University-Industry Collaboration in the Automotive, Biotechnology, and Electronics Firms in Malaysia

Rajah Rasiah * and Chandran Govindaraju VGR

This paper seeks to examine existing explanations of drivers of university-industry collaboration. The Probit regression results support prevailing theory on the importance of R&D intensity, partner diversity and access to wider channels of information matter for university-industry collaboration. However, categorizing size as a dichotomous dummy variable of SME and large firms showed an inverse relationship, while actual employment size was not statistically significant. Size was inversely correlated with university- industry collaboration. Separate Probit estimations for the specific industries of automotive, biotechnology and electronics indicate the following as the important drivers. First, R&D intensity, importance of university as a source of knowledge and age were important in automotive firms. Second, R&D intensity, channels of R&D information and R&D partner diversity were important in biotechnology firms. Third, the channels of R&D information and R&D partner diversity were important in electronics firms. Size was statistically significant in automotive and electronics firms but the coefficients were negative when a dummy was used and not statistically significant when the actual employment was used. Closer examination showed higher university-industry collaboration means among medium size firms.

Keywords: University-industry collaboration, R&D, Automotives, Biotechnology, Electronics, Malaysia

JEL Classification: O32, L25, L62, L63

* Corresponding Author, Professor, Technology and Innovation Management, Department of Administrative Studies and Politics, University of Malaya, Kuala Lumpur, Malaysia, (Tel) +03-7967-3606, (Fax) +03-7967-3719, (E-mail) rajah@um.edu.my; Lecturer, Department of Economics, University Technology MARA Johor, Malaysia, (Tel) +07-9352055, (Fax) +07-935-2277, (E-mail) vgrchan@gmail.com, respectively. We are grateful to the International Development Research Council (IDRC) for their generous grant that was used to pay Pemm Consult to gather the firm-level data used in the paper. Although the actual survey was conducted in 2007, the data is for 2006.

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I. Introduction

Whatever the instrument of analysis, there is consensus that institutions and public goods organizations are an important influence on firm-level R&D activities.[1] Although employees in gain a significant part of their knowledge through training and learning by doing in firms (Marshall 1890; Penrose 1959; Kim and Park 2003), universities are considered important silos of R&D activities whose knowledge is often tapped by firms to generate new products, processes and services. The prime difference lies in the new institutional economists who believe that markets enjoy the superior defining role (Coase 1992; North 1991; Williamson 1985) and the evolutionary economists who believe in non-market institutions to have equally important influences (Nelson and Winter 1982; Nelson 2008; Lall 1994; Katz 2006; Rasiah 1994).

Recognizing that R&D activities carried out in universities play an important role in driving firm-level innovations, the Malaysian government implemented explicit policies since the early 1990s to stimulate university-industry R&D linkages. Following the Action Plan for Industrial Technology Development (APITD) of 1990 the government launched the Malaysian Technology Development Corporation (MTDC), Malaysia Industry, Government High Technology (MIGHT), the Intensification of Research in Priority Areas (IRPA) grant and a number of other broader organizations to *inter alia* support university-industry R&D linkages. As part of the plan to innovate and commercialize research findings, the government increased strongly the allocation for R&D and commercialization of technology to RM 1.6 billion under the 8^{th} Malaysia Plan over the period 2001-2005 compared with RM 1 billion under the Seventh Malaysia Plan over the period 1996-2000 (Malaysia 2001, 2006). The government also launched the Second Science and Technology Basic Plan strongly advocates national innovation system reform toward a network based system by active interactions between innovation actors over the period 2001-2006 (Malaysia 2006). The government also added the science fund under the Ministry of Science Technology and Innovation (MOSTI) to *inter alia*, support R&D in universities with preference given to applications that show links with firms. Despite massive government focus, Rasiah (2007, 2008, 2009a, and 2009b) produced

[1] Since the neoclassical school believes in spontaneous responses of economic agents through relative price relationships, public goods such as knowledge are little examined and hence are excluded from this paper.

evidence to show little university-government relationships established in automotive and electronics firms.

Hence, it will be worth examining one, the state of university-industry collaborative relationships and two, the drivers of it in Malaysia. The rest of the paper is organized as follows. The next section discusses the relevant literature to serve as the theoretical guide. Section three presents the methodology and data. Section four and five analyses the results. Section six provides the conclusions and implications.

II. Theoretical Considerations

There is an extensive range of evolutionary work supporting the important role played by university-industry linkages in stimulating R&D activities in firms. However, the role of particular variables in driving R&D related collaboration between universities and firms is scant. Evidence from evolutionary economists find such relationships stronger in developed countries where the embedding high tech environment (including universities) strong (see Rasiah 2004). While it is obvious that firms tend to carry out more R&D activities the stronger the supporting knowledge infrastructure there is also evidence that little R&D collaboration exists in locations where the high tech infrastructure is weak. However, little is known over what matters in driving university-industry R&D collaboration activities in developing countries other than the widely researched newly industrialized economies of Korea, Taiwan and Singapore, and anecdotal evidence from others such as Brazil and India.

Evidence on what matters for R&D collaboration are numerous (*e.g.*, Ahn 1995; Chen 1994; Mansfield 1991; Mansfield and Lee 1996; Bayona *et al.* 2001). These studies have identified various reasons explaining the establishment of cooperative relationships between universities and other research organizations, and industry. This section reviews some of the past literature and establishes the conceptual framework of the study with testable hypotheses.

A. R&D Intensity and University-Industry Collaboration

The stock of *ex ante* knowledge to absorb effectively spillovers from other economic agents is an important determinant for collaborative relationships. Using R&D as a proxy of absorptive capacity, Cohen and Levinthal (1990) and Kamien and Zang (2000) argued that it will be positively correlated with collaborative activities. Similarly, Kleinknecht and Reijnen (1992), Colombo and Gerrone (1996), Dutta and Weiss (1997), Hagedoorn *et al.* (2000) showed produced evidence of R&D intensity determining cooperative R&D outside of the firm. Other studies which shows the link between level of technological intensity and the number of alliances includes Hagedoorn (1995), Koza and Lewin (1998), Powell *et al.* (1996), and Beise and Stahl (1999). For instance, Beise and Sathl (1999) argues that the firm's own R&D activities reflects the firms ability to absorb the public research results that is important for university-industry collaboration. The arguments on the positive effects of R&D on collaboration are due to the complementary effects of firm's own R&D research activities with the universities.

B. R&D Partner Diversity and Collaboration

Partner diversity offers the openness necessary for firms to collaborate and appropriate R&D synergies. Partner diversity also means openness and readiness of firms to collaborate for R&D activities. The more diverse the partners are or the source of information obtained from other partners, the more likely that the firms will consider universities as a potential R&D partners. Fontana *et al.* (2006) found that openness of firms to significantly affect the collaboration with public research organization. Similarly, Laursen and Salter (2004) found that firms searching strategies and number of external channels of information used to innovate to have higher probability of considering university knowledge. Relying on the multiple case study approach, Numprasertchai and Barbara's (2005) findings suggest that trust and balanced mutual benefits are the main factors explaining successful research collaboration. Indeed this study recommended universities in developing countries to extend more collaborative efforts with variety of partners to be successful. The theoretical logic here is that diversity provides a wide range of options for knowledge synergies to be appropriated. Sanchez and Tejedor's (1995) study showed that informal establishments enjoying no assistance from the liaison office and large firms tend to collaborate more with universities (Sanchez and Tejedor 1995).

C. Perceived Importance of Universities and Collaboration

Without understanding the benefits that universities offer as complementary sources of R&D activities, it is unlikely that firms would seek to collaborate with them. Many other theoretical studies indicated that the key for collaborative motives are learning by interacting, development of well planned strategies that focused on interaction with industry and identifying the proper channels of communication (Hameri 1996). Drejer and Jorgensen (2005) found that the low frequency of public-private research collaboration is the result of a lack of proper mechanisms, such as, simple information channels, to ensure that firms know the benefits of collaboration, guidelines for organizing collaborative projects, public co-funding, and mechanisms for solving conflicts between public and private actors.

In Malaysia, firms still perceive that public universities and research institutes to be lacking the transparency because of their bureaucratic orientation, and hence this acts as an impediment to collaborative activities. Based on interviews with 51 Spanish companies, Baranano (1995) found that the largest R&D projects reach the highest level of innovation success but yet these companies complain on the bureaucratic procedures, such as, in coordinating actions, ways of working, and culture associated with collaboration process. These impediments should be overcome to raise collaborative activities. Hence, it is clear that firms that perceive university as less important are likely not to establish stronger collaboration.

D. Channels of Information and Collaboration

Assess to more channels of information generated by universities may enhance R&D collaboration between them and the firms. A study by Fontana *et al.* (2006), suggests that firms' access to knowledge through publications and involvement in public policies affect the levels of their collaboration with universities. Similarly, Laursen and Salter (2004) argued that firms' searching strategy for external knowledge as an important determinants of the use of universities by the firms. In this aspect, availability of more channels of information will provide greater access to university knowledge. While this may hold true, other intervening variables may be essential for it to be reflected in commercialization synergies. Mora-Valentin *et al.* (2004) showed that for research organization, previous links, communication, commitment, trust and the partners' reputation are important factors in fostering collaboration.

E. R&D Strategy and Collaboration

R&D strategy is often considered to be a key determinant of firms' participation in R&D collaboration activities with universities. The first step is to check if a firm's conduct includes the undertaking R&D activities. The second step is to check if the firm seeks to access R&D support through its own facilities by internalizing such operations. The third is to examine if the firm in addition also wishes to access R&D operations from external sources. Some firms even outsource completely the core aspects of R&D. For example, Fontana *et al.* (2004) found that firms that outsource R&D expenditure and patent to protect innovation show higher level of collaboration with universities and R&D organizations.

F. Size

Past research indicates that size plays an important role in the probability of firms collaborating with universities and R&D organizations (Arundel and Geuna 2004; Mohnen and Hoareau 2003; Cohen *et al.* 2002; Laursen and Salter 2004). The conventional wisdom is that larger firms tend to collaborate more than the smaller firms. However, the relationship between size and collaboration is less clear. For instance, owing to the lack of resources, and with less capability to undertake R&D, small firms may source for alternative source of partners to innovate. Motohashi (2004) identified that in Japan, university-industry collaboration has spread over to the small and young firms in recent years. Owing to insufficient R&D resources, small firms find collaboration with universities as an important source of R&D knowledge. Larger firms who can afford their own in-house R&D resources may be less likely to collaborate with universities.

However, some amount of scale may be necessary if firms are actually engaged in R&D operations to complement their manufacturing and production activities. Such firms may actually access R&D knowhow from highly specialized R&D outfits or universities in horizontally integrated value chains (see Best 2001; Rasiah 1994, 1995). If this is the case, then, medium sized firms may show higher incidence of collaboration with universities then small and large firms. Since three industries are examined in this paper, such a size-based relationship may be found in some of them.

III. Methodology

Given the qualitative nature of the university-industry R&D collaboration variable, the choice of a suitable model for identifying the drivers is important. Hence, this paper uses descriptive statistics to examine the state of collaboration, R&D intensity and other related variables before identifying the relevant independent variables. These variables are then used in a Probit model to examine the drivers of university-industry collaboration with R&D intensity being the key explanatory variable.

A. Data

Primary data collected from firms using a professional body that was funded by the International Development Research Centre (IDRC) is used in the paper. The professional body, *i.e.,* Pemm Consult, used a structured sampling frame using size and ownership as the only criteria to select the firms. A total of 150 firms were chosen from the industries of automotives, biotechnology and electronics. The response rate is shown in the Table 1.

B. Variable Specification

In this section we specify the dependent and independent variables for analysis. On the right hand side of the model we also distinguish between explanatory and control variables.

a) University-Industry Collaboration

In assessing the degree of collaboration, the firms were asked to assign a value of 1 to 4 (not important to very important) on the reasons for collaboration with universities. The reasons for collaboration includes transfer of technology, technological/consulting advice, absorb technological information, obtain information on engineers, scientist and trends in R&D, contract research to complement firm R&D, contract research that the firm cannot perform, student recruitment, use of university resources, perform product/process testing and improve quality control. The mean values of importance taking account of the 10 reasons identified give an indication of the extent of collaboration between firms and universities. Consequently, using the mean value of the total sample as the threshold value, two dichotomous variables to gauge the dif-

TABLE 1
SAMPLED DATA, MALAYSIA, 2006

	Automotives	Biotechnology	Electronics
Questionnaires sent	150	150	150
Responses	84	127	150
Response rate	56.0	84.7	100.0

Source: IDRC Survey (2007).

ferent categories of collaborators were created; (1) low collaborator (zero as the value) and (2) high collaborator (one as the value). Therefore, the dependent variable was measured as:

$$COLL = 1 \text{ if high collaboration (1) and 0, otherwise}$$

C. Explanatory Variables

All R&D and related variables, including R&D strategy and nature of R&D links, were classified as explanatory variables in this paper.

a) R&D intensity

We use the standard measures of R&D intensity. In the survey the firms were asked to report their average percentage of R&D expenditure over sales in the last three years. Using this information, the ratio of R&D expenditure over sales was measured as:

$$R\&D = (\text{R\&D expenditure/Sales})\%$$

b) R&D strategy

Firms in the survey indicated the regularity of R&D activities and how they are organized. The firms indicated whether or not they had regular or occasional R&D activities and whether it is centralized or decentralized. This allows us to construct two dummy variables indicating the nature of firms' R&D strategy. The two different R&D strategies were measured as:

$$RDS1 = 1 \text{ if firms have regular R\&D activities and, 0, otherwise}$$
$$RDS2 = 1 \text{ if firms have centralized R\&D activities and, 0, otherwise}$$

c) R&D Partner Diversity

The firms in the survey also indicated the importance of other channels of information about R&D activities. Firms were asked to rate from 1 to 4 (not important to very important) the importance of other channels of information (11 sources) for their R&D activities, which includes patents, publications and reports, conferences and meetings, informal information exchanges, hiring of technical personnel, licensed technology, joint R&D projects, contract research, reverse engineering, trade associations, and fairs and expositions. If the mean value of all the sources of information is high, then it indicates that the firms have multiple sources of information from different partners. Therefore, R&D partner diversity (*PD*) was measured as:

$$PD = \sum \text{score of all sources}/11$$

d) Importance of Universities for Firms

Likert-scale scores (1 to 4; not important to very important) were used to measure perceived lack of importance of university as a source of R&D activities for firms. Firms were requested to rate the degree of importance of universities as a source of R&D activities, which include reasons like firms have enough internal R&D activities, universities have no understanding of firm business, research institutes have no understanding of firm business, contract agreements are difficult, lack of trust, low quality of research, geographical distance, difficulties in dialogue, and intellectual property issues. Since the reasons are in negative connotation, the scale was recorded and the average scores of all the reasons were used to measure the importance of universities as a source of information for firms' activities. The perceived importance of universities and public research institutes as a source of information was measured as:

$$UNI = \sum \text{score of lack of importance of universities and public institutes as a source of R\&D}/10$$

e) Channels of Information

The channels available for firms to access information from universities is measured using likert-scale measurements (1 to 4; not important to very important). Firms were asked to indicate how much each of the universities channels of information (15 channels) contribute to their innovative activities, which include patents, publications and reports, conferences and meetings, informal information exchange, hiring of post graduates, technology licensing, consulting, contract research, joint or cooperative R&D projects, university networks, temporary personnel exchange, incubators, science and technology parks, spin-offs and university/research institute owned firms. The mean value of the scores was used to represent the channels of information (*CI*) which was measured as:

$$CI = \sum \text{ score of all channels of information}/15$$

D. Control Variables

Firm-specific characteristic such as size, age, and industry dummies were included as control variables in the paper.

a) Size

Size is argued to provide both scale (larger numbers) and scope (smaller numbers) effects. We included size for these reasons. Because of the arguments advanced earlier and the interviews we had with 21 firms that suggest that medium-sized firms are likely to collaborate more with universities than small and large firms we expected no statistical relationship if simply employment figures were used. Indeed, there was no statistical relationship between size and the degree of university-industry collaboration when actual employment size was used. We expect a negative sign if small and medium-sized firms are classified together as a dummy variable against large firms. Firms with more than 500 workers are considered as large. It was measured as:

$$Si = 1 \text{ when } S \geq 500, \text{ and } Si = 0 \text{ otherwise.}$$

Where S refers size of firm i.

b) Age

The age of the firm is also important as the older ones may have stabilized to understand the local environment so as to be able to interact with universities. However, new firms may have more drive to seek institutional arrangements to participate in knowledge-intensive activities more than old firms. Also, multinationals with enormous experiential knowledge may relocate cutting edge knowledge at host-sites. Age was measured as:

Ai=number of years since establishment in Malaysia.

Where *A* refers to age of firm *i*.

For the overall model, the sector classification includes three dummy variables to represent automotives, biotechnology, and electronics.

E. Analytical Model

Since the dependent variable is dichotomous (low and high collaboration) the appropriate estimation models would be logit or probit (Greene 2003). We preferred the probit model, which is specified as:

$\text{prob}(Y_i=1 \mid X_i)=\int_{-\infty}^{x'\beta}\phi(t)dt=\phi(X_i'\beta)$, where the firm is either high collaborator ($Y_i=1$) or a low collaborator ($Y_i=0$) and the choice depends on vector X. Therefore, this involves fitting a probit model for collaboration (*COLL*) based on the following specification:

Prob[*COLL*=1]=*F*(*constant, R&D, RDS*1, *RDS*2, *PD, UNI, CI, AGE, SIZE*)

where:

COLL=low or no collaboration (0) and high collaboration (1)
R&D=average ratio of R&D expenditure over sales for the past 3 years
RDS1=firms with occasional R&D (0) and regular R&D (1)
RDS2=firms with decentralized R&D (0) and centralized R&D (1)
PD=R&D partner diversity
UNI=importance of university as a source of R&D
CI=available channels of information on university R&D
AGE=years in operation
SIZE=small and medium size firm (0) and large firm (1)

The same estimation techniques apply for the three industry probit estimations but without the sector dummies.

IV. University-industry Collaboration

A univariate analysis was conducted on the key variables used in the paper (see Table 2). The mean age in the sample is 17.5 years with

TABLE 2
DESCRIPTIVE STATISTICS BY SECTOR, MALAYSIA, 2006

	All firms (n=313)				Electronics (n=122)				Biotechnology (n=122)				Automotive (n=69)			
	Mean	S.D	Min	Max	Mean	S.D	Min	Max	Mean	S.D	Min	Max	Mean	S.D	Min	Max
AGE	17.54	11.06	1.00	63.00	19.68	9.65	3.00	47.00	13.51	11.58	1.00	63.00	20.86	10.40	1.00	40.00
CI	2.02	0.62	1.00	4.00	1.93	0.58	1.00	3.87	2.08	0.66	1.00	4.00	2.04	0.57	1.00	3.40
R&D	0.08	0.05	0.00	0.35	0.078	0.06	0.00	0.35	0.09	0.05	0.00	0.30	0.07	0.04	0.00	0.20
PD	2.14	0.75	1.00	4.00	2.07	0.72	1.00	3.64	2.16	0.76	3.55	1.00	2.21	0.80	1.00	4.00
UNI	2.07	0.95	1.00	4.00	2.04	0.92	1.00	4.00	2.24	0.94	3.40	1.00	1.82	0.97	1.00	4.00
COLL	2.32	0.62	1.10	4.00	2.14	0.65	1.10	4.00	2.47	0.55	1.20	3.70	2.45	0.57	1.30	3.20

Notes: The sample size, $n<N$ (survey responses) because of some firms' not filling some questions. The mean score of *COLL* (collaboration) is the average of the total likert scale scores on 10 reasons indicated for collaborating with universities. These averages were used to categories, two groups of firms, *e.g.,* low and high collaborators. *CI*, *PD*, and *UNI* are average score of the Likert-scale measures, respectively.
Source: Computed from IDRC Survey (2007).

those of electronics, biotechnology, and automotive being 19, 13, and 20 years, respectively. Access to universities and research institutes R&D information (*CI*) on average is 2.02 for the overall sample. Biotechnology firms reported to have better access to R&D activities at universities than automotive and electronics firms. Because of the basic research nature of R&D work undertaken by biotechnology firms their motivation to collaborate with universities is found to be high. In fact, many of the biotechnology firms — which are primarily focused on agricultural related research activities — have established linkages with the main public universities (*e.g.,* University Malaya, University Sains Malaysia, University Putra Malaysia, and University Kebangsaan Malaysia), which might be the reason why they tend to exhibit a higher mean score compared to other sectors. The means scores indicate that on average in the past 3 years only 8 percent of the revenue is invested in R&D related activities in the overall sample. The breakdown by sector was 9.0 percent by biotechnology firms, 7.8 percent by electronics firms and 7.0 percent by automotive firms. Automotive firms were found to have higher partner diversity (*PD*) (access to R&D information from other firms) than compared to biotechnology and electronics firms.

On perceived importance of universities, biotechnology firms showed a higher mean of 2.24 than the overall sample (2.07), and 2.04 of electronics firms and 1.82 of automotive firms. The mean score of university-industry collaboration in the overall sample is 2.32. Biotechnology (2.47) and automotive (2.45) firms shows higher means than the electronics (2.14) firms.

V. Drivers of University-Industry Collaboration

The key statistical parameters of the Probit regressions were significant for analysis. A number of the findings corroborate with existing theory but some interesting departures also emerge. Table 3 provides estimates of the impact of explanatory variables on the likelihood of being a collaborator for the overall sample. In both models, the results indicate that R&D intensity has a positive and significant relationship with university-industry collaboration. In other words the likelihood of firms establishing collaboration links with universities rises as their own R&D intensity increases suggesting that in order to undertake collaborative R&D activities with external partners, firms need internal R&D capability, which supports the absorptive capacity argument of Cohen and Levinthal (1990).

Among the other explanatory variables, it is found that understanding the importance of university collaboration (*UNI*) and having access to multiple channels of university's innovative activities (*CI*) to increase the likelihood of collaboration. In addition, consistent with the findings of Bayona *et al.* (2001), partner diversity (*PD*) or openness to R&D activities shows a strong relationship with university-industry collaboration. Firms who more motivated to access external partners for R&D activities also show higher likelihood of collaboration.

Among the control variables, size is found to be significant at 1% confidence level. In other word, this factor has the strongest effect to differentiate between firms being a collaborator and not being a collaborator. However, size is found to have a negative effect on the likelihood of being a collaborator. Instead of small firms showing the highest likelihood of collaboration it is the medium-sized firms that show the highest university-industry collaboration. The low likelihood of university-industry collaboration among large firms may also be a consequence of a lack of dynamic R&D activities at Malaysian universities or simply that large firms' focus on areas of R&D unrelated to the specializations in Malaysia.

TABLE 3
ESTIMATED PROBIT REGRESSION, MALAYSIA, 2006

Variable	Model 1	Model 2
	Coefficient	Coefficient
C	-2.700(-3.976)***	-1.955(-3.815)***
R&D	3.740(1.999)**	3.974(2.136)**
RDS1	-0.192(-0.394)	-0.167(-0.371)
RDS2	0.319(1.194)	0.476(1.854)*
UNI	0.290(2.807)***	0.195(2.027)**
CI	0.885(3.645)***	-
AGE	0.010(1.209)	0.007(0.855)
SIZE	-0.587(-2.637)***	-0.528(-2.532)***
PD	-	0.499(3.207)***
LR (X^2)	143.40***	129.57***
Log-likelihood	-139.42	-146.344
Pseudo R-squared	0.339	0.306

Notes: ***<0.01, **<0.05, and *<0.10, respectively. Figures in parenthesis are the z-statistics. + Reference sector is electronics sector. Since PD and CI are highly correlated, we estimate their effects separately, resulting in two models.
Source: Computed from IDRC Survey (2007).

The probit estimation for specific sectors is reported in Tables 4, 5, and 6. R&D intensity is found to be significant at 5% and 10% confidence levels among automotive and biotechnology firms, respectively. It suggests that in these sectors, higher levels of R&D activities are likely to drive firms to collaborate with universities. In contrast, the R&D intensity is not significant among electronics firms. Perceived importance of university as a source of R&D activities plays an important role in distinguishing the high collaborators and low-collaborators in the automotive sector.

In the automotive sector, size, and age plays an important role in driving university-industry collaboration. It is found that older and small and medium firms are likely to collaborate with university than newer and large firms (see Table 4). R&D intensity, channels of R&D information (*CI*) and partner diversity (*PD*) have a significant impact on the likelihood of being a high collaborator among biotechnology firms (see Table 5), which suggests that firms' having more access to information on universities and firms searching for more R&D partners tend to enjoy higher R&D collaborative activities.

TABLE 4

ESTIMATED PROBIT REGRESSION, AUTOMOTIVE FIRMS, MALAYSIA, 2006

Variable	Model 1	Model 2
	Coefficient	Coefficient
C	-4.392(-2.542)***	-4.239(-3.357)***
R&D	7.396(4.476)**	7.875(3.486)**
RDS1	-0.927(-1.645)	-0.939(-1.482)
RDS2	0.713(1.131)	0.723(1.269)
UNI	0.894(3.469)**	0.921(3.218)**
CI	0.033(0.0454)	-
AGE	0.051(2.741)**	0.052(2.758)**
SIZE	-1.167(-1.961)*	-1.186(-1.953)*
PD	-	-0.102(0.278)
LR (X^2)	17.883***	17.972***
Log-likelihood	-19.766	-19.722
Pseudo R-squared	0.311	0.312

Notes: ***<0.01, **<0.05, and *<0.10, respectively. Figures in parenthesis are the z-statistics. Since PD and CI are highly correlated, we estimate their effects separately, resulting in two models.

Source: Computed from IDRC Survey (2007).

TABLE 5

ESTIMATED PROBIT REGRESSION, BIOTECHNOLOGY FIRMS, MALAYSIA, 2006

Variable	Model 1	Model 2
	Coefficient	Coefficient
C	-4.822(2.147)**	-6.294(-2.901)
R&D	2.238(1.852)*	2.968(1.860)*
RDS1	1.216(1.030)	4.691(2.291)**
RDS2	0.295(0.482)	0.786(1.244)
UNI	0.243(1.112)	1.122(2.047)**
CI	1.701(2.930)***	-
AGE	-0.003(-0.181)	-0.021(-1.334)
SIZE	-1.378(1.819)*	0.071(0.126)
PD	-	2.144(3.177)***
LR (X^2)	41.972***	46.771***
Log-likelihood	-42.455	-40.055
Pseudo R-squared	0.331	0.368

Notes: ***<0.01, **<0.05, and *<0.10, respectively. Figures in parenthesis are the z-statistics. Since PD and CI are highly correlated, we estimate their effects separately.

Source: Computed from IDRC Survey (2007).

TABLE 6
ESTIMATED PROBIT REGRESSION, ELECTRONICS FIRMS, MALAYSIA, 2006

Variable	Model 1	Model 2
	Coefficient	Coefficient
C	-3.309(-3.446)***	-2.103(-3.112)***
R&D	0.593(0.499)	2.299(0.868)
RDS1	0.188(0.300)	0.262(0.487)
RDS2	0.455(1.328)	0.466(1.384)
UNI	0.105(0.689)	0.072(0.494)
CI	1.139(3.801)***	-
AGE	0.021(1.608)	0.022(1.677)*
SIZE	-0.496(-1.989)*	-0.499(-2.044)**
PD	-	0.423(1.806)*
LR (X^2)	31.370***	17.621***
Log-likelihood	-70.922	-73.568
Pseudo R-squared	0.181	0.107

Notes: ***<0.01, **<0.05, and *<0.10, respectively. Figures in parenthesis are the z-statistics. Since PD and CI are highly correlated, we estimate their effects separately, resulting in two models.
Source: Computed from IDRC Survey (2007).

Although SMEs are likely to have higher collaboration activities with universities, only access to more channels of university R&D information (CI) is found to have a strong impact in the electronics sector (see Table 6). Similarly, partner diversity is found to have some influence at 10% confidence level.

VI. Conclusions

This paper sought to identify the important drivers of university-industry collaboration in automotive, biotechnology, and electronics firms in Malaysia. It started with the assumption that R&D intensity is critical in stimulating university-industry collaboration. The results indicate that R&D intensity indeed enjoyed a significant relationship with university-industry collaboration in the overall sample and in automotive and biotechnology firms. This also tends to support the view that only firms engaged in R&D activities are willing to collaborate with universities. The basic research undertaken by universities may seem to be relevant to complement firms R&D activities that may have translated in strengthening university-industry collaboration. Therefore, universities seeking to foster university-industry collaboration should identify firms endowed with R&D activities to establish linkages.

The results also show that the likelihood of firms collaborating with universities depends on their perceived importance of universities as a source innovation, access to multiple channels of information on university innovation activities and partner diversity or R&D openness. To foster university-industry collaboration, the universities should consider the promotion of universities as centres of excellence for R&D activities. The positive image created by the universities is likely to attract more industrial collaboration. Consequently, creating multiple channels of information on the R&D activities of the universities is important for firms to realize the benefits and to establish linkages with them. Universities' technology transfer units in Malaysia should play a proactive role in creating access to the channels of information on university's innovative activities. The significant results of these variables demonstrate that universities should formulate strategies that take cognizance of firms' demands.

In addition, SMEs rather than large firms seem to collaborate most with universities. The highest likelihood of collaboration is actually enjoyed by medium-sized firms. Therefore, it can be argued that medium-sized firms with sufficient scale but lacking the requisite human capital and other resources seek most support from universities in Malaysia. However, it may also be that the R&D capabilities at Malaysian universities are either not sufficiently advanced or not in areas sought by large firms. Further research is necessary to confirm this.

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Appendix Table 1

Correlation Matrix, All Firms, 2006

	AGE	CI	PD	RD	UNI	RDS2	RDS1	SIZE	SE	SB
AGE	1.00									
CI	0.067	1.000								
PD	0.151**	0.708**	1.000							
R&D	-0.040	0.304**	0.330**	1.000						
UNI	-0.059	0.034	0.094	0.127*	1.000					
RDS2	-0.091	0.229**	0.106*	0.227**	0.219**	1.000				
RDS1	0.029	0.257**	0.273**	0.276**	0.279**	0.365**	1.000			
SIZE	0.288**	0.002	-0.027	0.086	0.039	-0.003	0.025	1.000		
SE	0.151**	-0.130	-0.070	-0.090	-0.033	-0.134**	-0.052	0.372**	1.000	
SB	-0.285**	0.128*	0.048	0.172**	0.170**	0.127*	0.099	-0.345**	-0.632**	1.000
SA	0.156**	0.001	0.025	-0.095	-0.159**	0.007	-0.054	-0.031	-0.428**	-0.428**

Note: $^{**}p<0.01$; $^{*}p<0.05$; ;SE, SB, and SA represents electronics, biotechnology, and automotive sectors, respectively; $n=313$.
Source: IDRC Survey (2007).

Appendix Table 2

Correlation Matrix, Automotives, 2006

	AGE	CI	PD	RD	UNI	RDS2	RDS1
AGE	1.000						
CI	0.221	1.000					
PD	0.229	0.708**	1.000				
RD	0.138	0.102	0.155	1.000			
UNI	-0.168	-0.455**	-0.374**	0.125	1.000		
RDS2	-0.056	0.195	0.042	0.231*	-0.061	1.000	
RDS1	0.070	0.040	0.292*	0.460**	-0.139	0.270**	1.000
SIZE	0.026	-0.042	-0.184	0.415**	0.225*	0.226*	-0.042

Note: $^{**}p<0.01$; $^{*}p<0.05$; + denotes dummy variables; $n=69$.
Source: IDRC Survey (2007).

Appendix Table 3

Correlation Matrix, Biotechnology, 2006

	AGE	CI	PD	RD	UNI	RDS2	RDS1
AGE	1.000						
CI	0.048	1.000					
PD	0.079	0.654**	1.000				
RD	-0.037	0.191*	0.250**	1.000			
UNI	0.027	0.289**	0.456**	0.270**	1.000		
RDS2	-0.029	0.253**	0.148	0.131	0.480**	1.000	
RDS1	0.004	0.412**	0.323**	0.397**	0.546**	0.511**	1.000
SIZE	0.518**	0.166	-0.023	0.018	0.067	-0.030	0.056

Note: $^{**}p<0.01$; $^{*}p<0.05$; + denotes dummy variables; $n=122$.
Source: IDRC Survey (2007).

APPENDIX TABLE 4
CORRELATION MATRIX, ELECTRONICS, 2006

	AGE	CI	PD	RD	UNI	RDS2	RDS1
AGE	1.000						
CI	0.110	1.000					
PD	0.241**	0.768**	1.000				
R&D	-0.002	0.472**	0.499**	1.000			
UNI	0.057	0.041	0.077	-0.056	1.000		
RDS2	-0.094	0.198	0.097	0.258	0.173	1.000	
RDS1	0.108	0.270*	0.228**	0.100	0.349**	0.333**	1.000
SIZE	0.184*	0.071	0.115	0.125	0.032	0.022	0.121

Note: $**p<0.01$; $*p<0.05$; + denotes dummy variables; $n=122$.
Source: IDRC Survey (2007).

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