

***“Technological behaviour and competitiveness at the firm level.
Empirical evidence from Mexico”***

Salvador Estrada

sestrada@ccee.ucm.es

Interuniversity Doctorate Programme in Economics and Management of Innovation and Technology Policy. Autonomous University of Madrid. Complutense University of Madrid. Polytechnique University of Madrid. Spain.

Staff researcher at Instituto de Análisis Industrial y Financiero. UCM. Madrid.

Aim:

The purpose of this paper is to analyse the importance of technology and innovation in influencing export behaviour of firms in developing countries. From microeconomic data it can be proven that, even in lower technological sectors, differences in technological capabilities can be an alternative to price based factors competitiveness in an open and integrated economy.

Background:

Theoretical Studies.

Neo-classical trade model predicts trade from firms in sectors that use the relative abundant factor intensively. A North-South trade model states that capital is a traded good; thereof endowments of unskilled and skilled labour are the key determinants of comparative advantage (Wood 1994). South countries are well endowed with unskilled labour and natural resources so a mixed export portfolio is expected: low skilled goods with a dominance of natural resource based products. In these models technology is a common production function across sectors. From the view of economics of technological change, technology is a proprietary asset rooted in the firm-specific and tacit nature of knowledge (Nelson&Winter 1982, Dosi 1988). Competitive process treats firms' survival so they've got to accumulate and develop a minimum technical

base to keep pace with entrants and incumbents (Metcalfe 1998). This base permits firms to use and exploit exogenous technology and to learn to adopt and introduce more complex manufactured goods (Katz 1976, Lall 1992, Bell&Pavitt 1993). In an evolutionary view of trade, the technology gap is the main determinant of trade (Posner 1961, Vernon 1966, Dosi, *et.al.* 1990, Cimoli&Soete 1992). Such a view implies that learning reflected by a certain absorptive technical capacity is a key element to enter the export market.

Empirical Studies.

Thus, the empirical issue to investigate is which firms can cope with export markets taking into account that firm-level factors are important influences of the ability to export as well as sectoral external influences. These dimensions will be assessed from micro data on technological and innovation activities. International marketing literature has studied size, industry, age and ownership as firms' relevant characteristics to influence export propensity. Few studies have incorporated technology and mostly for industrialised countries.

This issue has been measured by total factor productivity or expenditures in research and development. Innovation economics have stressed the existence of a bias interpretation because several activities influence technical change and technological capabilities among different size and industrial activity. So the measurement of different inputs are required in order to address firm heterogeneity.

Last decade had witnessed the development of models that incorporate several measures of technological change (e.g. for industrialised countries Wakelin 1997,1998; Sterlacchini 1999, Basile 2001, Lefebvre&Lefebvre 2001, Nassimbeni 2001, Roper&Love,2002 and for developing countries Willmore 1992, Kumar&Siddhartan 1994, Zhao&Li 1997, Wignaraja 2001, vanDijk 2002, Özcelik&Taymaz 2004). (See table 5 for a summary of main results). An overview of them cannot result on an evident and robust conclusion about the effect of technological variables on firm's export behaviour neither on advanced countries nor developing ones.

Hypotheses:

Literature revision on trade behaviour at firm level suggests the following hypotheses:

- 1) Employment, sales, age, ownership of exporting firms will significantly differ from non-exporting companies and size and age are expected to have a non-linear relationship with export probability.
- 2) Also, efforts in technological acquisition (embodied and disembodied) will significantly differ.
- 3) R&D expenditures, R&D-related capabilities, investments oriented to develop new products (training, marketing, design, engineering and tooling up), the introduction of new products and improved products impacts on sales may significantly varied between exporters and non-exporters.
- 4) The importance of the variables in determining export propensity will differ by size and industrial sector (using Pavitt's taxonomy).

Data and Methods:

A sample of 1087 Mexican manufacturing establishments actives in 1999 has been obtained in the "Guanajuato's survey on innovation and technological activities". (Table 1.) Data draw information on size, age, ownership, sales, exports etc. Innovation and technological activities are defined according with Frascati and Oslo Manuals. (For definitions see table 2).

Two kinds of statistical methodologies are used to explore differences between exporters and non-exporters. Differences in continuous variables are tested with an ANOVA analysis. Categorical variables are assessed by means of a Chi-square independence test. In addition to these exploratory analyses a confirmatory analysis is carried utilising the multivariate technique of logit regression.

To probe the reliability of this general model, several regressions will be run against subsample of firms in order to asses sign and significance of determinants of the general model.

Finally, the whole set of variables will be used in forward step wise regression to search for non observed effects according to particular features as size, age, property, sector and usage of external technical services.

Results:

Preliminary results already published elsewhere –Estrada 2002;Estrada&Heijs 2003 - and current analysis show that in the Mexican case (1) size have a non-linear relationship with export probability, (2) foreign equity (FEQUITY) clearly affects positively export activity, (3) embodied technology acquisition (MACH99) tends to influence negatively

export probability meanwhile disembodied technology acquisition (DISTECH99) has no effect, (4) R&D intensity (R&D), technical skills (proxied by engineers in working force) (ENGINEERS) and technical services contracting (TECHSERV) have a positive effect, (5) activities related with the introduction of new products (marketing – MKTING-, training and design) seems to have no effect. The number of new products introduced (NEWPROD) and sales intensity of improved products (IMPROVED) affect negatively export probability. (7) Diversification strategy based on the monoproduction (SALES1) has a significant relationship with export probability. Also, sectoral pattern of technical change affiliation affects export probability, in a positive manner (See table 3 for a family of models that depicts this situation).

But regarding firms' specific features, models seem to be better fitted to explain export probability of small and medium sized firms, older firms (born before North American Free Trade Agreement, 1994 backwards), independent firms, firms belonging to Traditional Consumer Goods, Specialised Supplier of Intermediate Goods and Equipment, and Science Based sectors as well as firms contracting external technical services (See table 4).

Alternative models using forward step wise regressions based on subsamples of firms revealed that when some variables are dropped, innovation related activities exert some influence on export probability. For example when dropped R&D intensity, introduction on new products and single product share on sales in the regression on Grown-up firms, disembodied technology and marketing activities are held on the model and showed positive effects. The technology acquisition variables seem to have no effect, but within regressions that dropped single product share or external services contracting, the

investment on machinery and expenditures on disembodied technology enters the models, respectively, the former with a negative sign and the latter with a positive one. Also if classical inputs of innovative efforts (expenditures on R&D) and outputs (new products or intensity of improved products on sales) are dropped, it appears to be significant alternative variable of effort like design or training.

Conclusions:

If technological capabilities matter for exporting activities, one possible application is to promote the regional innovation system toward exports, fostering technological capabilities as a key driver of international competitiveness. The probability that a Mexican manufacturing firm devotes part of its production to foreign markets positively depends on size (until certain threshold), foreign capital share, R&D intensity, high levels of monoproduction and external technical services use. A limited range of new products introduction and low dependence on improved products sales is related also with export behaviour. Moderate efforts on equipment and machinery acquisitions can be consider a likely feature for exporters. However, determinants of export probability variate regarding firm size, age, property, industrial sector and usage of external technical services. Further research is requested in order to clarify the role of other innovative activities different from R&D.

Table 1. Data set and representation.

Manufacturing sectors	Universe	%	Sample	%	Sampling error
Food and beverages	120	11,04	75	19,23	0,02
Textiles, leather and footwear	349	32,11	108	27,69	0,03
Wood, paper and printing	30	2,76	18	4,62	0,04
Oil, chemicals, rubber and plastics	259	23,83	81	20,77	0,04
Mineral non metallic products	11	1,01	11	2,82	0,00
Basic metals	17	1,56	7	1,79	0,10
Fabricated metal products	44	4,05	13	3,33	0,10
Machinery, equipment and transport	244	22,45	70	17,95	0,04
Furniture and others	13	1,2	7	1,79	0,08
Total	1087	100	390	100	0,02

Source: Guanajuato's Survey on R&D, technological activities and innovation 1999 (INEGI-CONCYTEG)

Table 2. Description of Variables and Statistics Descriptives.

Variables	Description	Mean	Standard deviation
Export status	1 = Exporting plant, 0 = otherwise	0,32	0,47
SIZE	Number of employees	150,01	296,21
SIZE2	Number of employees squared	110163,96	843220,75
AGE	Number of years since established	13,80	13,96
AGE2	Number of years since established squared	385,03	1231,48
FEQUITY	Percentage of foreign equity in firm	6,19	23,72
MACH99	Percentage of sales devoted to machinery and equipment purchases	7,32	13,45
DISTECH99	Percentage of sales devoted to disembodied technology purchases	0,56	2,35
FR&D	1 = Formal R&D activity, 0 = otherwise	0,06	0,23
R&D	Percentage of sales devoted to R&D expenditures	0,27	1,51
ENGINEERS	Percentage of personnel holding an engineering degree	3,91	13,07
MKTING	Percentage of sales devoted to marketing of new products expenditures	0,15	1,60
TRAINING	Percentage of sales devoted to training expenditures related to new products	0,02	0,15
DESIGN	Percentage of sales devoted to design, engineering and tooling up expenditures	0,40	2,93

TECHSERV	1 = External technological services contracted, 0 = otherwise	0,23	0,42
IMPROVED	Intensity of improved products on sales	18,10	31,31
NEWPROD	Number of new products introduced during last three years	0,89	3,62
SALES1	Intensity of a single product or line product on sales	73,41	25,24
PAVITT1	= 1 if firm belongs to a Producer of traditional consumer goods sector (PTC)	0,47	
	= 2 if firm belongs to a Specialised supplier of intermediate goods and equipment sector (SS)	0,20	
	= 3 if firm belongs to a Scale intensive and mass assembly sector (SI)	0,03	
	= 4 if firm belongs to a Science based sector	0,15	
	ref. cat.:firms belonging to a Producer of traditional intermediate goods sector (SB)	0,15	

Table3. Technological determinants of export probability of Mexican manufacturing firms.

Variables	Models (1) Coeff.	(2) Coeff.	(3) Coeff.	(4) Coeff.	(5) Coeff.	(6) Coeff.	(7) Coeff.
SIZE	0,003 ***	0,002 ***	0,002 ***	0,002 ***	0,002 ***	0,002***	0,002***
SIZE2	-6,9E-07 **	-6,6E-07 **	-5,8E-07 **	-0,000 **	-0,000 **	-0,000**	-0,000**
AGE	0,001 NS	0,004 NS	0,004 NS	0,004 NS	0,006 NS	0,007 NS	0,007 NS
AGE2	-3,45E-05 NS	-9,4E-06 NS	-6,1E-06 NS	-0,000 NS	0,000 NS	-0,000 NS	-0,000 NS
FEQUITY	0,027 ***	0,026 ***	0,026 ***	0,026 ***	0,028 ***	0,028***	0,028***
MACH99	-0,014 **	-0,016 **	-0,016 **	-0,016 **	-0,012 NS	-0,012 NS	-0,012 NS
DISTECH99	0,073 **	0,022 NS	0,018 NS	0,018 NS	0,012 NS	0,014 NS	0,014 NS
FR&D (dummy)	1,022 ***	0,681 *					
R&D			0,096 NS	0,094 NS	-0,127 **	0,132**	0,117*
ENGINEERS	0,018 ***	0,017 **	0,019 ***	0,019 ****	0,022 ***	,023***	,023***
MKTING	0,057 NS	0,023 NS	-0,016 NS	-0,018 NS	-0,022 NS	-0,030 NS	-0,008 NS
TECHSERV(dummy)		0,978 ***	1,005 ***	1,001 ***	1,259 ***	1,252***	1,244***
TRAINING				-0,108 NS	0,028 NS	0,031 NS	0,059 NS
IMPROVED					-0,006 **	-0,005**	-0,006**
NEWPROD					-0,079 ***	-0,075***	-0,067***
SALES1						0,009***	0,009***
DESIGN							-0,029 NS
PAVITT	***	***	***	***	***		
PTC	2,676 ***	2,686 ***	2,737 ***	2,738 ***	3,020 ***	2,931 ***	2,935***
SS	1,027 **	1,037 **	1,044 **	1,043 ***	1,086 **	1,107 **	1,110**
SI	1,861 ***	1,694 ***	1,790 ***	1,810 **	1,896 ***	1,830 ***	1,836 ***
SB	1,110 **	1,126 **	1,213 ***	1,214 ***	1,350 ***	1,364 ***	1,370 ***
Constant	-3,327 ***	-3,512 ***	-3,582 ***	-3,583 ***	-3,719 **	-4,386***	-4,389***
-2 L. L.	1028,27	1001,87	1003,67	1003,61	982,131	975,263	974,547
Pseudo r2	0,370	0,394	0,393	0,393	0,413	0,419	0,419
Chi-Squared	333,273	359,675	357,872	357,936	379,414	386,282	386,997

Classification

% of correct cases

Non-exporters	79,3	83,4	82,2	82,3	80,0	80,0	79,1
Exporters	64,0	62,8	64,0	64,0	64,6	68,6	68,6
Total	74,4	76,8	76,4	76,4	75,1	76,4	75,7

N	1087	1087	1087	1087	886	201	886
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*** Means statistically significant at the 1% level. ** Means statistically significant at the 5% level.
* Means statistically significant at the 10% level. NS Means no significance. + Means positive and statistically significant at least at 10% level. - Means negative and statistically significant at least at 10% level.

Source: Own elaboration based on Guanajuato's Innovation Survey (INEGI-CONCYTEG 2000).

Table4. Technological determinants of export probability of Mexican manufacturing by subsamples of firms regarding Size, Age, Property, Sector and Usage of External Technological Services.

Variables	GEN MOD	SIZE			AGE			PROPERTY			SECTOR				TECHSERV	
		S	M	L	Y	G	O	IND	NG	MNC	TCG	SS	SI	SB	NTS	TS
SIZE	+	+	+	NS	NS	+	+	+	+	NS	+	+	NS	+	+	NS
SIZE2	-	-	-	NS	NS	-	-	-	NS	NS	-	NS	NS	-	-	NS
FEQUITY	+	+	+	+	+	+	+				+	+			+	+
R&D	+	+	NS	NS	NS	+	NS	+	NS	NS	NS	+	NS	NS	NS	+
ENGINEERS	+	+	NS	NS	NS	+	+	+	NS	NS	+	+	-	+	+	+
TECHSERV	+	+	+	NS	+	+	+	+	NS	NS	+	+	NS	+		
IMPROVED	-	NS	-	NS	NS	-	NS	-	+	NS	-	NS	NS	+	NS	-
NEWPROD	-	NS	-	+	-	NS	NS	-	NS	-	-	-	NS	NS	+	-
SALES1	+	NS	-	NS	NS	NS	+	+	NS	-	NS	+	NS	NS	+	NS
PAVITT	*	*	*	NS	*	*	*	*	NS	NS					*	*
TCG	+	+	NS	NS	+	+	+	+	NS	+					+	+
SS	+	NS	NS	NS	NS	NS	+	+	NS	r.c.					NS	+
SI	+	NS	NS	NS	NS	NS	NS	+	NS	NS					NS	+
SB	+	NS	NS	NS	NS	NS	+	NS	NS	+					NS	+
constant	-	NS	NS	-	-	-	-	-	-	-	-	-	NS	-	-	-

GENMOD is the General Model obtained in Table3 as model (7).

S=Small firms (1-100 employees), M= Medium firms (101-250) and L=Large firms (over 250 workers).
Y= Young firms (born before North American Free Trade Agreement, 1994 on wards), G= Grown-up firms (born on the Transition Period towards Openness, 1985-1993), Old= Old firms (born during or before the Import Substitution Period).

IND= Independen firms, NG= firms belonging to National Groups, MNC= firms belonging to Multinational Corporations.

TCG= Traditional Consumer Goods, SS= Specialised Suppliers of Intermediate Goods and Equipment, SI= Scale Intensive and mass-assemblers, SB= Science Based.

NTS= Non user of external technical services, TS= User of external technical services.

Table 5. Summary of literature and own empirical results.

Categories	Variables	GEN ALT		Empirical studies
		MOD	MOD	
Structure	SIZE	+		AC (10+) and DC (10+)
	SIZE2	-		AC (9-) and DC (1-)
	FEQUITY	+		AC (2+) and DC (6+, 1NS)
	AGE	NS	-	AC (2NS) and DC (2NS, 2+, 2-)
	AGE2	NS		DC (1NS, 1-)
Technology outsourced	MACH99	NS	-	AC (2NS) and DC (2+)
	DISTECH99	NS	+	DC (1NS, 1+)
	TECHSERV	+		AC (1NS)
Technological efforts	R&D	+		AC (3+, 3NS) and DC (6+, 1NS, 1-)
	ENGINEERS	+		AC (5+) and DC (3+, 2NS)
	MKTING	NS	+ -	DC (2-)
	TRAINING	NS	-	AC (1NS) and DC (1NS, 2-)
	DESIGN	NS	+ -	AC (2+)
Innovative scope	IMPROVED	-		AC (1-, 1NS, 1+) and DC (1+)
	NEWPROD	-		AC (2+, 1NS)
	SALES1	+		AC (1+, 1NS, 3-)
Sectoral influence	TCG	+		AC (3+, 2NS, 1-) and DC (8+, 7NS, 6-)
	SS	+		AC (2+) and DC (2NS)
	SI	+		AC (2+, 1NS) and DC (3NS)
	SB	+		AC (1+) and DC (2+, 1NS)

Source: Own elaboration based on empirical results and Wakelin 1997,1998; Sterlacchini 1999, Basile 2001, Lefebvre&Lefebvre 2001, Nassimbeni 2001, Roper&Love,2002 for advaced countries (AC) and Willmore 1992, Kumar&Siddhartan 1994, Zhao&Li 1997, Wignaraja 2001, vanDijk 2002, Özcelik&Taymaz 2004 for developing countries (DC), among others.

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