

Innovation in Low Technology Manufacturing: the role of foreign technology transfer and external networking

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February 2007

Abstract

This paper explores the determinants of three innovation outputs in low technology manufacturing factories. Two innovation outputs were laid out in Schumpeter's typology (1934): a) new products, and b) new production processes. The third one, c) improvements in existing products, is drawn from Kline and Rosenberg's (1986) insight that innovation implies not only the creation of completely new products or processes but relatively small or incremental changes in product performance which may, over a long period, have major technological and economic effects.

The theoretical base for identifying the determinants of innovation outputs stems from two bodies of literature. First, innovation is dependent on the factory's network of relationships, both internal and external. The internal network is equated to intra-firm cooperation, which encompasses the relationship of local foreign owned factories with their headquarters. The external network is divided between inter factory/firm relationships and institutional interactions (Zanfei, 2000). Second, as Kline and Rosenberg (1996) had considered, innovation inputs that produce technological change are: a) adaptation and development within the factory but also b) acquisition of machinery and equipment and c) human capital.

The previous analytical framework is then applied to a cross-country¹ factory-level database of low-technology manufacturing industries, the World Bank's "Investment Climate Survey" (ICS).

¹ The database contains a total of 1772 observations of manufacturing firms legally registered in 4 countries (El Salvador, 465 obs.; Guatemala, 431 obs.; Honduras, 439 obs.; Nicaragua, 436 obs.). Information collected in 2003.

The results support the idea that external networks, mainly interaction with universities, and purchasing of foreign licenses constitute a mechanism for generating innovation outputs in low-technology sectors. However, foreign ownership does not seem to be a driver of innovative outputs, which could speak of enclave characteristics of foreign owned factories. On the input side, the results show importance and robustness of: 1) machinery and equipment acquisition since new technology is embodied in those capital goods, 2) the relevance of adaptation and development within the factory where learning by doing is an integral component for gaining incremental innovation outputs in low technology manufacturing industries., and 3) The hiring of new personnel helps to absorb, use and adapt new technology and it is assumed that technological know-how is embodied in technical personnel.

Introduction

According to Malecki (1994) there are several levels of meaning for the term entrepreneurship. First, entrepreneurship refers to small firms; and in many settings in the developing world, a large proportion of them are survival enterprises outside the legal status of other economic activities (De Soto, 1989). Second, entrepreneurship refers to firm formation or the addition of new enterprises to the economy. Finally, entrepreneurship entails innovation (rather than imitation). This view is compatible with Schumpeter's typology (1934) of entrepreneurial opportunities included in: a) new products, b) new production processes, c) new markets, d) new sources of raw materials and e) new forms of organization.

Moreover, Baumol, et al (2006) also uses the term entrepreneur within the third level of meaning: "as an entity, new or existing that provides a new product or service, or that develops and uses methods to produce or deliver existing goods and services at lower costs". In this way entrepreneurs increase the wealth of a nation or region. The Kaufmann Foundation policy paper (2006) mentions the existence of two types of entrepreneurs, innovative and replicative, but it stresses that radical innovation, associated with innovative entrepreneurs, has driven productivity growth. In this paper we equate the term entrepreneur to Baumol's definition within which Schumpeter's typology fits well. Since entrepreneurs are wealth creators, it is vital to devise public policies designed to foster the entrepreneurs' production of innovative outputs.

However, entrepreneurs usually encounter some obstacles to their attempts to generate new products and processes. As Storey (2003) points out, "in the context of public policy intervention the key assumptions most likely to be contravened are those of perfect information and the absence of externalities". The Kauffman Foundation policy

paper (2006) states that a way to level the playing field between entrepreneurs and larger established firms is to provide equal awareness to all of foreign technology. Therefore, it is argued that foreign technology could be a mechanism to transfer new technology and decrease the information “gap” for local innovative firms. Furthermore, other literature acknowledges that access to foreign technology could lead to positive productivity externalities to domestic firms (Smarzyka, 2003).

Developing countries are situations where access to foreign technology may occur. Thus, full or partial foreign ownership of local firms should enhance technology transfer, and it could take two forms: 1) a subsidiary of a multinational company, b) a domestic firm partly foreign owned. Other vehicles of technology transfer are subcontracting and licensing. However, the empirical literature finds mixed evidence on the existence of positive productivity externalities including technology transfer generated by the presence of foreign multinational companies in the host country (Alfaro, et al 2006).

Within a developing country context, this paper examines the drivers of innovative outputs. Access to foreign technology within the firm’s internal network (intra-firm cooperation) is one driver. However, foreign technology can also be accessed through external networking (inter firm networking) by subcontracting and licensing. Further, external inter firm networking also encompasses relationships with suppliers and clients, but also interactions with local as well as non-local institutions, such as universities and chambers of commerce and other trade associations (Zanfei, 2000). Finally, the last drivers are innovation inputs, considering efforts in technology adoption and adaptation, but also including non-R&D inputs to innovation such as acquisition of machinery and equipment and training (Kline and Rosenberg, 2000).

Finally, the paper explores significant differences in innovation by manufacturing sector and firm size.

The paper is presented in 5 parts. Part 1 explores the role of public policy in encouraging foreign technology transfer, in particular foreign direct investment. Part 2 examines the literature on internal and external networks to the firm and innovation outputs with special emphasis on low technology industries, which are prevalent in most of the developing world and their interaction with high technology industries. Part 3 presents a model on the drivers of innovation output. Innovation outputs are defined as in the classic work of Schumpeter (1934), and the drivers are built on previous work on internal and external networks by Zanfei (2000) and innovation inputs (Kline and Rosenberg 1986). Part 4 tests the model and presents the results using firm level data from the World Bank's Investment Climate Survey of 4 Central American countries. The data comprises firm information at the factory level in low technology sectors. Finally, Part 5 presents the results and offers some observations on the public policy implications of the results.

Part I- Public Policy and foreign technology transfer

As a starting point, public policies should not try to give preferential targeting to specific industries as it usually lowers national welfare because governments are less efficient than markets at allocating resources across alternative uses and because resources are likely to be wasted on lobbying efforts by industries seeking special treatment (RAND, 2004). However, Helpman and Krugman (1985) observe that

governmental protection and promotion of a particular industry is suitable if the industry creates large spillover benefits for other economic activities.

It has been argued that access to foreign technology decreases the information “gap” faced by innovators (Kauffman Foundation, 2006) and also produces spillovers to the rest of local firms. Blomström and Kokko (1998) describe the scenarios by which these spillovers enhance economic growth, “spillovers may take place when local firms improve their efficiency by copying technologies of foreign affiliates operating in the local market either based on observation or by hiring workers trained by the affiliates. Another kind of spillover occurs if multinational entry leads to more severe competition in the host country market and forces local firms to use their existing resources more efficiently or to search for new technologies” (in Smarzycka pp 5 2003)

However, empirical analysis based on firm-level panel data, which examines whether the productivity of domestic firms is correlated with the extent of foreign presence in their sector or region cast doubt on the existence of spillovers from FDI in developing countries.² (Smarzycka, 2003; Alfaro & Rodriguez-Clare 2004). Although, the picture is more optimistic in the case of industrialized countries as a recent paper by Haskel, Pereira and Slaughter (2002) provides convincing evidence of positive FDI spillovers in the UK.

Rodriguez-Clare (1996) finds that linkage or spillover effects of foreign companies on host countries are more likely to be positive when the good or service produced by foreign companies uses intermediate inputs intensively, when there are large costs of communication between headquarters and the local plant and when host and home countries are not too different in terms of the variety of intermediate goods

² Haddad and Harrison (1993) on Morocco, Aitken and Harrison (1999) on Venezuela and Djankov and Hoekman (2000)

produced. Moreover, if these conditions are reversed then multinationals could have a negative effect on the developing economy through creation of enclaves with little connection to the domestic economy.

Therefore, the existence of FDI spillovers in the same sector seems dubious and to have spillovers across sectors there is a need of a defined set of conditions. Spillovers across sectors can be characterized by the links between foreign firms and their local suppliers (backward linkages). Such spillovers can operate through: (i) direct knowledge transfer from foreign customers to local suppliers; (ii) more demanding requirements regarding product quality and on-time delivery introduced by multinationals, that provide incentives to domestic suppliers to upgrade their production management or technology; (iii) indirect knowledge transfer through labor turnover; (iv) increased demand for intermediate products due to multinational entry, that allows local suppliers to reap the benefits of scale economies; (v) competition effects, by which multinationals acquiring domestic firms may choose to source intermediates abroad thus breaking existing supplier-customer relationships and increasing competition in the intermediate products market (Smarzyska, 2003).

Altenburg (2000) among other authors finds that linkages between foreign firms and local suppliers are stronger if foreign affiliates are domestic-market-oriented and thus tend to purchase more locally than export-oriented foreign firms. Second, it has also been argued that affiliates established through mergers and acquisitions or joint ventures are likely to source more locally than those that are built from the scratch (i.e. greenfield projects). While the latter have to take time and effort to develop local linkages, the former can take advantages of the supplier relationships established by the acquired firm or their local partner (UNCTC 2001).

Part II – Internal and external networks and inputs in low technology industries

So a question remains about what the role of host countries and local firms is (both foreign subsidiaries and locally owned). Is their role almost exclusively in the adoption and diffusion of a centrally created technology (i.e. by foreign companies)?

Foreign companies have recently transitioned towards a new organizational mode defined as a “double network” Zanfei (2000). On one hand, the internal network functions or links between different units of the same firm, for instance vertical and unidirectional knowledge transfer from headquarters to local subsidiaries. However, the knowledge spillovers to other firms outside the foreign owned company are uncertain as described in the previous part of the paper. The potential for knowledge spillovers is related to the type of FDI and the level of human capital in the host country. FDI in high technology industries is more likely to generate knowledge-intensive spillovers (Acs et al. 2006). Therefore one obvious question this paper tries to answer is if knowledge spillovers, in terms of innovative outputs, occur also in low technology sectors.

On the other hand, subsidiaries develop external networks with other firms and institutions separate from the foreign owned firm to gain access to local sources of information and application abilities (Zanfei, 2000).

Locally owned firms also benefit from both inter firm and institutional external networks. In addition, locally owned firms have other channels to access foreign technology besides foreign ownership, technology transfer occurs through market transactions deliberately negotiated between parties (Barba Navaretti & Venables, 2004). Transfers may take the form of licensing agreements or be part of a package of upgrading efforts associated with the supply of inputs (i.e. subcontracting). However, according to

Acs et al (2006) foreign firms may have concerns about piracy of intellectual property, reverse engineering of goods and also differing production qualities of branded goods.

The framework for analyzing the drivers of innovative output in terms of the channels for technology transfer that a firm either foreign or locally owned has been presented. Now the investigation turns to a question of what inputs are needed to generate the innovative outputs, focusing on those prevalent in low technology manufacturing firms.

In manufacturing sectors learning by doing is an integral component for gaining incremental innovation, therefore the separation of R&D facilities from the manufacturing plant are ineffective (Kelley et al, 2004). Specifically, in low technology industries many of the innovations and adoption of related activities operate in practical and pragmatic ways by doing and using (Von Tunzelmann and Acha, 2005). In poor developing countries firms are very likely to lack the budget to perform R&D or few firms categorize any expenditure as R&D (Recanatini et al, 2000), and thus adoption and adaptation by doing and using are major inputs to the generation of innovative outputs.

Yet, low technology manufacturing firms are a vehicle for spreading and implementing technologies embodied in equipment and capital goods and basic materials requiring only traditional R&D expenditures. Low technology firms generate innovative outputs by using new machinery and equipment. Therefore, low technology sectors could serve as carrier industries for diffusing the gains of new technologies and for incorporating advancements in the production of the products they yield as well as providing feedback to tune up products and processes.

For example, wearing apparel and fur (ISIC – 18) production can benefit from the use of inputs generated by advanced technology industries such as computer and

advanced instrumentation manufacturing which are used to design durable water repellent finishes in textiles or to test windproof fleece. In that sense, innovation in industries regarded as low technology could be fostered by increasing interaction with advanced technology inputs. There is a complementarity between low technology and high technology manufacturing, because most products from the latter are producer goods (i.e., inputs into traditional production), not consumer goods (Kelley et al, 2004).

Local firms both foreign and locally owned are more likely to use high technology inputs if the market for the final product is global. In this case, local suppliers may not be able to satisfy the demand of high technology inputs because of higher quality requirements or constraints imposed by the parent company, etc. (Smarzycka, 2003).

Part III- A Model on the drivers of innovative output

Data

The paper uses a cross country database at the factory level for four Central American countries³, the World Bank Investment Climate Survey (ICS). The sample of 1771 observations was drawn from industrial registries in the four countries and encompasses establishments from seven low technology manufacturing sectors (see footnote 6 for the list). The survey requested a broad array of factory characteristics as well as firm traits on plant size, sector, innovation and technology change channels.

The ICS database is moderately disaggregated, the industries are defined at the 2 digit International Standard Industrial Classification (ISIC) system. The 4 countries studied are participant in a Free Trade Agreement with the US (CAFTA) allowing them

³ The database contains a total of 1772 observations of manufacturing firms legally registered in 5 countries (El Salvador, 465 obs.; Guatemala, 431 obs.; Honduras, 439 obs.; Nicaragua, 436 obs.)

to enjoy tariff free exports for certain line items. However, the information is not panel data, which poses some weakness to the study: a) no research can be done on the effects of policy interventions and the process of industry evolution. B) Attrition bias may arise when firms disappear (exit) because of mergers, acquisition, consolidation, or bankruptcy, or when a firm is included in the sample only if it survives up to the point of interview. Without accounting for attrition, the sole reliance on surviving firms will inevitably bias (usually upward) performance measurements (i.e. production of innovation outputs).

Dependent Variable: Innovative Outputs (IO) (see annex 1 for variable operationalization)

Following the Schumpeterian typology, innovation outputs take the form of: a) new products, b) new production processes and an additional one in the form of c) improvements in existing products. The rationale behind this last innovation output is based on Kline and Rosenberg's (1986) insight that innovation implies not only the creation of completely new products or processes but incremental changes in product performance which may (over a long period) have major technological and economic implications. The ICS surveys obtain information for these three innovation outputs by asking if the establishment (plant) had initiated any of the three types of output innovations in the previous 2 years, therefore each is a dichotomous variable where 0 = "did not initiated the activity" and 1 = "initiated the activity". As we can see in Table 1, the results of the ICS suggest that a substantial proportion of low technology factories produce innovative outputs. About half of factories had produced new products or

improved significantly existing ones. Moreover, 80% of surveyed factories report that they developed new production processes,

Table 1 – Factories producing innovative outputs

Type of Innovation	# Factories	%
1-new products	935	52.8
2- new production processes	1,423	80.4
3- improvements in existing products	862	48.7

Source- World Bank Investment Climate Survey- Author's calculations

Independent Variables

A- **Internal networks** (Intra firm cooperation variables, IN): the factory is considered under foreign ownership if foreign capital is 10% or greater, which will be an indication of a joint venture. This is the same cut off used by Smarzyka (2003). A firm is also considered under foreign ownership if the establishment's (factory) main channel to acquire technology comes from the headquarters, which would be the case of a multinational subsidiary. Therefore the variable *forown* is binary and equal to 1 if it satisfies any of the two previous conditions, and equal to 0 otherwise.

B- **External network** (Inter firm networking variables, EN): Barba Navaretti & Venables' (2004) suggest that market channels employed by domestic firms (both foreign and locally owned) to access foreign technology could take the form of subcontracting and licensing. This is measured as a dummy variable equal to 1 if the factory's main channel for acquiring new technology was purchasing a foreign license (*forlic*). Also, a dichotomous variable is created if factory's sales to

multinational firms are greater than 10%, which would be an indication of subcontracting (*forsubcont*).

Yet, inter firm networking also encompasses relationships between the factory and: a) suppliers of equipment (*locsuppl*), b) clients (*locclient*) and c) licensing from other domestic firms (*loclic*). The dummy value is equal to 1 if the interaction implied a major channel for technology acquisition.

Finally, two measures of identification with a part of the institutional network (Zanfei, 2000) are created in the form of the relationships between the factory and institutions such as universities and public institutions (*locuniv*) and local chambers of commerce and other trade associations (*locchamb*).

C- Innovation input variables (II): for a sizable proportion of low technology firms in developing countries adoption and adaptation while using new technologies within the factory are primary channels for innovation rather than classical expenditures in R&D. If the factory developed and adapted technology (*D&A*) it is an input for generating innovative outputs and, therefore, the dummy has a value of 1, and 0 otherwise. Non R&D inputs to innovation are also considered (Kline and Rosenberg 1986), assuming that newer equipment represents a higher level of technology, and that technological know-how is embodied in technical personnel. If Machinery and equipment acquisition (*newequip*) and hiring of human capital (*humanK*) are channels for new technology incorporation, the dummies take the value of 1, and 0 if not.

Table 2 – Channels to introduce technological innovations

A- Internal networks			
Intra firm cooperation variables			
1-foreign ownership	forown	# factories	204
		%	12%
B- External network			
Inter firm variables			
2-subcontracting	forsubcont	# factories	170
		%	10%
3-foreign license	<i>forlic</i>		46
			3%
4-suppliers of equipment	locsuppl	# factories	200
		%	11%
5-local license	loclic	# factories	18
		%	1%
6-clients	<i>locclien</i>		128
			7%
Institutional networking variables			
7-universities and public institutions	locuniv	# factories	45
		%	3%
8-chambers of commerce	locchamb	# factories	67
		%	4%
C- Innovation input variables			
9- Machinery and equipment acquisition	newequip	# factories	942
		%	53%
10-Human capital hiring	humanK	# factories	654
		%	37%
11-development and adaptation	D&A	# factories	523
		%	30%

Source- World Bank Investment Climate Survey- Author's calculations

The factories surveyed in the ICS had made relatively more use of innovation inputs as channels of technological change, with machinery and equipment acquisition being the more frequent (Table 3). On the other hand, a smaller proportion of factories had used both internal intra firm network and external networks (inter firm and institutional).

Control Variables

- Firm size⁴: Micro/small: 1-25 permanent workers, Medium: 26-75 permanent workers, Large: more than 75 workers
- Industry Sector⁵.

The distribution of factories by size are consistent with what has been observed in developing countries, the so-called "missing middle" phenomenon, where there are some large firms and many small firms, but very few middle-sized firms, which are common in industrialized countries (Recanatini, et al, 2000). Some believe an explanation of this phenomenon lies in a the presence of a small market, which have also been suggested as a barrier to technological change.

Table 3 – Descriptive Statistics of Factory Sector and Size

Sector / Factory Size	ISIC	Micro/small		Medium		Large		total		% foreign owned
		# factories	%	# factories	%	# factories	%	# factories	%	
Textiles	17	33	47%	14	20%	23	33%	70	4%	23%
Wearing apparel and fur	18	170	48%	50	14%	136	38%	356	20%	23%
Chemicals and chemical products	24	96	45%	59	28%	56	27%	211	12%	13%
Food products and beverages	15	222	54%	90	22%	96	24%	408	23%	10%
Wood & products of wood & cork, exc. Furniture	20	200	74%	48	18%	21	8%	269	15%	6%
Leather and articles; footwear	19	55	80%	8	12%	6	9%	69	4%	4%
Other non-metallic mineral prod.	26	162	80%	26	13%	15	7%	203	11%	2%
Rubber and plastic products	25									
Metal products	28	125	68%	46	25%	14	8%	185	10%	9%
Total		1063	60%	341	19%	367	21%	1771	100%	12%

Source- World Bank Investment Climate Survey- Author's calculations

⁴ Firm sizes: micro/small, medium. Contrast dummy: large firm

⁵ Sectors: Beverage and food, Textiles, Garment manufacturing, Furniture and wood Paper and printing, Chemicals, rubber and plastics, Non-metallic products, Shoe manufacturing and leather. Contrast dummy: Metallic products

Model specifications

(1) Model 1, logistic regression: $IOi^6 = b1 \text{ Factory Size } i + b2 \text{ Sector} + E$

(2) Model 2, logistic regression: $IOi = b1 \text{ Factory Size } i + b2 \text{ Sector } j + b3 \text{ Internal network (intra-firm) variables (IN)} + b4 \text{ External Network (Inter firm + Institutional) variables (EN)} + b5 \text{ Innovation inputs (II)} + E^7$

The ICS has a set of questions to define innovative vs non innovative factories, so the innovation function specification has a binary variable accounting for the propensity to innovate. A logistic regression technique is appropriate to accommodate the dichotomous characteristic of the dependent variable and its results are easier to interpret than other dichotomous regression techniques (e.g. probit).

Part IV – Results of the model test

Model 1

The first model tests the influence of factory size and firm sector on the three innovation outputs. The model shows that micro and small establishments (*microsmall*) (1-25 permanent employees) have about half the odds of generating two types of innovative outputs: a) new products and b) improvements in existing products, when compared to large firms. However, the capacity to generate any type of innovative outputs of medium sized factories, which employ 26 to 75 employees, is not statistically

⁶ Innovation output a) a) new products, b) new production processes, c) improvements in existing products.

⁷ Number of independent variables: a rule of thumb is that there should be no more than 1 independent for each 10 cases in the sample. In applying this rule of thumb, keep in mind that if there are categorical independents, such as dichotomies, the number of cases should be considered to be the lesser of the groups (ex., in a dichotomy with 480 0's and 20 1's, effective size would be 20), and by the 1:10 rule of thumb, the number of independents should be the smaller group size divided by 10 (in the example, $20/10 = 2$ independents maximum). <http://www2.chass.ncsu.edu/garson/PA765/logistic.htm#indep>

different from large firms (See Table 4). These results are compatible with Von Tunzelmann and Acha's (2005) view; they state that smaller firms in low technology industries are widely seen as dragging down overall performance. However, smaller firms in advanced technology sectors are seen as innovators.

Table 4-Model 1 Results

Dependent / independent variables	a) new products	b) new production processes	c) improvements in existing products
FACTORY SIZE			
Microsmall	Odds ratio 0.66	0.76	0.66
	Z-statistic (3.17)**	-1.63	(3.29)**
Medium	Odds ratio 0.86	1.16	0.81
	Z-statistic -0.93	-0.69	-1.32
FACTORY SECTOR			
Confec	Odds ratio 0.70	0.99	0.85
	Z-statistic (1.92)*	-0.06	-0.86
Bebalim	Odds ratio 0.79	0.85	0.76
	Z-statistic -1.30	-0.74	-1.53
Qcpl	Odds ratio 1.24	1.27	1.10
	Z-statistic -1.04	-0.88	-0.48
Furnwood	Odds ratio 0.82	1.10	0.93
	Z-statistic -1.01	-0.40	-0.40
Leashoe	Odds ratio 0.89	3.14	0.94
	Z-statistic -0.42	(2.28)*	-0.21
Nonmetal	Odds ratio 0.54	0.54	0.53
	Z-statistic (2.96)**	(2.52)**	(3.01)**
Textile	Odds ratio 0.68	0.89	1.56
	Z-statistic -1.36	-0.33	-1.51
Constant	Odds ratio 1.84	5.01	1.48
	Z-statistic (3.22)**	(6.70)**	(2.09)*
Observations	1771	1771	1771

* Significant at 5% level

** Significant at 1% level

When testing for sector influence on innovative outputs, the most consistent results are for non metallic products factories (*nonmetal*) which fabricate glass and ceramic products among others. The logistic model finds that odds of generating any of the three innovative outputs are about half of the metal products establishments. In addition, the testing shows only two other significant results: 1) the generation of new products in the wearing apparel and fur (*confec*) factories have .7 lower odds than metal

products establishments. This result is particularly noticeable since almost a quarter of factories in the wearing apparel and fur sector are foreign owned and a large fraction are large establishments (38%, Table 3). This result is similar to those of Smarzycka (2003) and Alfaro & Rodriguez-Clare (2004) who do not find evidence of spillovers from foreign ownership in local factories within the same sector. As a conclusion, innovation within the wearing apparel and fur sector at the local level is not fostered by a high presence of foreign owned factories, which is associated to larger factory size. 2) On the contrary, the creation of new production processes in the leather and articles-footwear (*leashoe*) factories have odds 3 times higher than of than factories in the metallic product sector. Foreign ownership in the *leashoe* sector only amounts to 4% of the factories and micro and small factories dominate the sector, totaling 80% of the establishment (table 3). The metallic sector excludes machinery and equipment and it manufactures relatively non- complex products such as parts, containers and structures, usually with a static, immovable function. Also, there is a large presence of micro and small firms in this sector (68%) and only 9% of the factories are foreign owned (Table 3).

Model 2

Establishment Size: In the complete model, the inclusion of the network and input variables, changes the significant relationships seen in Model 1. Now, odds ratio are found to be not significant, while the corresponding correlations are still significant. Therefore no certain global statements about significance can be made. Nevertheless, the odds ratio for firm size in the new product and improvements in existing products are very close to one, which suggest that there is not a difference in production of innovation outputs for different factory sizes.

Table 5 - Model 2 Results

	a) new products	b) new production processes	c) improvements in existing products
FACTORY SIZE			
Microsmall	Odds ratio 0.82	1.16	0.95
	Z-statistic -1.29	-0.76	-0.35
Medium	Odds ratio 0.93	1.37	0.94
	Z-statistic -0.45	-1.42	-0.36
FACTORY SECTOR			
Confecce	Odds ratio 0.70	1.03	0.92
	Z-statistic (1.79)*	-0.10	-0.40
Bebalim	Odds ratio 0.77	0.83	0.78
	Z-statistic -1.39	-0.80	-1.28
Ocupl	Odds ratio 1.18	1.14	1.03
	Z-statistic -0.74	-0.48	-0.14
Furnwood	Odds ratio 0.79	1.08	0.92
	Z-statistic -1.18	-0.30	-0.38
Leashoe	Odds ratio 1.16	4.41	1.47
	Z-statistic -0.51	(2.91)**	-1.27
Nonmetal	Odds ratio 0.58	0.61	0.61
	Z-statistic (2.51)**	(1.98)*	(2.20)*
Textile	Odds ratio 0.74	0.98	1.88
	Z-statistic -1.03	-0.06	(2.01)*
A- INTERNAL NETWORKS - INTRA FIRM COOPERATION VARIABLES			
Forown	Odds ratio 0.77	1.20	0.96
	Z-statistic -1.53	-0.78	-0.24
B- EXTERNAL NETWORK - INTER FIRM VARIABLES			
Forsubcont	Odds ratio 1.00	1.30	1.30
	Z-statistic -0.01	-1.10	-1.50
Forlicen	Odds ratio 2.07	2.31	2.02
	Z-statistic (2.14)*	-1.56	(2.09)*
Locsuppl	Odds ratio 0.97	0.94	1.48
	Z-statistic -0.17	-0.32	(2.44)**
Loclic	Odds ratio 1.29	0.91	3.02
	Z-statistic -0.49	-0.15	(1.90)*
Locclient	Odds ratio 1.81	1.43	1.53
	Z-statistic (2.93)**	-1.26	(2.15)*
INSTITUTIONAL NETWORKING VARIABLES			
Locuniv	Odds ratio 2.42	2.17	3.72
	Z-statistic (2.51)**	-1.44	(3.62)**
Locchamb	Odds ratio 1.19	2.69	0.86
	Z-statistic -0.66	(2.09)*	-0.57
C- INNOVATION INPUT VARIABLES			
Newequip	Odds ratio 2.15	1.84	2.47
	Z-statistic (7.13)**	(4.39)**	(8.24)**
humanK	Odds ratio 1.51	1.95	1.31
	Z-statistic (3.80)**	(4.40)**	(2.41)**
D&A	Odds ratio 1.24	1.61	2.19
	Z-statistic (1.84)*	(2.87)**	(6.69)**
Constant	Odds ratio 0.81	1.79	0.41
	Z-statistic -0.93	(2.08)*	(3.76)**
Observations	1771	1771	1771

* Significant at 5% level

** Significant at 1% level

Sector: In general, results of sectoral influence are consistent to Model 1's. A) For the generation of the first type of innovative outputs, creation of new products, out of 7 manufacturing sectors, two had statistically significant results. Factories of garment and

fur manufacturing and non metal product manufacturing show odds that are .7 and .6 of those factories devoted to metal product manufacturing. Both results are similar to Model 1, supporting the robustness of this finding. B) The second type of innovative outputs, new production processes is found to have greater odds in factories of leather and shoe manufacturing and lower in non metal product factories, as has been reported for Model 1. C) Finally, textile (*textile*) factories show odds 1.9 times higher than those of metal manufacturing establishments. The characteristics of the textile manufacturing are similar to those of the garment and fur manufacturing sector. The presence of foreign ownership is as high as in the garment manufacturing sector, 23% and the fraction of large firms is large too (33%, table 3). On the contrary, the odds of making improvements in existing products for Leather and articles-footwear (*leashoe*) factories is 4.4 times larger than those factories engaged in metal products manufacturing. Finally, factories in the non metallic production (*nonmetal*) sector show odds that are 6 of the odds of metal product manufacturing factories. In summary, innovation does not happen homogeneously across all manufacturing sectors, more importantly the relationship with foreign firms does not guarantee innovation outputs at the factory level.

Internal networks: the presence of foreign ownership (*forown*), the intra-firm channel for technological change is not a mechanism to foster innovation within the factory on any of the three innovation outputs considered. . This finding is consistent with the literature review provided by Alfaro and Rodriguez-Clare (2004) who describe the lack of foreign direct investment spillovers within the same. If spillovers are to happen, they are more likely to be vertical rather than horizontal in nature. For example, foreign ownership may have positive spillovers in local suppliers through backward linkages (Smarzynska, 2003). The model tested accounts for the overall participation of foreign

firms in all sectors and its influence in both within and across sector spillovers, and the results show no significance in fostering the production of innovation outputs.

External network:

Inter firm network (Foreign): Factories with access to foreign technology through inter firm licensing (*forlicen*) have odds that are twice as high for the development of new products or for improvement of existing products as those that do not have access to this technology. Though, only 3% of the surveyed firms purchased a foreign license, the impact on innovative outputs is quite significant. The other market channel to access to foreign technology was subcontracting, the results contradict the idea that foreign firms purchasing locally intermediate inputs and services would foster innovation through a package of upgrading efforts associated with the supply of inputs (Barba Navaretti and Venables, 2004 and Smarzycka, 2003).

Inter firm network (Local): the factories' relationships with other firms prove vital to develop improvements on existing products. Factories that acquired technology through cooperation with suppliers of machinery and equipment (*locsuppl*), collaboration with client firms (*locclient*) and local licensing (*loclic*) show odds 1.5 times higher of improving existing products than those factories that lacked those interactions.

Additionally, the odds of creating new products are 1.8 times larger for factories that get hold of technology through interactions with clients.

Institutional networks: the model results suggest that factories with relationships with universities and public institutions (*locuniv*) have greater odds of creating new products and improvements of existing products than those factories without those interactions.

Though the specific interaction activity has not been elucidated, it well may be that training provision and consulting are ways that universities and institutions foster

innovation in local plants. Additionally, the third type of innovation output, a new production process is more likely if the factory has acquired its technology from interacting with local chambers of commerce (*locchamb*). The collaboration and learning from peers seems to be vital in the course of devising new production processes.

Innovation inputs: the most consistent and important drivers for all three innovation outputs are the inputs described by Kline and Rosenberg (1986). As Table 5 show, factories that engaged in development and adoption of technology (*D&A*), hiring new personnel (*humank*) and acquiring new machinery and equipment (*newequip*), show higher odds for the development of innovative outputs. The result stresses the importance of non-R&D inputs in the generation of innovation especially in low technology industries. Moreover, in developing countries, adoption and adaptation of new technologies within the factory are primary channels for innovation rather than classical expenditures in R&D. The hiring of new personnel (*humank*), helps to absorb, use and adapt new technology and it is assumed that technological know-how is embodied in technical personnel (Griliches, 1969 and Nelson and Phelps, 1966). Finally, the acquisition of new machinery and equipment (*newequip*) embodies technological progress and represents a higher level of technology.

Part V- Conclusions and Public Policy Implications

First, the results suggest that policies designed to attract FDI in the four countries studied should take into account the innovation differences across sectors. As the analyses show, low technology manufacturing sectors with major relationships with foreign capital and with a big proportion of large factories are not necessarily more

innovative. It well may be that the lack of innovation is related to enclave characteristics of foreign ownership, as it seems to be the case of the wearing apparel sector. On the contrary, the textile manufacturing sector has similar characteristics, but innovation seems to be more likely. In that sense policies designed to foster FDI should consider sectoral characteristics. Nevertheless, the classical optimal public policy approach, subsidies, place very stringent information requirements on policy, because the subsidy needs to be calibrated in a way that matches the value of the innovation outputs.

Second, despite the unclear role of foreign ownership in innovation, the results suggest that when local firms master foreign technology using licensing, innovation is more likely to occur. This is a market channel that proved to be essential in the catching up process of East Asian economies (Matthews, 2001)

Third, for low technology manufacturing sectors in the 4 countries studied, external networks are found to be important in the production of innovation outputs in inter-firm relationships as well as institutional relationships. Potential policies to help the creation of public private Institutional structures that foster coordination between the institutional network and firms (factories) as well as enhance adoption and accelerate diffusion of foreign technology that would increase innovation of local firms are desirable.

Finally, results on innovation inputs stress the importance not only of adaptation and development within the firm in generating innovative outputs but the value of machinery and acquisition equipment and contracting new human capital. This is more relevant in the case of low technology manufacturing industries where learning by doing is an integral component for gaining incremental innovation.

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Annex I - Variable definitions

A- Firm Size		
Microsmall	1-25 permanent workers	
Medium	26-75 permanent workers	
B- Firm Sector		ISIC 3 (1)
Confecce	Wearing apparel and fur	18
Bebalim	Food products and beverages	15
Qcpl	Chemicals and chemical products	24
Furnwood	Wood & products of wood & cork, exc. Furniture	20
Leashoe	Leather and articles; footwear	19
Nonmetal	Other non-metallic mineral prod.	26
	Rubber and plastic products	25
Textile	Textiles	17
C- Internal (inter-firm) Networking		
Forown	10% or more of foreign capital	
	main technology channel= technology from headquarters	
D- External Networking (intra-fim) Foreign		
Forlicen	main technology channel= foreign licenses	
Forsubcont	percentage of sales to MNCs>10%	
E- External Networking (intra-fim) Local		
Locsuppl	main technology channel= cooperation with local suppliers of machinery and equipment	
Locclient	main technology channel= cooperation with client firms	
Loclic	main technology channel= licensing from local firms	
F- External Networking - Institutional Local		
Locuniv	main technology channel= universities or public institutions	
Locchamb	main technology channel= from chamber of commerce	
G- Innovation Inputs		
D&A	main technology channel= developing/adapting technology within the firm	
Newequip	main technology channel= acquiring new machinery / equipment	
humanK	main technology channel= hiring new personnel or consultants	

Notes: (1) Industrial standard international classification

Source: <http://www.oecd.org/dataoecd/14/28/1936170.htm>