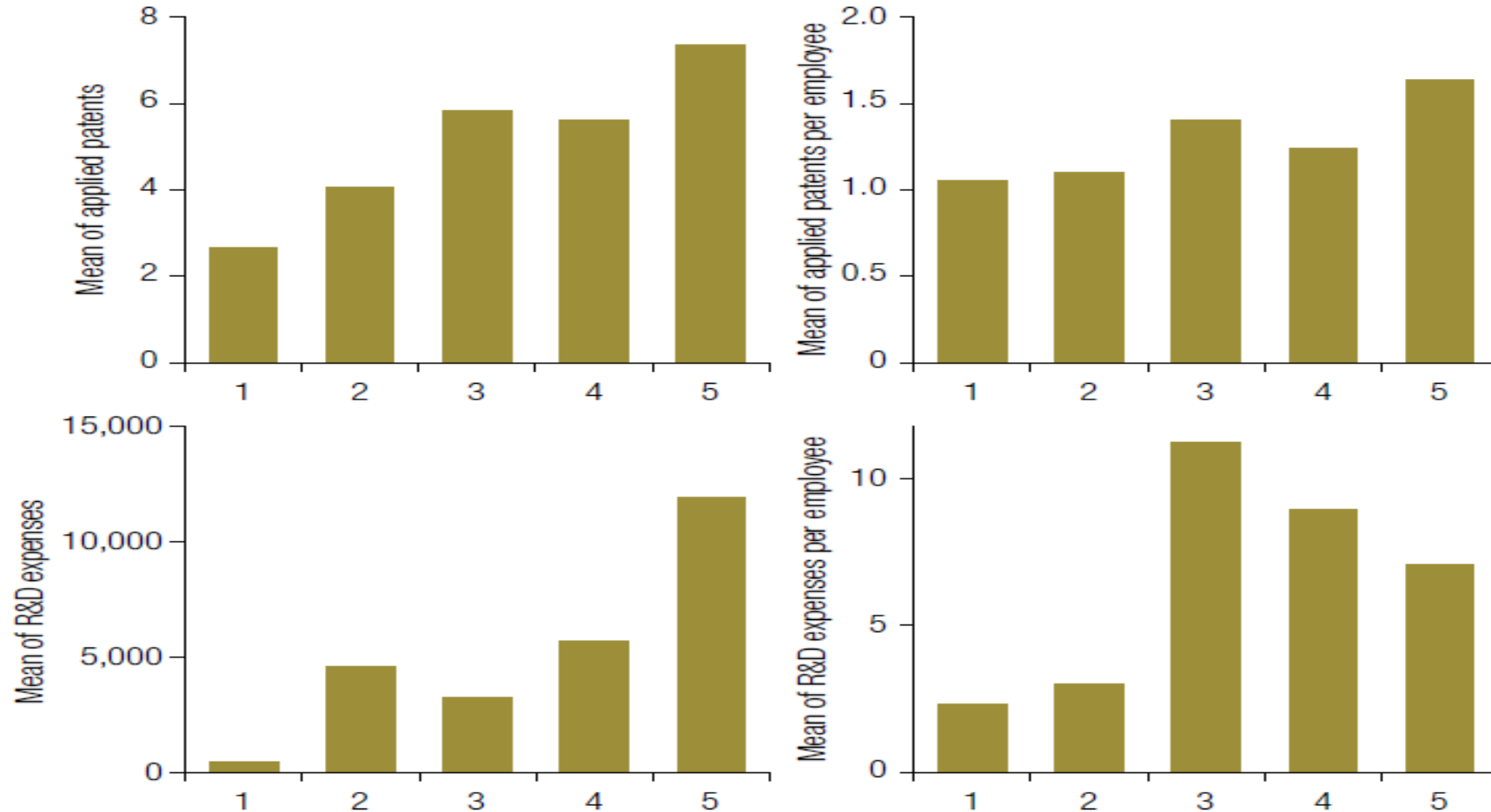
5. SOME CORRELATIONS - BETTER MANAGED FIRMS INVEST MORE ON INNOVATION INPUTS



5. SOME CORRELATIONS - BETTER MANAGED FIRMS HAVE BETTER INNOVATION OUTCOMES –ES DATA

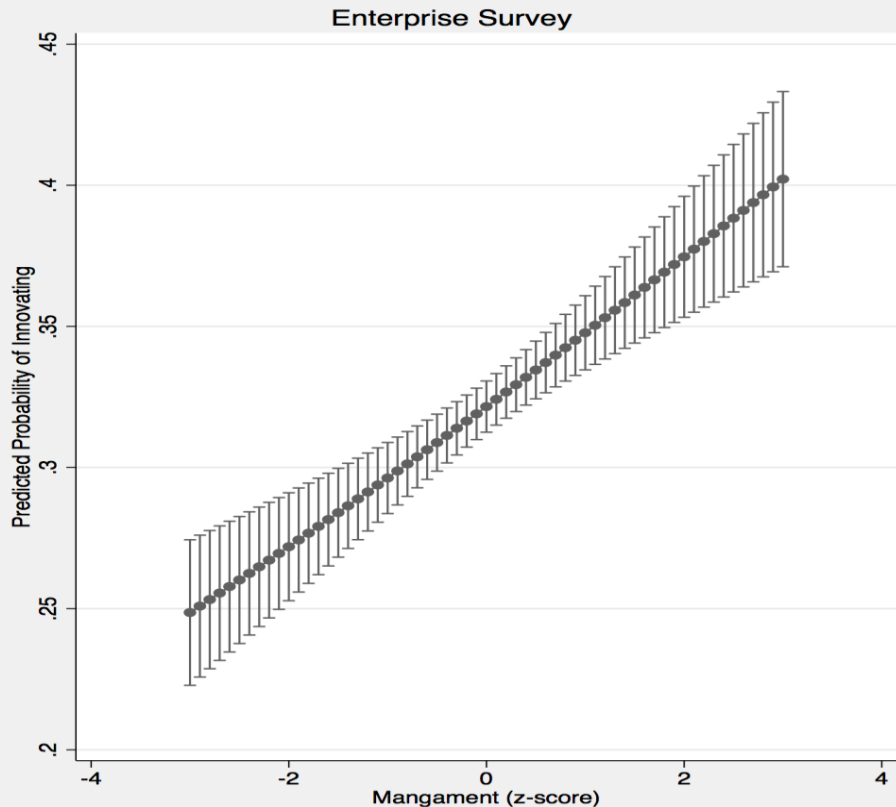


5. SOME CORRELATIONS - BETTER MANAGED FIRMS HAVE BETTER INNOVATION OUTCOMES –WMS/ORBIS

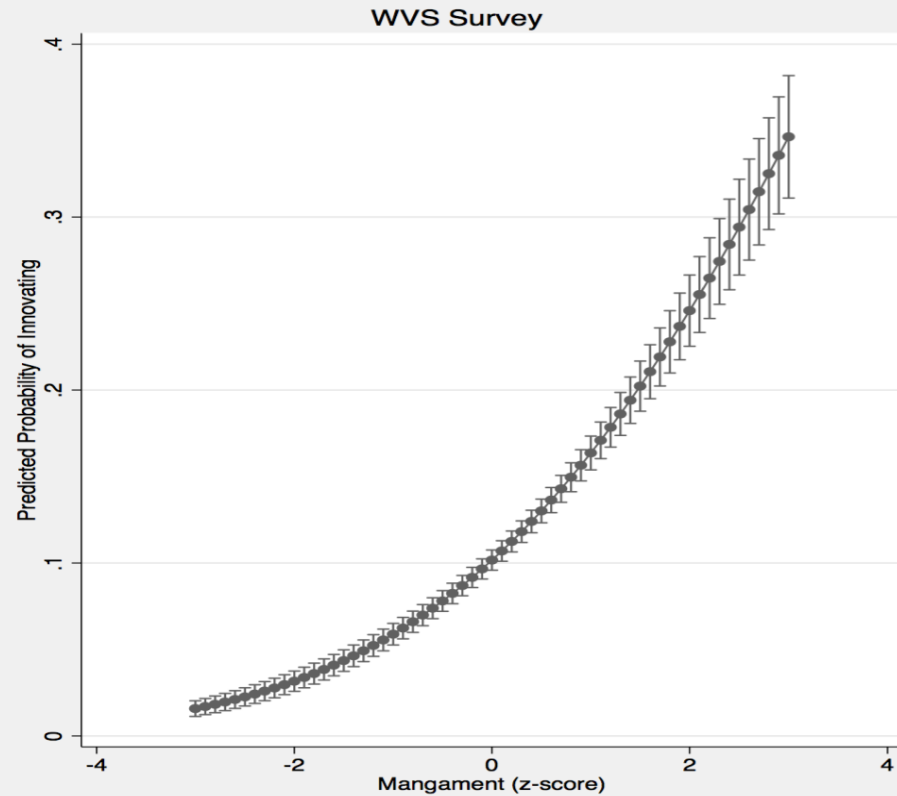


5. SOME CORRELATIONS

Unconditional Prediction: Innovation vs Management



Notes: Results from a Probit model. Countries with more than 200 firms were considered. Total observations = 10212



Notes: Results from a Probit model. The dependent variable is equal to 1 if the firm applied a patent. Countries with more than 200 firms were considered. Total observations: 11093

6. RESULTS – R&D - WMS/ORBIS DATA

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	PROBIT	PROBIT	PROBIT-IV	PROBIT	PROBIT-IV	PROBIT	PROBIT-I
	Pooled	Pooled	Pooled	High- Income	High- Income	Middle- Income	Middle- Income
z-management	0.382*** (0.040)	0.133** (0.061)	-0.329 (0.273)	0.179** (0.083)	-0.144 (0.351)	0.107 (0.104)	-0.774* (0.401)
log(size)		0.166*** (0.053)	0.250*** (0.065)	0.158** (0.073)	0.224** (0.094)	0.114 (0.081)	0.239*** (0.083)
Export (Dummy)		0.627*** (0.220)	0.611*** (0.214)	1.182*** (0.333)	1.126*** (0.341)	0.211 (0.308)	0.373 (0.279)
Foreign / MNE		0.405*** (0.138)	0.513*** (0.139)	0.543*** (0.175)	0.608*** (0.176)	0.054 (0.256)	0.413 (0.276)
% workforce with college degree (log)		0.096* (0.049)	0.129*** (0.050)	0.070 (0.066)	0.094 (0.068)	0.101 (0.081)	0.174** (0.077)
Constant	0.010 (0.036)	-2.106*** (0.563)	-2.623*** (0.579)	0.125 (0.598)	-0.254 (0.706)	-1.354* (0.727)	-2.500** (0.740)
Country Dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Sector Dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
N	1320	1099	1099	670	670	383	383
Rsqr-adj	0.053	0.409	.	0.465	.	0.107	.
LL	-864.707	-445.988	-1733.767	-215.670	-1033.204	-199.135	-599.488
p-exog			0.109		0.360		0.088

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Instrument bonuses as a share of revenue

6. RESULTS – R&D – ES DATA

Table 4. Determinants of R&D. ES Probit Marginal Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	PROBIT	PROBIT	PROBIT-IV	PROBIT	PROBIT-IV	PROBIT	PROBIT-IV	PROBIT	PROBIT-IV
Invests in R&D/Marginal effects	Pooled	Pooled	Pooled	High-Income	High-Income	Middle-Income	Middle-Income	Low-Income	Low-Income
z-management	0.213*** (0.02)	0.147*** (0.02)	0.744*** (0.12)	0.168** (0.07)	1.015*** (0.10)	0.130*** (0.02)	0.669*** (0.14)	0.454*** (0.11)	0.525 (1.56)
log(size)		0.205*** (0.02)	0.094*** (0.03)	0.198*** (0.07)	-0.033 (0.07)	0.208*** (0.02)	0.114*** (0.04)	0.124 (0.08)	0.14 (0.16)
Export (Dummy)		0.217*** (0.04)	0.132*** (0.04)	0.408*** (0.16)	0.087 (0.16)	0.222*** (0.04)	0.148*** (0.05)	-0.162 (0.21)	-0.171 (0.22)
Skill Production Labor		-0.079 (0.07)	-0.083 (0.06)	0.480** (0.24)	0.195 (0.21)	-0.112 (0.07)	-0.108 (0.07)	-0.493 (0.34)	-0.471 (0.56)
Foreign/MNE		-0.015 (0.07)	-0.078 (0.06)	0.069 (0.17)	-0.047 (0.14)	-0.029 (0.08)	-0.082 (0.08)	0.106 (0.23)	0.098 (0.27)
Financial constrain		-0.002*** 0.00	-0.001*** 0.00	0 0.00	-0.002 0.00	-0.002*** 0.00	0.002*** 0.00	-0.006** 0.00	-0.004 0.00
Constant	-0.240* (0.13)	-1.152*** (0.20)	-0.357 (0.29)	-2.155*** (0.42)	-0.924** (0.47)	-1.240*** (0.18)	0.881*** (0.24)	-0.068 (0.54)	-0.181 (1.08)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	9622	7571	7082	540	497	6704	6277	318	302
R-Squared	-4760.83	-3643.16	-12784.24	-273.86	-887.33	-3207.81	-11328.4	-134.26	-515.3
Pseudo log-likelihood			14.5		13.14		8.85		0
p_exog			0		0		0		0.96

Instrument – degree of obstacle from informal competition – contractual quality – downward bias??

6. RESULTS – INNOVATION EQUATION – WMS/ORBIS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	PROBIT	PROBIT	PROBIT-IV	PROBIT	PROBIT-IV	PROBIT	PROBIT-IV
	Pooled	Pooled	Pooled	High- Income	High- Income	Middle- Income	Middle- Income
z-management	0.278*** (0.047)	0.147** (0.060)	0.617** (0.251)	0.132** (0.066)	0.690*** (0.231)	0.489** (0.215)	-1.166 (1.027)
R&D (Dummy)	1.060*** (0.091)	0.713*** (0.141)	0.594*** (0.165)	0.728*** (0.182)	0.537*** (0.208)	0.620** (0.294)	0.899** (0.403)
Other controls	No	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
Sector Dummies	No	Yes	Yes	Yes	Yes	Yes	Yes
N	1320	1132	1132	704	704	258	258
Rsqr-adj	0.157	0.310	.	0.199	.	0.534	.
LL	-620.225	-446.883	-1773.194	-356.420	-1212.108	-48.588	.
p-exog			0.094		0.044		0.048

Instrument financial constraint - % profit margin

6. RESULTS – INNOVATION - ES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	PROBIT	PROBIT	PROBIT	PROBIT- IV	PROBIT	PROBIT-IV	PROBIT	PROBIT-IV	PROBIT	PROBIT- IV
innovation any product or process	Pooled	Pooled	Pooled	Pooled	High- Income	High- Income	Middle- Income	Middle- Income	Low- Income	Low- Income
R&D (dummy)	0.630*** (0.04)	0.620*** (0.04)	0.603*** (0.04)	2.445*** (0.13)	1.117*** (0.14)	2.543 (1.69)	0.560*** (0.04)	2.435*** (0.13)	0.976*** (0.21)	2.420** (0.97)
normalized management score	0.099*** (0.02)	0.067*** (0.02)	0.044** (0.02)	-0.044** (0.02)	0.019 (0.07)	-0.057 (0.19)	0.066*** (0.02)	-0.038* (0.02)	0.103 (0.09)	-0.082 (0.21)
R&D*management			0.100** (0.04)							
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	9753	7848	7848	7620	565	530	6925	6771	346	310
log-likelihood	-5183	-4091	-4088	-7732	-318.4	-572.52	-3546.36	-6792.46	-189.05	-296.31
chi2				19.51		0.11		20.88		0.8
p-value exog				0		0.74		0		0.37

Standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Marginal effects. Controls: size, exporter, skills, labor contract constraints

Instrument financial constraint - % own working capital

6. RESULTS – INNOVATION – POISSON/NBREG – NUMBER OF PATENTS

Table 7. Determinants of Innovation (Patents). Poisson and Negative Binomial Models: Innovation (Patent) and Management Quality

	(1) Poisson	(2) Poisson	(3) NBREG	(4) NBREG
count patent applications				
R&D (z)	0.146*** (0.004)		0.082 (0.131)	
R&D (Dummy)		1.626*** (0.050)		1.864*** (0.312)
z-management	0.216*** (0.014)	0.182*** (0.014)	0.184 (0.146)	0.221 (0.141)
log(size)	0.334*** (0.010)	0.303*** (0.010)	0.238** (0.102)	0.157 (0.097)
% workforce with college degree (log)	-0.121*** (0.009)	-0.103*** (0.009)	-0.004 (0.115)	-0.067 (0.114)
Multinational	0.479*** (0.027)	0.415*** (0.028)	-0.146 (0.239)	-0.104 (0.230)
Constant	-16.321 (485.504)	-18.172 (822.972)	-19.585 (2312.626)	-20.838 (3853.381)
lnalpha				
Constant			2.062*** (0.072)	1.987*** (0.073)
Country Dummies	Yes	Yes	Yes	Yes
Sector Dummies	Yes	Yes	Yes	Yes
N	1132	1132	1132	1132

7. SOME CONCLUSIONS

- Management quality appears an important input for innovation – directly and via the enhancement of R&D (less robust). This is in line with accounts that managerial quality is needed to manage innovation projects efficiently (ISO standard)
- Caveat – only cross-section and not strong instruments – likely biased coefficients
- Two key implications:
 - Empirical research on determinants of innovation is incomplete due to lack of data – need to include MOPS type module in innovation surveys.
 - Innovation Policy bias towards R&D needs rebalancing –management upgrading is a key innovation policy complementary factor.



THE INNOVATION PARADOX

DEVELOPING-COUNTRY CAPABILITIES
AND THE
UNREALIZED PROMISE OF
TECHNOLOGICAL CATCH-UP

Xavier Cirera

William F. Maloney

World Bank

The Productivity Project: <http://www.worldbank.org/en/topic/competitiveness/brief/the-world-bank-productivity-project>

8. NEXT STEPS

- Explore and analyze the ***differences across income regions*** – when is management quality more important than R&D for innovation.
- Relate these inputs to the ***type of innovation outcome and novelty*** - new to the firm, new to the international market
- Finding a strong ***instrument*** to try to minimize endogeneity issues