Chapter 11

Knowledge Flows, Organization and Innovation: Firm-Level Evidence from Malaysia

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CHAPTER 11

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Technological upgrading of a country's manufacturing sector requires the enhancement of firm-level capabilities. Knowledge flows within firms and that between firms and other entities are important aspects of this process. The nature and significance of such knowledge flows for innovation-related activities (such as in-house R&D, acquisition of technology-embedded investments and training) are likely to differ for each type of activity. The link between innovation and knowledge flows are particularly important for innovation activities in the form of acquisition of machinery, equipment and software There is also some weak evidence that globalization-related variables such as foreign direct investment and exporting can affect certain types of innovation activities such as training and acquisition of machinery, equipment and software. This study also finds that firm-level organizational dimensions and innovations are related to both internal and external knowledge flows. However, there is evidence that the links between innovative firms in Malaysia and other firms abroad in terms of co-operative activities is relatively weak. This raises the issue of whether such firms are able to tap the global technological-pool effectively.

Keywords: Innovation, Knowledge Flows and Organization

JEL Classification: 032, L60

1. Introduction

Many developing countries today actively engage in globalization to achieve sustained economic growth and development. A number of these countries have sought to implement industrial and trade policies aimed at promoting export-oriented industrialization processes. In Southeast Asia, countries such as Malaysia, Thailand and Vietnam have successfully developed export-oriented manufacturing bases comprising low to semi-skilled manufacturing assembly operations with some basic research and development activities. Despite such successes, there is a growing cognizance among policymakers in these countries of the need to upgrade their manufacturing base by producing higher value-added and more technologically sophisticated products.

How can developing countries upgrade the technological profile of their manufacturing sector? What role does globalization play in this process? Irrespective of what policy measures are proposed and implemented, it is clear that the process of technological upgrading will have to take place at the firm-level (Lall, 2000, p.19). The process of technological upgrading occurs through the accumulation of knowledge that is internally generated as well as sourced from external parties, such as suppliers, customers and universities (Griliches, 1979). Furthermore, the process of technological upgrading depends on factors that are both internal and external to the firm. Internal factors include the structure of incentives and organization within the firm. External factors include government incentives for innovation (such as tax incentives for R&D activities), investment climate, infrastructure and market competition.

Given that the majority of advanced technology resides in more developed countries, globalization clearly plays an important role in the process of technological upgrading amongst firms in developing countries (Keller, 2004). This could take place through knowledge flows resulting from the import of technologically-embedded inputs, export participation, foreign direct investment (FDI), cross-border movement of workers and training (Goldberg *et al.,* 2008, p.1). Furthermore, a useful approach to analyze the sources of knowledge flows and their impact on technological capability is in conjunction with the organizational aspect of a firm (Teece, 2000). After all, the firm is an organization - one characterized by internal hierarchies (with multiple principalagent relationships between owners, board of directors, managers and employees) and structures (divisions and departments). The boundaries of the firm are also fluid - leading to flows of technological knowledge from external parties, such as customers, suppliers, competitors and research centres. The usefulness of taking the organizational and knowledge flow perspectives is that it allows an analysis of innovation to go beyond conceptualizing the firm as a black box (or production function).

Despite the potential usefulness of examining innovation from the organizational and knowledge flow perspectives, these approaches are relatively empirically under-researched, due to a lack of suitable data. Until recently, most studies have utilized firm-level data in the form of R&D expenditures, value-added and patent counts. This has lead to most studies concentrating on investigating the linkages between innovation and productivity levels. However, more recent survey data sets, such as those from the EU's Community Innovation Surveys (CIS) have provided opportunities for scholars to empirically examine the nature and significance of organization and knowledge flows for innovating firms.

The objective of this study is to undertake an empirical analysis of the importance of knowledge flows and organization to innovation. Given the outward orientation of the Malaysian economy, a key focus will be an investigation of how these elements are related to aspects of globalization, such as exporting, foreign ownership and collaboration with foreign partners. In addition to strengthening the literature in this area, an understanding of these micro-dimensional aspects of the innovation process is also crucial for policymakers as they provide insights into how firms build up technological capabilities.

The data utilized for this study comes from the National Survey of Innovation conducted by the Malaysian government. The firm-level survey data covers the Malaysian manufacturing sector during the period 2002-2004. The outline of the paper is as follows. Section 2 provides a review of the related literature. Methodological issues are discussed in Section 3. The empirical results are discussed in Section 4. A number of policy implications are drawn out in Section 5. Section 6 concludes.

2. Literature Review

The micro-level empirical literature on knowledge flows, organization and innovation is fairly diverse. Theoretical and empirical contributions in this area come from a number of areas, such as international trade, innovation studies and strategic management. Each of these areas has a distinct methodological orientation and focus but share the common objective of understanding the process of innovation. Each strand of this literature is briefly discussed in this section.

2.1. International Trade

The first strand of literature, which comes from the area of international trade, relates to theoretical and empirical investigations of the relationships between productivity and trade using a "heterogeneous firms" framework. The empirical evidence based primarily on panel data from industrial surveys has thus far supported the self-selection theory. This theory argues that the more productive firms are the more likely they are to self-select into export markets (Greenaway and Kneller, 2004). Subsequent empirical works have incorporated innovation (in the form of investments in R&D) as a factor that affects productivity and hence, export participation e.g. Baldwin and Gu (2004), Aw *et al.* (2007) and Aw *et al.* (2010). In many of these works, the firm has been primarily modelled as production function.

More recently, trade theorists have emphasized the importance of organization in understanding not only the nature of firms' decisions to export but also to engage in foreign direct investment (FDI) (e.g. Antras and Helpman (2004), Helpman (2006) and Antras and Rossi-Hansberg (2009)). The organization is primarily analyzed in terms of the vertical boundaries of a firm which entails the decision whether to make (vertical integration) or buy (outsource/vertical disintegration).[1] Adding cross-border dimensions to such decisions takes into account the trade (outsourcing abroad) and FDI (vertical integration or insourcing abroad) phenomena. The theoretical findings in this area suggest that not only are the make and buy decisions of firms important in

[1] The theoretical framework is that of the incomplete contract approach to the theory of the firm e.g. Hart (1995).

explaining trade and FDI, these decisions are also simultaneously determined. In addition, the quality of contracting institutions matters (as they impact hold-up problems). There is some empirical evidence that productivity is related to firms' decisions to outsource, export or invests abroad (Tomuira, 2007). Decisions on vertical boundaries involving domestic production, FDI or outsourcing domestically or internationally have also been estimated by Tomuira (2009) - with such decisions being found to be positively influenced by firm size and R&D intensity.

The incorporation of innovation within a trade/FDI and organization framework is still at a very early stage of theorization e.g. Naghavi and Ottaviano (2009) and Naghavi and Ottaviano (2010). Most of the recent advances made on the investigation of the relationships between trade, organization and innovation have been theoretical in nature. Empirical work in this area has been hampered by the lack of micro data with sufficient detail on both the innovational and organizational aspects. Productivity and innovation related variables are usually available in census data but organization-related data is not. There have been very few attempts to derive proxy-variables for organization e.g. Nunn and Trefler (2008). Despite such data-related problems, the emerging empirical literature on ownership, production structure and trade suggests that this area of research is likely to continue to be important (see Hayakawa *et al.* (2010)'s review of the literature).

2.2. Innovation Studies

The second strand of literature is based on innovation studies. In contrast to the international trade literature (which primarily uses census data), innovation studies usually use cross sectional data from innovation surveys such as the EU's *Community Innovation Survey* (CIS). The literature focuses primarily on the investigation of the relationship between innovation and productivity using an innovation production function (e.g. OECD, 2009 and Mairesse and Mohnen, 2010). The benchmark model in this literature is the "CDM Model" which is a structural model that links research investment to innovation output and productivity (Crepon *et al.*, 1998).[2] Subsequent studies have involved an estimation of an extended version of the CDM model by the

[2] Applications of the model to the case of Malaysia have been undertaken by Lee (2008).

inclusion of other explanatory variables, such as external information and knowledge linkages (Griffith *et al.*, 2006).

In more recent works, a great deal of effort has gone into more explicit modelling and empirical testing of the importance of knowledge flows in the innovation process. This approach is consistent with the early work by Griliches (1979) who emphasized the multiple sources of knowledge in the innovation process, namely, new and existing knowledge within a firm and from outside the firm. The importance of knowledge management policies to innovation and productivity was investigated and found to be statistically significant in Kremp and Mairesse (2004).[3] The studies by Loof and Heshmati (2002), Criscuolo *et al.* (2005), Munier (2006) and Crespi *et al.* (2008) confirm the importance of internal (intra-firm) and external (competitors and suppliers) sources of knowledge flows for innovation. The importance of internal and external production and information networks to innovation is also emphasized in a recent study by Machikita and Ueki (2010) based on micro data collected in Indonesia, Thailand, the Philippines, and Vietnam.

2.3. Strategic Management

A third strand of relevant literature comes from strategic management in the form of emphasis on the resources and capabilities of firms. Proponents of the resource-based theory argue that a firm's superior performance is driven by the use of strategic and unique resources that are valuable, rare, difficult to imitate and non-substitutable (Barney, 1991). In terms of innovation, key research emphasis could be on unique organizational elements (structures, processes and routines) and the accumulation of some of the firm's unique resource via knowledge flows.

The dynamic capabilities approach goes beyond the accumulation of valuable and distinctive resources. It focuses on the adaptability of firms in environments which are characterized by rapid technological change. More specifically, a dynamic capability is defined as a firm's "ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments" (Teece *et al.*, 1997, p.516).

[3] The knowledge management policies covered in Kremp and Mairesse (2004) includes written policy of knowledge management, culture of knowledge management, policy of retaining employees and alliances as well as partnerships for knowledge acquisition.

The organization aspects that are emphasized in the dynamic capabilities approach include organizational learning and the ability to undertake reconfiguration and transformation in a changing environment (ibid, p.520).

Undertaking empirical work on innovation and organization within a framework suggested in the value-based theory and dynamic capability approaches is very difficult and challenging. Such studies have had to rely on detailed micro data containing proxies for a small subset of variables in these theories. Most of the empirical work that are loosely related to these theories examine the knowledge flows between firms and the type of collaborative arrangements (e.g. alliance) that make them possible e.g. Decarolis and Deeds (1999).

3. Methodology

The diversity of the literature related to this research suggests the need for an eclectic framework of analysis that incorporates the various elements related to innovation, knowledge flows and organization. The framework contains elements that are found in the different theories, without comparing and testing which theory would best fit the data. This is because each theory tends to focus on different factors that may be complementary to each other. Furthermore, even if alternative explanations are available to explain some of the factors, the data is not rich enough to empirically test the validity of the different theories and approaches.

3.1.Framework of Analysis

3.1.1. Innovation and Knowledge Flows

Innovation is a complex process. Most studies on innovation have attempted to model the process of innovation as comprising of a number of inter-linked components starting from factors determining innovation activities (inputs such as R&D expenditures) to some measure of firm performance (namely: outputs, such as patents, sale of new products and/or productivity).

A number of factors, such as financial constraints, firm size and market competition, may influence a firm's decision to undertake investments in innovation activities/inputs (such as R&D expenditures and training). If successful, such activities could produce product innovations and/or process innovations which could be accompanied by new patents or industrial designs. These innovation outcomes or outputs have impacts on the firm's performance in the form of productivity improvements or increases in revenues.

The linear innovation model provides a convenient way to model innovation and firm performance using a production function approach:

$$\text{Output} = f(T, K, L, \varepsilon) \tag{1}$$

where T is innovation output (e.g. patents, product or process innovations), K physical capital and L employment and ε other unobservables. This productivity equation can be estimated together with the research and innovation equation using the Heckman selection approach in the CDM model (Crepon *et al.* (1998)).

Incorporating knowledge flows in the linear innovation model requires an understanding of the different sources of knowledge flows and how they might impact the innovation process. In this regard, Griliches (1979) postulates three sources of knowledge in the innovation process, namely:

1. New knowledge generated within the firm via new investments such as R&D;
2. Use of existing knowledge (within a firm or from related firms in the same group, such a parent or subsidiary company); and
3. Knowledge from outside the firm (e.g. sellers, buyers and other sources, such as universities).

One approach that has been used to incorporate these different types of knowledge flows is by including them as explanatory variables in the productivity equation. For example, in Criscuolo *et al.* (2005) and Crespi *et al.* (2008), the productivity equation and changes in knowledge stock of a firm i is modeled as follows:

$$T\dot{F}P_i = f(\dot{A}_i, \varepsilon_{1i}) \tag{2}$$

and

$$\dot{A}_i = f(R_i, A'_i, A'_{-i}, \varepsilon_{2i}) \tag{3}$$

where $\dot{TFP}_i$ is total factor productivity (TFP) growth, R_i investment in new knowledge, such as R&D and training, A'_i knowledge flows within the firm, A'_{-i} knowledge flows from outside the firm, and ε_{1i} and ε_{2i} unmeasured changes that affect TFP growth and knowledge production, respectively. The variable $\dot{A}_i$ is proxied by patents in Crespi *et al.* (2008). However, the information from the strategic management literature clearly suggests a more complex view of knowledge flows. Knowledge flows could affect decisions to undertake innovation. They could also be inputs in the innovation process. It also implies that it would very difficult to find a single proxy variable for changes in knowledge stock $\dot{A}_i$.

Given the complexity of knowledge flows and the difficulties in finding a single proxy for knowledge stock, it may perhaps be useful to just model the decisions to invest in innovation activities R_i and innovation production by incorporating knowledge flows. One possible approach is to incorporate them into a set of research and innovation equations, such as those used in the CDM model.

Another potential useful approach to analyzing the importance of knowledge flows is in terms of firms' technology absorption capacity. Goldberg *et al.* (2008) makes a distinction between innovation and absorption. Innovation is defined as involving new-to-the-world knowledge and can be characterized by an outward shift in the technological frontier. In contrast, improvements in absorption capacity moves a firm closer to the technological frontier. Examples of absorption include the adoption and upgrading of new products and process developed elsewhere, upgrading licensing technology, and improving organizational efficiency (Goldberg *et al.*, 2008, p.2). Knowledge flows is likely to be an important determinant of the absorption capacity of firms.

3.1.2. Knowledge Flows and Organization

Finally, it may still be a useful exercise to examine what factors influence the channels of knowledge flows used, for both knowledge flows within the firm (A_i') and knowledge flows from outside the firm (A_{-i}'). Such factors may include those related to globalization, such as import of machinery, exporting and foreign direct investment/foreign ownership. The determinants for the different types of knowledge flows could be expressed as follows:

$$A_i' = f(M, E, F, X, \varepsilon_{3i}) \quad (4)$$

$$A_{-i}' = f(M, E, F, X, \varepsilon_{4i}) \quad (5)$$

where M is import of machinery, E export participation, F foreign direct investment/foreign ownership, X the set of control variables and, ε_{3i} and ε_{4i} unmeasured factors affecting knowledge flows.

Another important set of factors are those related to organizations. Organization as a concept is in itself complex and multi-dimensional. This is evidenced by the different ways in which the notion of organization has featured in the different literatures. It could be modelled in terms of vertical boundaries as it is done in the international trade literature. One possible approach is to model decisions on vertical boundaries as a two-stage process, the first stage involving the decision to make or buy and the second stage involving the decision to either source it domestically or from foreign markets.

This is the approach taken in Tomuira (2009). Organization could also take on hybrid-forms, such as alliances and joint ventures - these being subsets of external linkages discussed in innovation studies literature. Alternatively, it could be conceptualized in terms of internal organizational structures and routines (as in the resource-based view) or in terms of some measures of structures, procedures and designs that enhance the adaptability of the firm (as in the dynamic capabilities view). The model and definitions used for model organization are ultimately constrained by data availability - this study is no exception in this respect. This is discussed in greater detail in the next section.

3.2. Econometric Specifications

Based on the general framework of analysis discussed earlier, the econometric analysis of the relationships between knowledge flows, organization and innovation is undertaken in a number of distinct steps.

3.2.1. Innovation and Knowledge Flows

As discussed earlier, knowledge flows can influence the decision to undertake innovation activities such as R&D. In addition, knowledge flows can be an input in the innovation process. The decision to invest in innovation activities d_R of firm *i* can be specified as:

$$d_R = \begin{cases} 1 & \text{if} \quad d_R^* = \alpha_1 KNOWF_i + \alpha_2 w_i + \eta > 0 \\ 0 & \text{otherwise} \end{cases} \tag{6}$$

where d_R^* is a latent variable associated with d_R, $KNOWF_i$ is the vector of knowledge flow variables, $\boldsymbol{w}_i$ the vector of other variables affecting the decision to undertake innovation activities and η other unmeasured variables affecting d_R.

Knowledge flow can be modeled as an input in the innovation process in terms of the observed amount of R&D investment by firm *i*:

$$R_i = \begin{cases} \beta_1 KNOWF_i + \beta_2 \mathbf{x}_i + \delta_1 & \text{if} \quad d_R = 1 \\ 0 & \text{otherwise} \end{cases} \tag{7}$$

where $KNOWF_i$ is the vector of knowledge flow variables, $\boldsymbol{x}i$ the vector of other variables affecting the total amount of investment in knowledge and δ_1 unmeasured variables affecting R_i. Both equations can be jointly estimated using the Heckman selection method.

There a number of proxies for innovation activities (R_i) that can be used. Three proxies for innovation activities are used in this study, namely, in-house R&D activity (RNDINTRA), acquisition of machinery, equipment and software (ACQMACH) and training (TRAINING). The different types of knowledge flows are expected to be related to each of these innovation activities in a different manner. While in-house R&D may be related to building internal capabilities, acquisitions could be related to embodied technology.

Training, on the other hand, is an investment in the purely human capital aspects of innovation. Following Crespi *et al*. (2008), knowledge flows are proxied by the different sources of information used for innovation. The major categories are information from within the company itself (KNOWFOWN), other companies within the same group (KNOWFGRP), suppliers (KNOWFSUP), customers (KNOWFCUS), competitors (KNOWFCOM), consultants (KNOWFCON), private and commercial research laboratories or centres (KNOWFPRI), universities (KNOWFUNI) and government or public research institutes (KNOWPUB). Based on the earlier discussions, the knowledge flows can be classified as follows:

- internally generated knowledge flows (A'_i) such as NOWFOWN and NOWFGRP, and
- knowledge flows from outside the firm (A'_{-i}), namely, KNOWFSUP, KNOWFCUS, KNOWFCOM, KNOWFCON, KNOWFPRI, KNOWFUNI and KNOWPUB.

Two sets of control variables are used for the above estimations. The first include firm-level variables such as firm size (SIZE, SIZE2), age of firm (AGE, AGE2), extent of foreign ownership (FOREIGN) and whether firms are limited liability listed companies (OWNLIMLIST), limited liability unlisted companies (OWNLIMUNLIST) or unlimited liability firms (OWNUNLIM). Industry-level control variables take the form of market concentration (HHI) and industry dummies. A useful industry variable which is not available, due to data constraints is import penetration ratio.

Finally, as innovation activities could be influenced by the assistance and support from government agencies, six explanatory variables are included to capture such effects. These are extracted from the survey and can be classified into two categories. The first category is a broad measure of government-related variables comprising non-tax incentives (NONTAXINCT) and tax incentives (TAXINCT). The second set includes more specific government-related assistance and support measures. These include technical consulting services (TECHCON), technical support services

(TECHSUP), duty-free import of machinery (DUTYFREE) and R&D Commercialization Fund (RNDFUND). Given the possible overlap between the two categories of government-related variables, they are included separately in the regression equations.

3.2.2. Knowledge Flows and Organization

Knowledge flows occur within given organizational structures. Even though the choice of organization may be considered to be endogenous in the long run, it is more plausible to assume it as an exogenous variable compared to knowledge flows.

A general specification of this relationship for a given firm *i*'s knowledge flow $KNOWF_i$ can be expressed as:

$$KNOWF_i = f(ORG_i, \mathbf{X}_i, e_i) \qquad (8)$$

where ORG_i is the vector representing organization variables, $\mathbf{X}_i$ the vector of control variables and e_i the error term. The above equation can be estimated using probit. The set of control variables used is similar to those used in estimating the relationship between innovation and knowledge flows.

The discussions in the previous studies suggest that organization is a complex concept with diverse meanings in different research literatures. Thus, several types of organization variables can be used in this study. They include the following:

1. The first relates to vertical boundaries of the firm. Detailed information on vertical relationship is not available. Instead this variable is proxied by a dummy variable FIRMSUB which takes the value of one if a firm is a subsidiary of another firm and zero otherwise.
2. A second type of variable for organization relates to organizational innovations that improves the adaptability of the firm to a changing environment (as in the dynamic capabilities literature). These include organizational innovations that:
    - Reduce the time to respond to customer or supplier needs (ORGTIME);
    - Improve the quality of goods and services (ORGGOOD);
    - Reduce cost per unit of output or service (ORGCOST); and

- Improve employee satisfaction and reduce employee turnover (ORGSATI).

3. A third set of variable relates to collaborative activities with external parties. In the survey data used, it is possible to identify to identify firms that engage in co-operative arrangements on innovation activities. This variable can be further classified in greater detail according to the different types of partners involved in such activities and whether they involve domestic (D) or external partners (F). The variables used in this study include co-operative arrangements with other companies within company group (COOPGRPF for foreign partners, COOPGRPD for domestic partners), suppliers (COOPSUPF, COOPSUPD), customers (COOPCUSF, COOPCUSD), competitors (COOPCOMF, COOPCOMD), consultants (COOPCONF, COOPCOND), private and commercial research laboratories or centres (COOPPRIF, COOPPRID), universities (COOPUNIF, COOPUNID) and government or public research institutes (COOPPUBF, COOPPUBD). The inclusion of this set of variables could provide some insights into the relative importance of foreign vs. domestic collaborations.

Finally, six variables representing government assistance and support for innovation-related activities are also included to capture their effects on knowledge flows within and between firms. They are identical to the ones used in the previous section.

3.3. Data

3.3.1. Data Source and Description

The micro data that will be used for this study is a firm-level cross-section data set from the National Survey of Innovation (NSI) conducted by the Malaysian Science and Technology Information Centre (MASTIC), Ministry of Science, Technology and Innovation. The survey covers the Malaysian manufacturing sector during the period 2002-2004. The survey was carried out in two stages - the first used a one-page questionnaire addressed to both innovating and non-innovating firms. In the second stage, a more detailed questionnaire was completed by innovating firms. The dataset used for this study comes from the second stage which covers only firms that innovated during the period 2002-2004.

Three variables are used to proxy innovation activities in this study, namely, in-house R&D activity (RNDINTRA), acquisition of machinery, equipment and software (ACQMACH) and training (TRAINING). This data is expenditure incurred for each activity during the period 2002-2004. Natural logarithmic of per-capita expenditure for these activities is used in the regressions.

The knowledge flow variables are binary variables derived from a three point Likert-type scale (low, medium and high importance) for the different sources of information. Each of the knowledge flow variables (e.g. KNOWFOWN) assumes a value of one for a firm if it indicates the source as of high importance and zero otherwise. The organization variable FIRMSUB is also a binary variable, assuming the value of one for firms indicating they are part of a company group and zero otherwise. The four organizational innovation variables (ORGTIME, ORGGOOD, ORGCOST and ORGSAT) are binary variables that assume the value of one if they are considered of high importance.

Innovation co-operation variables take the form of binary variables. In addition, there are some firms with both foreign and domestic collaborative partners. There are sixteen dummy variables - two (foreign, local) for each type of partner. The four control variables used in this study are all firm-level variables. Firm size (SIZE) is measured in terms of the (natural logarithmic of) number of employees in 2004. The age of the firm (AGE variable) is measured by the number of years established as of 31 December 2004. The variable FOREIGN measures the degree of foreign ownership - it is a binary variable with the value of one if 10% or more of the ownership equity in the firm is in the hands of foreigners. The exporting variable (EXPORT) takes the form of a dummy variable which assumes the value of one if the value of exports is positive and zero otherwise. Three ownership variables are used in this study - OWNUNLIM (sole proprietorship and partnership with unlimited liability), OWNLIMPRI (private companies with limited liability) and OWNLIMLIST (public listed companies with limited liability).

Data on industry market concentration comes from a separate source, namely the Department of Statistics. The most recent estimates of the Herfindahl-Hirschman Index

(HHI) that could be obtained are for year 2000. Estimates of the HHI at the aggregated level (2-digit) are derived from disaggregated 5-digit HHI estimates (computed by the Department of Statistics) using a weighted approach. The weights used are based on turnover figures for the various industries obtained from the Department of Statistics' Census of Manufacturing Industries 2001.

3.3.2. Descriptive Statistics

The descriptive statistics for the sample data used in this study are summarized in **Table 1**. The firm size distribution (measured in terms of total number of employees) suggests that most firms in the sample are small and medium enterprises (SMEs). Close to half of the firms in the sample have between 50 to 249 employees. The age of the firms ranges between 2 years and 76 years with the average age being 14 years. A relatively smaller proportion of the firms (17.5%) in the sample data are foreign-related companies (defined as equity equal to or more than 10% in the hands of foreigners). About 64% of the firms in the sample data are engaged in export markets. The predominant mode of ownership amongst firms in the sample is private limited (90%). Only a very small proportion (3.4%) is public listed companies.

Table 1. Basic Descriptive Statistics

Size (no. employees)	**1 to 19**	**20 to 49**	**50 to 249**	**> 249**	**Total**
Number of firms	58	89	208	84	439
Percentage	13.2%	20.3%	47.4%	19.1%	100.0%
Age (years)	**1 to 5**	**6 to 10**	**10 to 20**	**> 20**	**Total**
Number of firms	30	180	151	78	439
Percentage	6.8%	41.0%	34.4%	17.8%	100.0%
Foreign Ownership (% equity)	**FO=0**	**0 < FO < 11**	**10 < FO < 51**	**50 < FO**	**Total**
Number of firms	362	6	24	47	439
Percentage	82.5%	1.4%	5.5%	10.7%	100.0%
Exporting	**Exporters**	**Non Exporters**			
Number of firms	279	160			439
Percentage	63.6%	36.4%			100.0%
Subsidiary	**YES**	**NO**			**Total**
Number of firms	96	343			439
Percentage	21.9%	78.1%			100.0%
Ownership Type	**Sole-Proprietor**	**Partnership**	**Private Limited**	**Public Listed**	**Total**
Number of firms	18	11	395	15	439
Percentage	4.1%	2.5%	90.0%	3.4%	100.0%

Table 1 (continued). Basic Descriptive Statistics

Importance of Information Source (%)	Not Used	Low	Medium	High	Total
Within company	10.8	28.28	28.79	32.13	100.00
Other company within group	67.53	6.44	14.95	11.08	100.00
Suppliers	10.8	26.99	40.36	21.85	100.00
Customers	6.96	40.46	36.86	15.72	100.00
Competitors	29.82	24.68	22.62	22.88	100.00
Consultants	52.31	15.13	15.64	16.92	100.00
Private Research Institutes	77.84	6.44	7.99	7.73	100.00
Universities	85.53	6.2	5.43	2.84	100.00
Publlic Research Institutes	66.93	14.47	10.59	8.01	100.00
Importance of Organizational Innovation (%)	**Not Relevant**	**Low**	**Medium**	**High**	**Total**
Time Responsiveness	7.75	29.58	39.2	23.47	100.00
Quality Improvement	5.16	46.95	30.05	17.84	100.00
Cost Reduction	6.35	44.00	28.00	21.65	100.00
Employee Satisfaction	7.57	36.88	29.08	26.48	100.01
Innovation Activities (Ringgit Malaysia)	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
In-House R&D	300	264297.8	901593.7	0	1.00E+07
Acquisition of Machinery etc.	347	448593.6	1586439	0	1.50E+07
Training	304	40052.69	135721.9	0	2000000

Source: MASTIC.

Knowledge flows are proxied by sources of information for innovation. The major sources of information that are regarded as ‘highly important’ include those originating from within the company itself, from competitors and from suppliers. Interestingly, research institutes (both private and public) and universities are not considered to be important sources of information for innovation. In terms of organization, only 22% of the firms in the sample are subsidiaries (i.e. belonging to a group of companies). More than 20% of firms regard three of the categories of organizational innovation effects, those relating to time, cost and employee satisfaction as highly important.

In terms of innovation activities, all three variables used in this study have very high standard deviations compared to the mean, indicating significant variations as well as very unequal distribution across firms in the sample.

The sample data used in this study covers some 22 industries in the manufacturing sector (**Table 2**). Given the relatively small sample size, there is some concern regarding the sample representativeness of the data, as a whole and in terms of each industry in the sector. This is an important issue as it determines whether the findings from this study represent a valid description of the sector. The size of the sample is compared to the size of the sample frame and the larger-sized manufacturing survey. Remember that the sample used in this study covers only innovating firms. Despite this, the sample coverage seems to be high in a few industries with an either relatively low number of total employees or number of firms, or both. The relatively small number of firms (less than 30) suggests that any attempts to undertake an industry-level analysis is likely to be constrained by the number of observations in each industry.

Table 2. Statistics on Sample Representativeness

	(1)	(2)	(3)	(4)	(5) = (1)/(2)	(6) = (3)/(4)
	No. of firms in Sample	**No. of firms in Sample Frame**	**Total Employees in Sample**	**Total Employees in 2004 Manufacturing Survey**	**(%)**	**(%)**
Food products and beverage	46	2,346	10,534	133,402	1.96	7.90
Textiles	2	339	913	37,483	0.59	2.44
Wearing Apparel	19	726	2,959	81,152	2.62	3.65
Leather	12	147	5,723	8,080	8.16	70.83
Wood and cork	21	1,025	2,777	116,329	2.05	2.39
Paper	28	377	8,376	34,821	7.43	24.05
Publishing	17	724	4,895	37,721	2.35	12.98
Coke, refined petroleum	19	47	2,767	4,353	40.43	63.57
Chemical	27	634	8,294	52,687	4.26	15.74
Rubber, plastic	35	1,509	5,471	174,568	2.32	3.13
Non-metalic minerals	25	728	2,637	56,427	3.43	4.67
Basic metals	19	501	2,281	42,941	3.79	5.31
Fabricated metal	27	1,509	2,599	73,703	1.79	3.53
Machinery, equipment	23	813	3,838	53,836	2.83	7.13
Office, accounting, computing machinery	4	65	1,798	64,293	6.15	2.80
Electrical machinery	20	425	2,126	68,131	4.71	3.12
Radio, TV, communication equipment	30	439	9,906	285,243	6.83	3.47
Medical, precision, optical instrument	10	50	3,573	24,956	20.00	14.32
Motor vehicle, trailers	9	253	3,318	51,128	3.56	6.49
Other transport	22	183	3,322	29,679	12.02	11.19
Furniture	22	1,340	3,988	101,361	1.64	3.93
Recycling	2	14	301	544	14.29	55.33
Total	**439**	**14,194**	**92,396**	**1,532,838**	**3.09**	**6.03**

Source: Data (1)-(3) from MASTIC, Data (4) from Ramstetter and Sharazat (2009).

4. Empirical Results

4.1. Innovation and Knowledge Flows

The relationship between innovation and knowledge flows are investigated for three types of innovation activities, namely, in-house R&D, acquisition of machinery and training. The results are discussed in terms of internal vs. external knowledge flows.

In-House R&D

In the case of in-house R&D, internal knowledge flows in terms of knowledge flows from other firms within the same group (KNOWFGRP) is negative and significantly related to the decision to undertake in-house R&D (selection equation) (**Table 3**). This suggests that firms in which such knowledge flows are important are less inclined to undertake in-house R&D. Knowledge flows from external parties appear to be more important, especially knowledge flows from customers (KNOWFCUS) – the variable being significant in both the intensity and selection equations. The negative sign for this variable suggests that the greater importance assigned to knowledge flows from customers is associated with lower propensity and intensity in in-house R&D. This could mean that firms which get good information and feedback from their customers do not see the need for in-house R&D.

Table 3. In-House R&D and Knowledge Flows

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	RNDINTRA	select	RNDINTRA	select	RNDINTRA	select
SIZE	-0.864	1.897***	-1.025*	1.890***	-0.800	1.685***
	(0.676)	(0.364)	(0.572)	(0.380)	(0.572)	(0.362)
SIZE2	0.0328	-0.152***	0.0426	-0.148***	0.0265	-0.130***
	(0.0602)	(0.0364)	(0.0529)	(0.0386)	(0.0523)	(0.0364)
AGE	0.0793**	-0.00791	0.0705*	0.0407	0.0882**	0.0534*
	(0.0386)	(0.0237)	(0.0379)	(0.0259)	(0.0412)	(0.0273)
AGE2	-0.00156*	-0.000301	-0.00148	-0.00101*	-0.00182*	-0.00117**
	(0.000918)	(0.000511)	(0.000903)	(0.000553)	(0.000959)	(0.000587)
FOREIGN	0.0861	-0.579***	-0.161	-0.272	0.0199	-0.399*
	(0.283)	(0.191)	(0.253)	(0.204)	(0.249)	(0.205)

Table 3 (continued). In-House R&D and Knowledge Flows

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	RNDINTRA	select	RNDINTRA	select	RNDINTRA	select
EXPORT	-0.363*	-0.209	-0.334	-0.349*	-0.221	-0.282
	(0.213)	(0.176)	(0.209)	(0.187)	(0.216)	(0.190)
OWNUNLIM	0.0568	-0.124	0.195	-0.106	0.596	-0.435
	(0.888)	(0.457)	(0.865)	(0.465)	(0.874)	(0.496)
OWNLIMLIST	0.784*	0.277	0.620	0.218	0.777*	0.0888
	(0.437)	(0.407)	(0.423)	(0.407)	(0.421)	(0.408)
HHI	0.000605**	0.000269	0.000429	0.000324***	0.000623**	0.000327***
	(0.000273)	(0.000186)	(0.000275)	(9.15e-05)	(0.000266)	(9.31e-05)
KNOWFOWN	0.202	-0.142	0.220	-0.247	0.185	-0.265
	(0.206)	(0.178)	(0.199)	(0.168)	(0.200)	(0.169)
KNOWFGRP	-0.0214	-0.544**	-0.0525	-0.574**	-0.0698	-0.507**
	(0.344)	(0.261)	(0.320)	(0.254)	(0.322)	(0.251)
KNOWFSUP	-0.00571	0.433**	-0.136	0.243	0.0158	0.277
	(0.233)	(0.200)	(0.215)	(0.196)	(0.217)	(0.201)
KNOWFCUS	-1.487***	-0.263	-1.392***	-0.474**	-1.438***	-0.424*
	(0.330)	(0.224)	(0.322)	(0.220)	(0.325)	(0.222)
KNOWFCOM	0.440*	0.164	0.315	0.182	0.368	0.130
	(0.227)	(0.195)	(0.223)	(0.194)	(0.227)	(0.195)
KNOWFCON	0.0317	-0.0592	-0.00667	-0.110	0.0468	-0.168
	(0.237)	(0.218)	(0.232)	(0.218)	(0.232)	(0.222)
KNOWFPRI	-0.414	0.630*	-0.406	0.403	-0.427	0.570
	(0.297)	(0.353)	(0.276)	(0.342)	(0.276)	(0.348)
KNOWFUNI	0.188	-0.452	0.205	-0.324	0.123	-0.210
	(0.490)	(0.518)	(0.475)	(0.513)	(0.471)	(0.516)
KNOWFPUB	-0.350	0.620*	-0.165	0.105	-0.211	-0.0136
	(0.330)	(0.344)	(0.305)	(0.350)	(0.307)	(0.352)
NONTAXINCT			-0.673***	1.077***		
			(0.204)	(0.205)		
TAXINCT			0.503	-0.0598		
			(0.392)	(0.351)		
TECHCON					-0.268	1.196***
					(0.252)	(0.313)
TECHSUP					-0.384	0.320
					(0.285)	(0.371)
DUTYFREE					-0.535*	-0.00665
					(0.285)	(0.271)
RNDFUND					0.289	-0.318
					(0.255)	(0.444)
Constant	8.156***	-5.395***	9.220***	-5.609***	8.008***	-5.165***
	(2.125)	(0.990)	(1.673)	(0.944)	(1.688)	(0.911)

Table 3 (continued). In-House R&D and Knowledge Flows

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	RNDINTRA	select	RNDINTRA	select	RNDINTRA	select
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	437	437	392	392	391	391

Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations based on data from MASTIC.

The market concentration (HHI) seems to be positively related to the decision to undertake as well as the amount (intensity) of in-house R&D expenditure. The significance and signs of the firm size and age variables suggests a nonlinear inverse-U relationship between in-house R&D and these variables. The importance of these variables to in-house R&D differs – age is significant in the intensity equation, while size is significant in the selection equation.

The significance of the two globalization-related variables, exporting (EXPORT) and FDI (FOREIGN) have negative signs and are not significant. Interestingly, government support and incentives in the form of non-tax seem to have a negative relationship with the intensity of in-house R&D.

Acquisition of Machinery, Equipment and Software

The acquisition of machinery, equipment and software should be considered to be a different type of innovation activity compared to in-house R&D. For this type of innovation activity, internal knowledge flows seem to be less important compared to external knowledge flows (**Table 4**). Knowledge flows from other firms within the same group are positively, albeit, weakly significant in relation to the acquisition of machinery, equipment and software. Four sources of external knowledge flows are important for acquisition of machinery, equipment and software, namely, suppliers (KNOWFSUP, positive), customers (KNOWFCUS, negative), competitors (KNOWFCOM, positive in intensity) and consultants (KNOWFCON, positive in selection). In contrast, the negative sign for the demand-oriented variable (KNOWCUS) suggests that when knowledge flows from customers are important, firms are not likely to spend on the acquisition of machinery, equipment and software that are related to innovation.

Table 4. Acquisition of Machinery, Equipment and Software, and Knowledge Flows

VARIABLES	(1) ACQMACH	(2) select	(3) ACQMACH	(4) select	(5) ACQMACH	(6) select
SIZE	-0.131	0.343	0.0824	0.373	0.104	0.302
	(0.344)	(0.278)	(0.335)	(0.313)	(0.332)	(0.308)
SIZE2	-0.0676*	-0.0314	-0.0921***	-0.0336	-0.0870**	-0.0287
	(0.0359)	(0.0287)	(0.0352)	(0.0327)	(0.0346)	(0.0317)
AGE	0.0864**	-0.0200	0.0791**	0.0307	0.0574	0.0319
	(0.0342)	(0.0194)	(0.0334)	(0.0235)	(0.0350)	(0.0236)
AGE2	-0.000827	-0.000139	-0.000822	-0.000859*	-0.000408	-0.000839*
	(0.000828)	(0.000398)	(0.000813)	(0.000471)	(0.000833)	(0.000469)
FOREIGN	0.453*	-0.523***	0.301	-0.211	0.189	-0.276
	(0.254)	(0.176)	(0.219)	(0.200)	(0.218)	(0.201)
EXPORT	-0.147	-0.0509	-0.208	-0.229	-0.144	-0.194
	(0.185)	(0.159)	(0.182)	(0.190)	(0.188)	(0.191)
OWNUNLIM	-0.435	0.331	-0.459	0.555	-0.270	0.425
	(0.358)	(0.328)	(0.347)	(0.384)	(0.346)	(0.390)
OWNLIMLIST	0.746*	0.290	0.749*	0.415	0.538	0.353
	(0.438)	(0.384)	(0.428)	(0.430)	(0.423)	(0.427)
HHI	0.000132	7.34e-05	0.000161	0.000109	0.000141	8.05e-05
	(0.000160)	(7.11e-05)	(0.000155)	(9.18e-05)	(0.000155)	(9.08e-05)
KNOWFOWN	-0.141	0.277*	-0.176	0.0724	-0.130	0.0739
	(0.183)	(0.162)	(0.172)	(0.172)	(0.171)	(0.172)
KNOWFGRP	0.448*	0.126	0.413*	0.0798	0.308	0.172
	(0.249)	(0.250)	(0.242)	(0.252)	(0.243)	(0.255)
KNOWFSUP	0.360*	0.347*	0.282	0.180	0.330*	0.189
	(0.200)	(0.194)	(0.183)	(0.200)	(0.183)	(0.204)
KNOWFCUS	-0.336	-0.150	-0.281	-0.256	-0.497**	-0.264
	(0.232)	(0.213)	(0.227)	(0.220)	(0.231)	(0.220)
KNOWFCOM	0.385**	-0.0214	0.350*	-0.0819	0.374**	-0.115
	(0.188)	(0.185)	(0.184)	(0.193)	(0.186)	(0.194)
KNOWFCON	-0.0189	0.511**	-0.0693	0.472*	-0.0605	0.426*
	(0.219)	(0.231)	(0.198)	(0.242)	(0.197)	(0.243)
KNOWFPRI	-0.328	-0.0145	-0.261	-0.421	-0.247	-0.214
	(0.296)	(0.321)	(0.293)	(0.342)	(0.288)	(0.348)
KNOWFUNI	0.403	-0.0899	0.285	-0.0555	0.459	0.0775
	(0.449)	(0.625)	(0.438)	(0.679)	(0.431)	(0.655)

Table 4 (continued). Acquisition of Machinery, Equipment and Software, and Knowledge Flows

VARIABLES	(1) ACQMACH	(2) select	(3) ACQMACH	(4) select	(5) ACQMACH	(6) select
KNOWFPUB	-0.263	0.659*	-0.236	0.558	-0.154	0.468
	(0.319)	(0.364)	(0.293)	(0.408)	(0.293)	(0.398)
NONTAXINCT			-0.376*	1.031***		
			(0.195)	(0.235)		
TAXINCT			1.377***	-0.501		
			(0.373)	(0.394)		
TECHCON					-0.396	1.272***
					(0.248)	(0.427)
TECHSUP					-0.595**	0.255
					(0.282)	(0.429)
DUTYFREE					0.657**	-0.0152
					(0.256)	(0.284)
RNDFUND					-0.375	-0.281
					(0.272)	(0.426)
Constant	7.742***	-0.199	7.536***	-0.574	7.496***	-0.347
	(0.984)	(0.682)	(0.911)	(0.764)	(0.911)	(0.762)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	437	437	392	392	391	391

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations based on data from MASTIC.

In general, the globalization-related variables such as foreign ownership (FOREIGN) and exporting (EXPORT) are relatively insignificant. The statistical significance of the negatively-signed size-squared-variable (SIZE2) suggests that large firms are less likely to spend on the acquisition of machinery, equipment and software. In contrast, younger firms (AGE) are more likely to spend greater amounts (per capita) on this type of activity.

Overall, government-related support and incentives are important (positive and significant), albeit, the manner in which they affect acquisition of machinery is fairly complex. Tax incentives are significant in intensity, whilst non-tax incentives are significant in selection. In the case of more specific government support and incentives for innovation, both technical consulting services (TECHCON, significant in selection) and duty-free import of machinery (DUTYFREE, significant in intensity) are positively related to the acquisition of machinery, equipment and software. Interestingly, technical support services (TECHSUP) from the government is negatively significant in relation to the acquisition of machinery, equipment and software. This implies that firms embarking on such acquisitions tend to assign less importance to these types of support services from the government.

Training

In the case of innovation-related training (TRAINING), both internal knowledge flows and external knowledge flows seem to be important. Knowledge flows sourced from another company within the same group (KNOWFGRP) is negatively related to the decision to undertake this type of training but is positively related to the amount spent on such activities (**Table 5**). As for external knowledge flows, the statistically significant variables in the intensity equations include knowledge flows from competitors (KNOWFCOM, positive) and knowledge flows from private research centres (KNOWFPRI, negative). The latter suggests that if firms consider knowledge flows from private research centres to be unimportant, the firms are likely to invest more in innovation-related training. The knowledge flow variables that are significant in the selection equation include KNOWFCOM (positive) and KNOWFCON (positive). Thus, knowledge flows from competitors (KNOWFCOM) is clearly an important source of external knowledge flows.

Table 5. Training and Knowledge Flows

VARIABLES	(1) TRAINING	(2) select	(3) TRAINING	(4) select	(5) TRAINING	(6) select
SIZE	-0.0413	0.602**	-0.102	0.645**	0.987**	0.482*
	(0.383)	(0.269)	(0.366)	(0.288)	(0.399)	(0.267)
SIZE2	-0.0611	-0.0522*	-0.0629*	-0.0555*	-0.148***	-0.0373
	(0.0384)	(0.0280)	(0.0366)	(0.0301)	(0.0406)	(0.0275)
AGE	0.0189	0.00112	0.00283	0.0364	-0.0319	0.0497*
	(0.0426)	(0.0220)	(0.0384)	(0.0266)	(0.0498)	(0.0290)
AGE2	-0.000266	-0.000332	0.000126	-0.000873	0.000804	-0.00118*
	(0.00108)	(0.000492)	(0.000960)	(0.000602)	(0.00123)	(0.000683)
FOREIGN	0.266	-0.134	-0.248	0.0931	0.0357	0.233
	(0.222)	(0.170)	(0.214)	(0.191)	(0.264)	(0.189)
EXPORT	0.00433	0.296**	0.0885	0.255	0.340	0.315*
	(0.208)	(0.150)	(0.194)	(0.161)	(0.236)	(0.162)
OWNUNLIM	0.125	0.103	-0.00104	0.207	0.594	-0.00491
	(0.433)	(0.315)	(0.392)	(0.336)	(0.491)	(0.328)
OWNLIMLIST	1.304**	-0.376	1.206**	-0.469	0.784	-0.640*
	(0.516)	(0.367)	(0.474)	(0.388)	(0.574)	(0.379)
HHI	-7.57e-05	0.000174***	0.000122	0.000212***	0.000186*	0.000192***
	(8.71e-05)	(6.64e-05)	(0.000256)	(7.56e-05)	(9.63e-05)	(7.34e-05)
KNOWFOWN	-0.160	0.158	-0.269	0.0360	-0.136	0.0134
	(0.187)	(0.147)	(0.173)	(0.150)	(0.212)	(0.148)
KNOWFGRP	0.633**	-0.377*	0.669**	-0.414*	0.0340	-0.434*
	(0.309)	(0.221)	(0.292)	(0.224)	(0.335)	(0.225)
KNOWFSUP	0.170	0.261	0.0884	0.162	0.244	0.150
	(0.204)	(0.177)	(0.186)	(0.181)	(0.240)	(0.175)
KNOWFCUS	-0.420*	0.129	-0.401*	0.0226	-0.333	-0.0344
	(0.242)	(0.201)	(0.218)	(0.202)	(0.279)	(0.199)
KNOWFCOM	0.337	0.321*	0.0682	0.298	0.618***	0.292*
	(0.211)	(0.174)	(0.185)	(0.185)	(0.238)	(0.170)
KNOWFCON	-0.0236	0.324*	-0.344	0.229	0.165	0.326*
	(0.231)	(0.193)	(0.223)	(0.196)	(0.256)	(0.189)
KNOWFPRI	-0.797**	-0.0832	-0.413	-0.125	-0.731*	-0.156
	(0.331)	(0.285)	(0.315)	(0.290)	(0.386)	(0.276)
KNOWFUNI	0.239	-0.297	0.207	-0.213	-0.0156	-0.0661
	(0.541)	(0.442)	(0.487)	(0.450)	(0.611)	(0.423)
KNOWFPUB	0.123	0.307	-0.0370	0.157	0.331	0.0575
	(0.327)	(0.299)	(0.296)	(0.298)	(0.386)	(0.282)
NONTAXINCT			-0.711***	0.149		
			(0.191)	(0.165)		

Table 5 (continued). Training and Knowledge Flows

VARIABLES	(1) TRAINING	(2) select	(3) TRAINING	(4) select	(5) TRAINING	(6) select
TAXINCT			0.127	0.00441		
			(0.372)	(0.357)		
TECHCON					0.00219	0.0635
					(0.322)	(0.222)
TECHSUP					-0.911**	-0.277
					(0.389)	(0.268)
DUTYFREE					0.298	-0.115
					(0.339)	(0.243)
RNDFUND					0.172	0.622
					(0.360)	(0.407)
Constant	7.030***	-2.053***	7.412***	-2.373***	2.783***	-2.098***
	(1.225)	(0.671)	(1.280)	(0.723)	(1.033)	(0.668)
Industry Dummies	No	No	Yes	Yes	No	No
Observations	437	437	392	392	391	391

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Source: Author's computations based on data from MASTIC.

The relationship between innovation-related training and the size of a firm is non-linear, or inverse-U to be more precise. Of the two globalization-related control variables, only exporting (EXPORT) is statistically significant in the selection equation – the positive sign suggesting exporting is associated with higher investment in innovation-related training. The statistical significance of the positively-signed Herfindahl-Hirschman Index variable suggests that market concentration is associated with greater investment in training. Finally, government-related support and incentives are not important to a firm’s decision to undertake and spend on innovation-related training.

4.2. Knowledge Flows and Organization

How are knowledge flows related to organization in the case of innovating firms? Are internal knowledge flows different from external knowledge flows in terms of organizational dimensions? The results from the econometric analysis of the relationship between the different types of knowledge flows and different aspects of organization are summarized in **Table 6**.

Overall, the relationship between the different types of knowledge flows and different aspects of organization appears to be a complex one.

Table 6. Organization and Knowledge Flows

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	KNOWFOWN	KNOWFGRP	KNOWFSUP	KNOWFCUS	KNOWFCOM	KNOWFCON	KNOWFPRI	KNOWFUNI	KNOWFPUB
SIZE	-0.0418	-0.280	-0.537	0.137	-0.676*	0.492	0.846	-0.962	1.728*
	(0.357)	(0.526)	(0.410)	(0.508)	(0.378)	(0.496)	(0.730)	(0.980)	(1.026)
SIZE2	-0.0199	0.0494	0.0477	-0.0118	0.0630	-0.0510	-0.0697	0.113	-0.150
	(0.0384)	(0.0529)	(0.0441)	(0.0528)	(0.0414)	(0.0544)	(0.0745)	(0.0981)	(0.104)
AGE	0.0886**	-0.0674	0.0203	0.0312	-0.00356	-0.0447	-0.00895	0.444	-0.0260
	(0.0429)	(0.0450)	(0.0314)	(0.0544)	(0.0316)	(0.0360)	(0.0686)	(0.591)	(0.0545)
AGE2	-0.00205*	0.00126	0.000352	-0.000364	-5.84e-06	0.00167**	-0.000615	-0.0244	-0.000159
	(0.00107)	(0.000914)	(0.000632)	(0.00127)	(0.000662)	(0.000793)	(0.00172)	(0.0275)	(0.00111)
FOREIGN	0.0958	-0.194	0.211	0.701**	0.145	-0.564*	0.207	-0.657	0.00239
	(0.253)	(0.342)	(0.280)	(0.316)	(0.265)	(0.324)	(0.443)	(1.096)	(0.448)
EXPORT	-0.274	-0.0802	-0.165	-0.742***	-0.402*	0.0860	-0.601*	-0.949	-0.445
	(0.193)	(0.283)	(0.231)	(0.273)	(0.212)	(0.222)	(0.323)	(0.690)	(0.338)
FIRMSUB	0.136	0.786**	0.0499	0.0472	0.265	0.0951	0.514	2.258*	1.277***
	(0.247)	(0.335)	(0.277)	(0.337)	(0.267)	(0.310)	(0.420)	(1.171)	(0.489)
OWNUNLIM	0.448	-0.0138	-0.315	0.489	0.222	0.260	Dropped	Dropped	Dropped
	(0.381)	(0.576)	(0.403)	(0.490)	(0.378)	(0.440)			
OWNLIMLIST	0.757	-1.351*	-0.136	0.954	0.647	-1.623	1.017	Dropped	-1.794
	(0.484)	(0.811)	(0.527)	(0.673)	(0.527)	(1.151)	(0.738)		(1.862)
HHI	0.000190	-5.87e-05	-9.34e-05	-0.000349	0.000124	0.000140	0.000182	0.000141	0.000285
	(0.000176)	(0.000235)	(0.000190)	(0.000238)	(0.000184)	(0.000185)	(0.000248)	(0.000341)	(0.000249)
ORGTIME	0.0364	-0.267	-0.646**	0.0670	0.261	0.0323	0.0758	-0.159	0.729
	(0.236)	(0.323)	(0.274)	(0.283)	(0.243)	(0.262)	(0.432)	(0.977)	(0.499)
ORGGOOD	0.445*	0.266	0.818***	0.816**	0.128	0.0578	0.759	0.652	-0.739

Table 6 (continued). Organization and Knowledge Flows

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	KNOWFOWN	**KNOWFGRP**	**KNOWFSUP**	**KNOWFCUS**	**KNOWFCOM**	**KNOWFCON**	**KNOWFPRI**	**KNOWFUNI**	**KNOWFPUB**
	(0.268)	(0.371)	(0.296)	(0.325)	(0.271)	(0.302)	(0.520)	(0.849)	(0.660)
ORGCOST	-0.00365	0.364	-0.0467	0.308	0.0587	-0.665**	-0.804	-0.180	-1.068**
	(0.249)	(0.344)	(0.275)	(0.307)	(0.258)	(0.294)	(0.510)	(0.773)	(0.544)
ORGSATI	-0.389*	0.0490	0.774***	0.238	0.111	0.406	-0.0268	1.431	-0.382
	(0.231)	(0.314)	(0.258)	(0.294)	(0.245)	(0.269)	(0.409)	(1.003)	(0.447)
COOPGRPF	-0.275	-1.345	-1.551	-11.83	-0.412	0.935	1.142	Dropped	0.375
	(0.641)	(1.364)	(1.223)	(826.6)	(0.711)	(0.821)	(1.232)		(1.065)
COOPGRPD	-0.479	-3.455	-4.436**	-28.70	-1.960**	-0.934	-4.998	Dropped	-4.836
	(0.748)	(2.157)	(2.065)	(1,738)	(0.965)	(1.071)	(569.3)		(3.413)
COOPSUPF	-0.00449	-2.083	1.439*	5.618	-0.0135	0.319	-5.375	Dropped	-0.855
	(0.670)	(1.504)	(0.770)	(752.0)	(0.668)	(0.943)	(0)		(1.446)
COOPSUPD	0.0283	-0.564	-0.911	-11.29	-1.231	-0.437	-9.690	Dropped	-5.698*
	(0.780)	(1.177)	(0.963)	(1,297)	(0.786)	(1.157)	(0)		(3.399)
COOPCUSF	-0.173	1.780**	-0.192	-4.589	1.226**	-1.192	-3.859	Dropped	0.796
	(0.609)	(0.907)	(0.731)	(752.0)	(0.623)	(0.986)	(681.1)		(1.372)
COOPCUSD	-0.373	1.575	2.437*	29.13	0.792	0.479	10.80	Dropped	5.713*
	(0.930)	(1.508)	(1.368)	(1,755)	(0.934)	(1.358)	(887.7)		(3.336)
COOPCOMF	-1.574	-16.72	1.569	8.416	-1.065	0.776	-11.07	Dropped	-2.727*
	(1.786)	(1,120)	(1.572)	(709.9)	(1.198)	(1.251)	(0)		(1.601)
COOPCONF	0.890	60.84	11.60	24.41	0.129	0.624	19.47	Dropped	-1.441
	(0.879)	(2,864)	(2,183)	(2,265)	(1.696)	(1.985)	(0)		(2.515)
COOPCOND	-0.868	-1.941	-1.242	-5.050	-0.338	0.567	0.0248	Dropped	0.722
	(1.154)	(1.790)	(1.385)	(495.7)	(0.831)	(1.128)	(0)		(1.446)

Table 6 (continued). Organization and Knowledge Flows

VARIABLES	(1) KNOWFOWN	(2) KNOWFGRP	(3) KNOWFSUP	(4) KNOWFCUS	(5) KNOWFCOM	(6) KNOWFCON	(7) KNOWFPRI	(8) KNOWFUNI	(9) KNOWFPUB
COOPCOND		-9.719	1.032	-34.80	-0.857	-1.513	4.392	Dropped	-0.611
		(487.0)	(1.273)	(2,235)	(0.982)	(1.521)	(0)		(2.365)
COOPPRIF	1.673	5.131**	18.14	14.31	1.318	-0.683	0.0207	Dropped	1.473
	(1.030)	(2.416)	(652.6)	(1,466)	(1.051)	(1.186)	(0)		(1.700)
COOPPRID	-5.239	-41.80	-18.45	-6.100	-6.535	-7.016	-25.82	Dropped	-12.14
	(194.8)	(2,162)	(2,208)	(2,506)	(130.3)	(244.1)	(0)		(228.1)
COOPUNIF	Dropped		-16.58	-12.66	Dropped			Dropped	5.218
			(565.5)	(1,916)					(3.237)
COOPUNID	2.081	18.26	1.709	41.13	4.164***	7.971	12.41	Dropped	
	(1.861)	(863.1)	(1.937)	(2,541)	(1.550)	(265.8)	(0)		
COOPPUBD	3.403	-41.25	10.32	-31.34	3.115	0.604	13.30	Dropped	9.241
	(194.9)	(2,200)	(460.9)	(2,116)	(130.3)	(360.9)	(0)		(228.1)
NONTAXINCT	-0.510**	-0.537	-0.364	-0.448	-0.697***	-0.285	0.629**	1.643*	0.825**
	(0.214)	(0.350)	(0.269)	(0.324)	(0.263)	(0.255)	(0.315)	(0.924)	(0.379)
TAXINCT	0.432	0.361	0.388	0.149	0.843	0.454	-5.433	Dropped	2.013**
	(0.499)	(0.722)	(0.516)	(0.823)	(0.527)	(0.529)	(0)		(0.902)
Constant	-0.686	-0.309	0.691	-0.856	1.054	-1.964	-3.748**	-2.521	-6.278**
	(0.953)	(1.353)	(1.034)	(1.325)	(0.984)	(1.226)	(1.885)	(4.010)	(2.666)
Industry Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	382	339	391	336	363	353	295	142	278

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. *Note:* Variables are dropped due to collinearity.
Source: Author's computations based on data from MASTIC.

In the case of internal knowledge flows, such as those taking place within a firm (KNOWFOWN), the age of a firm plays an important role. The inverse-U relationship suggests that such knowledge flows are considered to be less important in the very youngest firms and the very oldest firms. As expected, there is a statistically significant relationship (with the correct positive sign) between knowledge flows from other companies within the same group (KNOWFGRP) if the firm is a subsidiary of a larger group of companies (FIRMSUB). Such knowledge flows are also associated with cooperative activities in innovation involving foreign customers (COOPCUSF) and foreign private research centres and labs (COOPPRIF).

Each type of external knowledge flow is influenced by a different set of factors. External knowledge flows that originate from suppliers (KNOWFSUP) are considered to be more important in firms that undertake organizational innovations aimed at improving the quality of the goods and services (ORGGOOD) and those that enhance employee welfare (ORGSATIS). Surprisingly, such knowledge flows are less important in firms that undertake organizational innovation that reduces the time to respond to customer or supplier needs (ORGTIME). These types of knowledge flows are also considered to be less important for firms that are engaged in cooperative activities with domestic firms outside their company group (COOPGRPD). In contrast, such knowledge flows are important for firms engaged in co-operative activities with foreign suppliers (COOPSUPF) and domestic customers (COOPCUSD).

The two globalization-related variables (FOREIGN and EXPORT) are significantly related to external knowledge flows originating from customers (KNOWFCUS). However, both have different signs. KNOWFCUS is more important in firms with foreign direct investment and less important in exporting firms. Organizational innovations aimed at improving the quality of goods and services (ORGGOOD) are positively and significantly related to this type of knowledge flow. Interestingly, this type of knowledge flow does not seem to be significantly related to the presence of cooperative activities.

Larger firms assign less importance to knowledge flows from competitors (KNOWFCOM). Cooperative activities in innovation with other domestic firms within the same group are associated with a lower emphasis on knowledge flows from competitors. Such knowledge flows receive greater emphasis in firms that have co-operative activities with their foreign customers and domestic universities. In contrast, firms with co-operative activities with domestic firms in the same group and those that consider non-tax incentives to be important will put less emphasis on knowledge flows from competitors.

Larger firms will tend to consider knowledge flows from consultants (KNOWFCON) as important. Firms with foreign direct investment will behave in an opposite manner. Firms undertaking organizational innovations to reduce costs would tend not to consider knowledge flows from consultants as important.

Very few of the firms in the dataset consider knowledge flows from universities and private research institutes to be important (see Table 1). As a result, the knowledge flows related to these sources do not exhibit significant relationships with organizational innovations, cooperative activities and general firm characteristics. However, knowledge flows from universities are positively affected by incentives from the government. Firms that are a subsidiary of another firm also consider such knowledge flows to be important.

To sum up, the different types of internal and external knowledge flows are likely to be driven by different organizational variables. Globalization-related variables such as FDI (positive) and exporting (negative) are generally found to be important for certain types of external knowledge flows especially those originating from customers. The impact of globalization on knowledge flows in terms of the relationship between external knowledge flows and cooperative activities with foreign parties are fairly limited. This is surprising given the significant number of exporters (63.6%) in the sample. It may imply that such firms are not sufficiently well integrated in the international production network.

5. Policy Implications

Technological upgrading of the manufacturing sector is a key challenge facing many policymakers today. How this is to be achieved and translated into a dynamic and competitive export sector remains a difficult question. The upgrading process obviously involves participating in the globalization process. At one end, firms need to source knowledge from the global technology pool which is located primarily in the more advanced and developed countries. At the other end, such firms need to know how to use such knowledge to enhance their competitiveness in their product markets.

The challenge is even greater for policymakers given the fact that such technological upgrading has to occur at the firm level. The traditional conception of innovation policy, for example, is that of solving a market failure problem where the firm is implicitly characterized as a black-box i.e. as a production function (hence, the focus on productivity as a measure of performance). This view is clearly incomplete as firms are heterogenous in many dimensions - in terms of the type of innovation activities that are carried out, the different types of knowledge flows that lead to the enhancement of technological capability, as well as the complexity of a firm's internal organization and its interactions with its environment. Findings from this paper provide some insights into these issues.

The factors driving the various types of innovation activities are likely to be different. As the sample data covers only innovating firms, the policy implications drawn are not aimed at transforming non-innovating firms into innovating firms. Instead, such policy implications are related to enhancing the innovativeness of already innovative firms.

Market concentration has a positive impact on in-house R&D – suggesting, perhaps, a conduct-based rather than structure-based competition policy is more conducive to enhancing firm-level in-house R&D. The existing government support and assistance schemes seem to have had limited links to in-house R&D. The same applies to innovation-related training. The relationship between machinery, equipment and software acquisition for innovation and governmental support and assistance is more encouraging. These findings suggest that government support and incentives for innovative activities are only relevant for physical capital deepening. This suggests that there is a need for a re-evaluation of existing policies with the view to encouraging more firms to undertake in-house R&D and training.

In terms of the role of globalization in technological upgrading, there is some evidence (albeit weak) that innovative firms with foreign direct investment do this via the acquisition of machinery, equipment and software that are innovation-related.

Similarly, exporting seems to be weakly related to innovation-related training. Thus, policymakers need encourage more in-house R&D activities amongst innovative firms that are exporting and involve foreign direct investment.

Of the different types of innovation activities, both acquisition of machinery, equipment and software and training are positively related to a number of different types of external knowledge flows. Thus, policy makers need to pay more attention to the role of these different types of external knowledge flows if they are interested in enhancing innovation activities. Evidence on this and on the significance of the co-operative activities related to them suggests that innovative firms in Malaysia have relatively weak knowledge-flow links with the global economy. Whether these factors limit technological upgrading by these firms is an important policy issue.

6. Concluding Remarks

Many developing countries today face the unenviable and difficult task of upgrading the technological base of their manufacturing sectors. For this to occur, technological capabilities have to be enhanced at the firm level. This requires a greater understanding of the process of innovation at the firm level. What this entails is an analysis of the organizational aspects of firms and their interactions with their external environment, which includes their customers, suppliers and competitors. Both are interrelated - the firm as an organization can influence its interactions with the outside world while at the same time being influenced by it too.

One way in which the firm-level capabilities (including technological ones) can be enhanced is through knowledge flows from within the firm (e.g. inhouse R&D) and from outside the firm. The research literature that analyzes some of these issues is fairly diverse in terms of its focus and methodology. In the past, empirical investigations of such issues have lagged behind theoretical discussions due to data constraints. More recently, such problems have been partially alleviated by the availability of innovation surveys, such as the EU's Community Innovation Surveys. This study uses a similar type of data set that covers innovating firms from the Malaysian manufacturing sector in order to empirically examine the relationship between knowledge flows, organization and innovation.

Two major issues are investigated in this study. The first issue pertains to the relationships between innovation and knowledge flows. The overall finding of this study on the issue is that this relationship is likely to depend on the type of innovation activities that are carried out.

For in-house R&D activity, knowledge flows from other firms within the same group of companies is negatively related to the decision to undertake such an activity. Interestingly, there could be less emphasis on in-house R&D investments if knowledge flows from customers are considered to be of high importance. Market concentration is likely to have a strong influence on in-house R&D.

In the case of acquisition of machinery, equipment and software, external knowledge flows are important especially those coming from suppliers, customers, competitors and consultants. However, globalization-related variables, such as foreign ownership (FOREIGN) and exporting (EXPORT) are relatively insignificant. Government-related support and incentives are important for this type of innovative activitiy.

In the case of training, if knowledge flows from other firms within the same group of companies are related to the propensity of and intensity in undertaking innovation-related training activities. Knowledge flows from competitors are also likely to be important. Furthermore, exporting and higher market concentration are associated with higher investment in innovation-related training. The statistically significance of the positively signed Herfindahl-Hirschman Index variable suggests that market concentration is associated with greater investment in training.

The relationship between knowledge flows and organization differs depending on the type of knowledge flow. Clearly, knowledge flows are related to organizational innovations. There is also evidence that the links between innovative firms in Malaysia and other firms abroad in terms of co-operative activities is relatively weak. This raises the issue of whether such firms are able to tap the global technological-pool effectively.

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