Obstacles to innovation : evidence from Malaysian manufacturing firms

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July 2007

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EVIDENCE FROM MALAYSIAN MANUFACTURING FIRMS

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Abstract

This paper investigates the obstacles to innovation faced by Malaysian manufacturing firms during the process of innovation. The data are from the National Survey of Innovation 2000-2001 (NSI-3). The shortcomings and the relevance of each of these obstacles are evaluated by type of innovator firm. For this, each firm is categorized - based on its level of innovation activity - as an innovator or as a non-innovator. The analysis also explores the differences between firms by industry type and firm size. The results show that among all obstacles, economic related factors appear to be the most important. Furthermore, the level of importance of obstacles is different for innovator and non-innovator firms. The paper concludes with an analysis of the complementarities between obstacles in order to arrive at the primary factors that are obstacles to innovation activity.

Introduction

Innovation is widely acknowledged as the key factor of competitiveness in firms and nations. Rapid technological developments, increasing global competition, shorter product life cycles, have increased the pressure to develop new knowledge and to innovate. Empirical results have shown that firms with innovation perform better, whether in term of output or employment growth, than those without (Crepon et al, 1998; Gellatly, 1999; Loof et al, 2001; Cox and Frenz, 2002; Cainelli, et al, 2003). Most studies focus on the determinants of innovation (see Cohen and Levin, 1989; Freeeman, 1990; Cohen, 1995; Kleinknecht and Mohnen, 2001; and abovementioned).

This paper proceeds with another approach to studying innovation by addressing the *obstacles* to innovation. If, as many studies show, innovation has positive effects on the firm, it is interesting to find out why not all firms engaged in innovation activities. Not many empirical studies of obstacles to innovation have been carried out: Mohnen and Rosa (1999) for Canadian service firms; Baldwin and Lin (2001) for Canadian

manufacturing firms; Mohnen and Rollers (2003) for four European countries-Ireland, Denmark, Germany and Italy; Galia and Legros (2004) for French manufacturing firms. These studies show that while firms may gain from the positive impacts of innovation, these might come at some cost. The authors are aware of only one 'partial' study carried out in Malaysia - Ong (undated) identified obstacles to innovation faced by firms in four industry sectors in Penang, Malaysia.[1]

This study investigates empirically the obstacles to innovation faced by manufacturing firms in Malaysia based on data from the Third National Survey of Innovation (NSI-3), a survey conducted by the Ministry of Science, Technology and the Environment in year 2003. First, the firms that faced shortcomings (delayed, uninitiated, burdened, abandoned) are identified. Then the relevance of various obstacles (as provided for in the NSI-3 questionnaire) is discussed. The NSI-3 obtained information on the relevance of each of nine obstacles, cost of innovation, economic risks, lack of sources of finance, lack of information on markets, lack of information on technology, lack of skilled personnel, lack of customers' response, legislation and regulation and organizational rigidities. The next part of the paper discusses complementarities between obstacles. This provides some insights of the important combinations of obstacles faced essential to the success of policies designed to promote innovation. If some obstacles are inter-related, then adopting a policy to address only some of these interrelated obstacles may have a lesser effect than adopting a package of policies that addressing all these inter-related obstacles in a holistic manner. The underlying reason is that 'the whole is more than the sum of its parts' (Mohnen and Roller, 2003:1).

Both aspects, relevance and complementarities, are compared for two groups of firms, innovators and non-innovators. It is possible that non-innovators encounter greater obstacles to innovation, or a combination of obstacles, and that this hinders firms from carrying out innovation activities. In other words, obstacles to innovation may occur *ex ante,* prior to engaging or making formal investment in the innovation process. On the other hand, it has been argued that obstacles to innovation are 'experienced' and 'learned', through the engagement in the innovation activities. Often, firms will only have a better understanding of the problems after engaging in innovation activities. During the innovation process, firms face various problems, and when trying to solve these problems, only then firms will learn about the true intensity of the

[1] Ong's (undated) study of obstacles to innovation is part of her study of innovation activities.

problems. Firms that do not engage in innovation activities, it is argued, might have a relatively low or surface understanding of problems that they encountered. A comparison between the two groups sheds light on the experiences of Malaysian manufacturing firms.

The rest of the paper is structured as follows. The next section presents a description of the data, the analytical framework for establishing the various types of innovator firms and the method used to measure the complementarities between obstacles. The third section discusses the findings. These are organized according to shortcomings, relevance of obstacles and complementarities of obstacles. The analyses consider all firms as well as the differences between innovator and non-innovator firms. The paper concludes with a summary and discussion on the obstacles to innovation and for firms in the manufacturing sector.

Methodology

Innovation process is described as the sequence of activities by an idea is transformed into a successful commercial product or process. Figure 1 shows the conceptualization of the innovation pathway that may be taken by a firm in the manufacturing sector. This conceptualization was based on transformation model framework (Bujis (1987) as discussed in Jong (2000)) has been extended to incorporate the degree of formality in firm's investment in the innovation activity as well as the possibility of facing problems during the innovation process. As can be seen from Figure 1, at a given point in time, a firm could be a successful innovator, one which has dropped out from the innovation path, or one that has initiated an innovation activity and is somewhere along the innovation path, depending on the status of the innovation activity. In other words, there is no guarantee at that point in time that the firm will see success in its innovation activity. It is also important to recognize that it is entirely possible that a firm may have more than one innovation activity at the same time. The firm may thus be at different points of the innovation path for each innovation activity, depending on its status.

Based on the various possible innovation paths that a firm could be on at a given point of time (Figure 1), two major types of innovator firms may be identified:

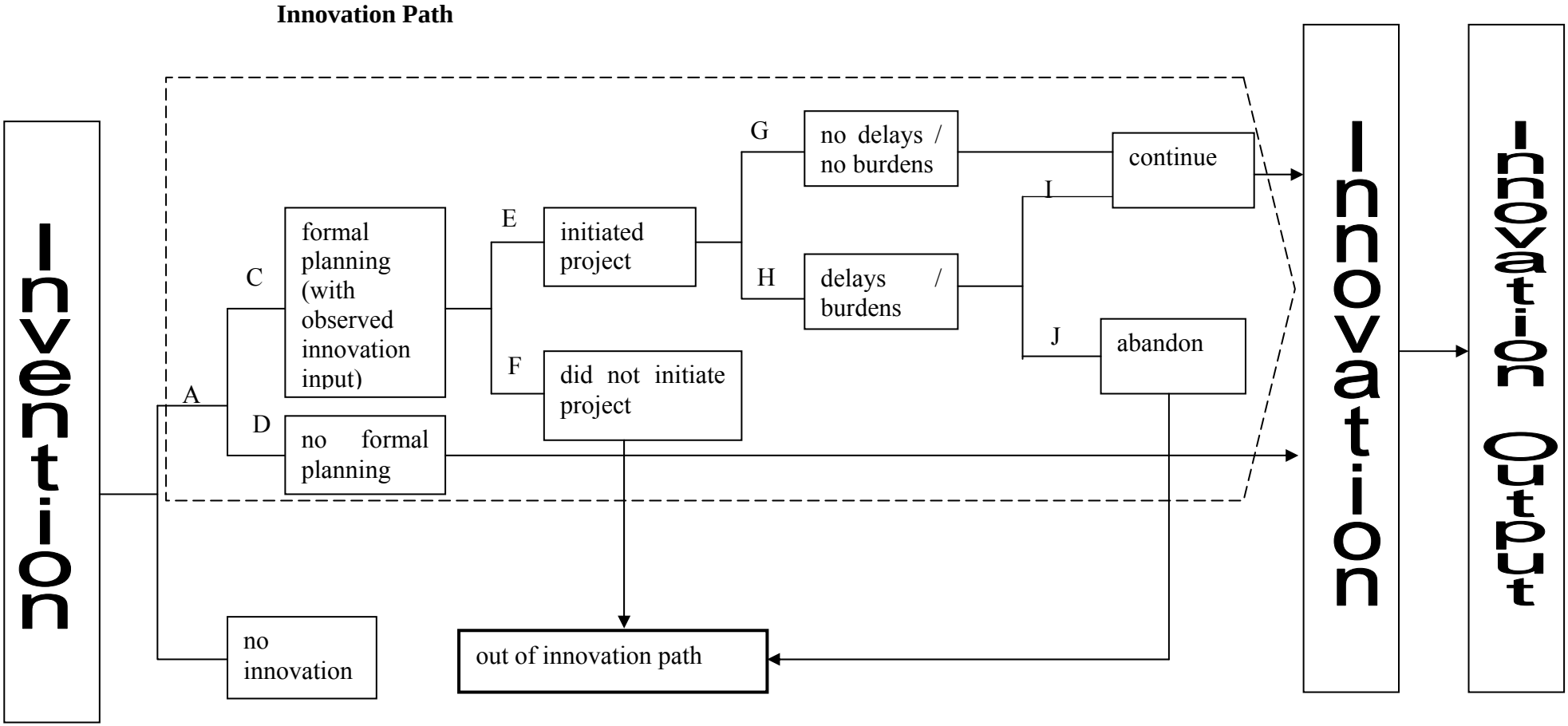
- *Non-Innovator* firms are firms that have not engaged in any innovation activities, and therefore will have zero innovation input and zero innovation output. These firms will be on innovation path B.
- *Innovator* firms are firms which at a given point of time, have engaged in innovation activities. They may be firms that have yet to succeed in their

innovation activities (somewhere on the innovation path A) or firms that have succeeded in their innovation activities (on innovation path ACE).

The data used in this paper come from the NSI-3, which obtained information in year 2003 for the reference period 2000-2001. For a detailed description of the survey methodology, refer to Malaysia (2003). It covers manufacturing establishments in both Peninsular Malaysia and East Malaysia. The NSI-3 provides a rich data source related to firms' innovation activity. Besides general information about the firms, it gathers innovation related information such as innovation objectives, innovation expenditure, sales of new or improved products; cooperation related to innovation; various sources of information for innovation, impact of innovation, and, finally, obstacles to innovation. The data were checked for consistency, and where possible missing information was obtained from the firms directly. Thus the data presented here may not always be directly comparable to published information on the NSI-3. The final sample used for the analysis consists of a total of 671 firms. This sample is representative of Malaysian manufacturing firms in terms of size of firm as measured by employment size.

The extent of problems related to innovation activities is assessed by examining the responses of firms to a question on type of shortcomings and to a battery of questions on various obstacles faced during their innovation activities between 2000 and 2001. Four shortcomings in innovation activities, delayed, uninitiated, burdened, abandoned, were identified in question No 10.1 of the NSI's questionnaire. Firms which answered affirmative on at least one shortcoming were then required to check on the relevance of specific obstacles. These were costs of innovation, economic risks, source of finance, lack of information on markets, lack of information on technology, lack of customer response, lack of skilled personnel, legislation and regulation, and organizational rigidities. Each obstacle to innovation could be evaluated as being 'not relevant', of 'low degree of importance', of 'medium degree of importance' and of 'high degree of importance'. Thus, the identification of obstacles is really the perception of the firms with regard to the relevance of each obstacle in a set of specific obstacles.

Figure 1 The Paths to Innovation



The complementarity between obstacles is based on the frequency of combinations of obstacles being cited of 'high importance'. It is measured using an index firstly proposed by Teece et al (1994) to measure the inter-business relatedness. So far, this index has been used to measure the coherence of firms' diversification strategy (*cf* Valcano and Vannoni, 2003; Karthik and Basant, 2004). One key feature of this measure is that the relatedness among a pair of obstacles is measured without assuming *ex ante* that both obstacles *i* and *j* are to be considered related. Consider a population of K diversified firms and define the following variables:

C_{ik}=1 if firm *k* finds obstacle *i* to be of 'high' important and 0 otherwise.

$n_i = \Sigma_k C_{ik}$ and $n_j = \Sigma_k C_{jk}$ are numbers of firms finding obstacle *i* to be of 'high' importance and obstacle *j* to be of 'high' importance, respectively;

$J_{ij} = \Sigma_k C_{ik} C_{jk}$ is the number of firms simultaneously finding obstacle *i* and *j* to be of 'high' importance with $0 < J_{ij} < \min (n_i , n_j)$

A measure of inter-obstacle complementarities is obtained for each cell (obstacle *i*, obstacle *j*) by comparing the observed number with the number of links that would emerge from random grouping. The latter can be calculated through the hyper-geometric random variable, X_{ij}. After having extracted without replacement from a population of K firms two samples n_i and n_j, the probability to find x firms finding both obstacles *i* and *j* highly important is the following

$$\Pr(X_{ij} = x) = \frac{\binom{n_i}{x}\binom{K - n_i}{n_j - x}}{\binom{K}{n_j}}$$

The mean and variance of X_{ij} are respectively:

$$\mu_{ij} = E(X_{ij}) = \frac{n_i n_j}{K}$$

$$\sigma_{ij}^2 = \mu_{ij}\left(1 - \frac{n_i}{K}\right)\left(\frac{K - n_i}{K - 1}\right)$$

The index of complementarities is constructed by comparing the observed value of J_{ij} and μ_{ij}, and scaling the difference with the standard deviation of X_{ij},

$$SR_{ij} = \frac{J_{ij} - \mu_{ij}}{\sigma_{ij}}$$

High values of SR_{ij} are evidence of a strong complementarities between obstacle i and j. The average complementarity score for obstacle *i* reflects the average propensity for this obstacle to be combined with all other obstacles. The average of positive scores for obstacle *i* indicates the propensity to be jointly cited as being of 'high' importance while the average of negative values indicates the propensity *not* to be jointly cited as being of 'high' importance.

Findings

The results of the analyses on obstacles to innovation are presented in three sections. These consider the situation for all firms as well as provide a comparison between Innovators and Non-Innovators. Of the 671 firms from the final sample, 279 firms or about 42 per cent of firms were identified as Innovators. If certain problems can hamper innovation activities, then one would expect that the proportion of firms citing that problem as a shortcoming or an obstacle would be higher for Non-Innovators than that for Innovators. The discussion is organized as follow. First, shortcomings are discussed by industry and size of firm as measured by size of employment. Then the relevance of each of the obstacles is evaluated. Finally, complementarities among obstacles are examined.

Shortcomings in Innovation Activities

Table 1 displays the distribution of firms which reported at least one shortcoming by type of innovator firms. Only 136 firms or about 20 per cent of firms reported that they encountered shortcomings in innovation activities during period 2000-2001. That is, majority of firms did not face any shortcomings. The proportion reporting at least one shortcoming was much lower for Non-Innovators compared to Innovators. This appears to support the contention that it is firms which are in the process of carrying out

innovation activities that are more likely to be able to report shortcomings. However, as we shall see below this is not always true across industry or firm size.

Table 1 : Percentage Distribution of Firms which Reported Shortcomings in Innovation Activities for Innovator and Non-Innovator Firms

Type of Innovator Firms	Number of firms	Number with shortcomings	Percentage with shortcomings
Innovator	279	75	26.8
Non-Innovator	392	61	15.6
All Firms	**671**	**136**	**20.3**

Table 2 shows the proportion of innovator firms and the proportion of firms reporting at least one shortcoming by industry sector. More than 75 per cent of firms in the vehicle and electronics industries were Innovators, while the corresponding percentage was less than 30 per cent for the machinery and wood industries. Among all industry sectors, the proportion of firms reporting at least one shortcoming in vehicle, non-metallic and electronic sectors were highest at 35 per cent, 33 per cent, and 27 percent, respectively. Firms in the following four industry sectors - rubber, metal and machinery and paper, were more frequently likely to report at least one shortcoming in innovation activities compared to the average firm. On the other hand, firms in industry sectors such as food, textile, wood, furniture, were less frequently likely to report at least one shortcoming in innovation activities. The chemical sector, which had a relatively high percentage of Innovators at about 55 per cent, had the lowest percentage of reporting at least one shortcoming at about 7 per cent.

Table 2: Distribution of Firms Which Faced Shortcomings in Innovation Activities by Industry Sector

Industry	No of firm	Percentage of Innovator firms	No of firm with shortcomings	Percentage with shortcomings
Vehicle	17	76.5	6	35.3
Non-metallic	33	45.5	11	33.3
Electronic	41	75.6	11	26.8
Rubber	44	52.3	11	25.0
Metal	100	34.0	24	24.0
Machinery	40	27.5	9	22.5
Paper	52	57.7	11	21.2
Wood	51	29.4	10	19.6
Furniture	43	34.9	8	18.6
Food	111	34.2	19	17.1
Textile	106	33.9	11	10.4
Chemicals	33	54.5	5	6.6
All Firms	**671**	**41.6**	**136**	**20.3**

Remark: full description of economic activities refers Table A in Appendix

Table 3 shows the proportion of innovator firms and the proportion of firms reporting at least one shortcoming by firm size. A greater percentage of medium-sized firms were likely to be Innovators (42.7 %) compared to small (31.9%) and large (25.5%) sized firms. The proportion of firms reporting at least one shortcoming was highest among medium sized firms (28.1%) and lowest among small sized firms (13.6%). One may expect medium and large sized firms to be stronger financially and have more resources than small sized firms, and therefore less likely to report shortcomings than their small sized counterparts. However, the results in Table 3 do not support this notion. It is possible, however, that innovation activity in small sized firms is more informal or less documented, so that identifying and reporting shortcomings is difficult.

Table 3: Distribution of Firms Which Faced Shortcomings in Innovation Activities by Firm Size

Category	Firm Size	No of firm	Percentage of Innovator firms	No of firm with shortcomings	Percentage with shortcomings
Small	Less than 20 employees	352	31.9	48	13.6
Medium	20- 249 employees	224	42.7	63	28.1
Large	250 and more employees	95	25.5	25	26.3
Total	**All Firms**	**671**	**41.6**	**136**	**20.3**

Table 4 presents the distribution of number of shortcomings faced by firms reporting shortcomings. About 73.5 per cent of firms reported facing only one shortcoming, 12.5 per two shortcomings and 7.4 per cent, three or more shortcomings. From this we see that about one in four firms (26.4 per cent) firms experienced more than one type of shortcoming. Interestingly, the distribution is not very different between Innovators and Non-Innovators.

Table 4: Distribution of Number of Shortcomings in Innovation Activities for Innovators and Non-Innovators

Type of Innovator Firms	Number of firms	No of reported shortcomings (%)		
		1	2	3 and 4
Innovator	75	73.4	13.3	13.3
Non-Innovator	61	73.7	11.5	14.8
All Firms	**136**	**73.5**	**12.5**	**14.0**

Table 5 presents the distribution of types of shortcomings in innovation activities. Among firms reporting at least one shortcoming, both delayed and uninitiated innovation activities were more frequently reported than other shortcomings. Over 41 per cent of firms reported delayed or uninitiated innovation activities as compared to 37 percent and 27 percent of burdened and of abandoned innovation activities, respectively. Nevertheless, certain types of shortcoming appear to be associated with the innovation status of firms. Innovators appear to more frequently report delays in innovation activities, while Non-Innovators seems to more frequently report having uninitiated innovation activities.

Table 5: Distribution of Types of Shortcomings in Innovation Activities for All Firms, Innovators and Non-Innovators

Type of Innovator Firm	Number of firms faced shortcomings	Type of shortcomings in innovation activities (%)			
		Delayed	Uninitiated	Burdened	Abandoned
Non-Innovator	61	26.2	57.4	37.7	27.9
Innovator	75	54.7	28.0	36.0	26.7
All Firms	136	41.9	41.2	36.8	27.2

Remarks: Since a firm may report more than one type of shortcoming, hence the row percentage will not equal to 100

To summarize, the majority of firms in the Malaysian manufacturing firms did not face any shortcomings in innovation activities. Innovators more frequently reported at least one shortcoming than Non-Innovators. The result appears to indicate that it is the firms which are in the innovation process that are more likely to report shortcomings. Nevertheless, this was not true across industry or firm size. The chemical sector, which had a relatively high percentage of innovator firms, reported the lowest percentage of reporting at least one shortcoming. Small sized firms, which have a relatively high percentage of innovator firms, also reported a relatively lower percentage of reporting at least one shortcoming than large sized firms. About a quarter of the firms, regardless of the innovation status of firms, reported facing more than one shortcoming. Both delayed and uninitiated innovation activities were more frequently reported than other shortcomings. Innovators more frequently reported having delayed innovation activities, while Non-Innovators more frequently reported having uninitiated innovation activities.

The Relevance of Obstacles

The survey questionnaire obtained the perception of the firm regarding the importance of each of nine obstacles, cost of innovation, economic risks, lack of appropriate sources of finance, lack of information on markets, lack of information on technology, lack of skilled personnel, lack of customers' response, legislation and regulation, and organizational rigidities.

Table 6 shows the distribution of number of obstacles cited being of 'high' importance for all firms, Innovators and Non-Innovators. Most firms (64.0%) cited between 1 - 3 obstacles out of the nine obstacles as being of 'high' importance. About 24 per cent cited 4 or more obstacles as being of 'high' importance. The proportion of Innovator firms in this category (25.3%) was slightly higher than that for Non-Innovators (21.3%). Consistent with this, the proportion of Innovator firms citing no obstacles as being of 'high' importance (10.7%) was lower than that for Non-Innovators (14.8%).

Table 6: Percentage Distribution of 'High' Importance Obstacles For All Firms, Innovators and Non-Innovators

No of obstacles cited as of high importance	All Firms		Innovators		Non-Innovators	
	No	%	No	%	No	%
0	17	12.5	8	10.7	9	14.8
1 – 3	87	64.0	48	64.0	39	63.9
4 and above	32	23.5	19	25.3	13	21.3
Total	136	100.0	75	100.0	61	100.0

Table 7 reports the perception of firms regarding the relevance of each of the nine obstacles to innovation for all firms, Innovators and Non-Innovators. If the categories of 'high' and 'medium' were to be combined, the percentage of firms citing at least one of these categories exceeds 50 per cent for every obstacle. In other words, a majority of firms found the obstacles listed in the survey as important. The obstacles have been ordered in Table 7 according the percentage of all firms citing the obstacle as being of 'high' importance. A quick review reveals that risk and finance related issues are more likely to be cited as being of 'high' importance. This is followed by market-related factors, then manpower and finally institutional issues. The ranking is generally similar for Innovators and Non-Innovators except for the category 'lack of skilled personnel' which was ranked higher by Non-Innovators than Innovators. We now discuss each obstacle in turn.

Among all obstacles, 'innovation costs too high' seems to be the foremost important obstacle faced by all firms. The high cost of innovation was cited being of 'high' importance by almost half of the firms. On the other hand, only about 18 per cent of firms perceived this obstacle as 'not relevant' to their innovation activities. While this was the foremost importance obstacle faced by Innovators and Non-Innovators, it was of greater relevance to Innovators rather than Non-Innovators. The proportion of firms citing this obstacle as 'not relevant' was lower among Innovators (12.0%) than Non-Innovators (24.6%).

'Excessive perceived economic risks' was cited as being of 'high' importance by about 32 per cent of the firms and 'not relevant' by about 23 per cent of them. Again, this obstacle was of greater relevance to Innovators rather than Non-innovators. The proportion of firms citing this obstacle as 'not relevant' was lower among Innovators (18.7%) than Non-Innovators (24.6%). On the other hand, this obstacle appears to be of greater importance to Non-Innovators than Innovators. About 42 per cent of Non-

Innovators cited this obstacle as being of 'high' importance compared to about 24 per cent of Innovators.

'Lack of appropriate sources of finance' was cited as being of high importance by about 29 per cent of the firms and not relevant by about 23 per cent of them. Consistent with other two obstacles, 'lack of appropriate sources of finance' was of greater relevance to Innovators than Non-Innovators. The proportion of firms citing this obstacle as 'not relevant' was lower among Innovators (17.3%) than Non-Innovators (29.5%). It was nevertheless of greater importance to Non-Innovators than Innovators. About 43 per cent of Non-Innovators cited this obstacle as being of 'high' importance compared to about 19 per cent of Innovators.

Clearly, the cost of financing is a major issue. Indeed more than 75 per cent of all firms found costs of innovation to be of 'high' or of 'medium' importance. Firms that face high costs of innovation may not be able to complete their innovation project within the original budget allocation. On the other hand, a study in Canada reveals that set up costs, rather than the running costs, are of greater concern for those that intend to engage in innovation activities (CSLS, 2005). Both economic risks and lack of financing were next most often cited as being of 'high' and of 'medium' importance. Of the 40 firms that reported lack of financing as a highly important obstacle, over 98 per cent were of small- and medium-sized firms. These findings are consistent with the findings of Baldwin and Lin (2001) who in their study of impediments to advance technology adoption found cost-related problems being the most frequently reported by the Canadian manufacturing firms. It is also interesting to note that the proportions of Innovator firms which found these obstacles irrelevant were lower than that for Non-Innovator firms, but that the proportions of Non-Innovators which cited these as being of 'high' importance were higher than those for Innovators. That is, more Non-Innovators perceived innovation activities exert higher economic risks and faced more financing issues than Innovators. This may be one reason why the majority of Non-Innovators did not initiate their innovation projects as noted earlier in the previous section.

Table 6 : The Relevance of Obstacles to Innovation for All Firms, Innovators and Non-Innovators

Obstacles to Innovation	Perception of Obstacles (%)											
	All Firms				Innovators				Non-Innovators			
	High Importance	Medium Importance	Low Importance	Not Relevant	High Importance	Medium Importance	Low Importance	Not Relevant	High Importance	Medium Importance	Low Importance	Not Relevant
Innovation costs too high	49.3	27.9	5.2	17.6	48.0	32.0	8.0	12.0	50.8	23.0	1.6	24.6
Excessive perceived economic risks	32.4	33.8	12.5	21.3	24.0	41.3	16.0	18.7	42.6	24.6	8.2	24.6
Lack of appropriate sources of finance	29.4	34.6	13.2	22.8	18.7	46.7	17.3	17.3	42.6	19.7	8.2	29.5
Lack of information on markets	30.9	30.9	19.9	18.3	30.7	34.7	16.0	18.7	16.4	29.2	23.0	34.4
Lack of information on technology	25.0	28.7	16.2	30.1	25.3	38.7	18.7	17.3	16.4	21.3	24.6	37.7
Lack of customer responsiveness to new products	24.3	30.9	19.1	25.7	30.7	34.7	16.0	18.7	18.0	21.3	16.4	44.3
Lack of skilled personnel	21.3	30.9	21.3	26.5	29.3	38.7	18.7	13.3	32.8	21.3	21.3	24.6
Insufficient flexibility of regulations and standards	14.0	35.3	12.5	38.2	17.3	37.3	20.0	25.3	9.8	32.8	3.3	54.1
Organizational rigidities	8.8	30.9	19.1	41.2	9.3	38.7	22.7	29.3	8.2	21.3	14.8	55.7

Combining the response of both medium and high degree of importance, the absolute differences between Innovator and Non-Innovator in the proportion of firms which cited 'excessive perceived economic risks', 'lack of appropriate sources of finance' and 'innovation costs to high' to be of importance were 1.9 per cent, 3.1 per cent and 6.2 per cent, respectively. For other obstacles, the corresponding differences ranging from 12 per cent to 26 per cent. The result indicates that the importance of finance and risk related factors, especially "excessive perceived economic risks', do not change even after firms engage in innovation activities. This implies that understanding of economic risks associated with innovation activities would have a low degree of association with firms' experience in innovation activities. So does the obstacle 'lack of appropriate source of financing'. The findings indicate both the Innovators and the Non-Innovators share a rather similar understanding of the finance and risks related obstacles that they faced. This is probably because finance and risk factors associated with innovation activities need to a great extent be decided prior to engaging in innovation, and that in this case experience in innovation does not distinguish Innovators from Non-Innovators.

'Lack of information on market' was cited by almost one third of firms (30.9%) reported shortcoming as being of 'high' importance and not relevant by about 18 per cent of them. This obstacle appears to be of greater relevance and of greater importance to Innovators than Non-Innovators. The proportion of firms citing it as being of 'high' importance was higher among Innovators (30.7%) than Non-Innovators (16.4%), while the proportion citing it as 'not relevant' was lower among Innovator (18.7%) than Non-Innovators (34.4%).

'Lack of information on technology' was cited as being of 'high' importance by about 25 per cent of the firms and not relevant by about 30 per cent of them. Consistent with the earlier result of market information, this obstacle appears to be of greater relevance and of greater importance among Innovators than Non-Innovators. The proportion of firms citing it as being of 'high' importance was higher among Innovators (25.3 %) than Non-Innovators (16.4%), while the proportion citing it as 'not relevant' was lower among Innovators (17.3%) than Non-Innovators (37.7%).

'Lack of customer responsive to new products' was cited as being of high importance by about 24 per cent of the firms and not relevant by about 26 per cent of them. Consistent with the other information-related obstacles, this obstacle is of greater relevance and of greater importance to the Innovators than Non-Innovators. The

proportion of firms citing it as being of 'high' importance was higher among Innovators (30.7%) than Non-Innovators (18.0%), while the proportion citing it as 'not relevant' was lower among Innovators (18.7%) than Non-Innovators (44.3%).

These three factors may be deemed to be information related factors that hamper innovation activities. Lack of market information related to the potential requirement and preferences of the end-user may lead to a firm producing products that are not meeting the users' needs, and hence may lead to lack of customer responsiveness towards firms' innovative products. In other words, recognition of the requirement of potential customers is important to ensure the success of firms' innovation process. The above results also show that information-related obstacles were of greater importance to Innovators than to Non-Innovators and suggest that the effect of information-related obstacles is greater after firms have engaged in innovation activities.

The next important obstacle is the labour-related obstacle. 'Lack of skilled personnel' was cited as being of 'high' importance by about 21.3 per cent of the firms and 'not relevant' by about 26.5 per cent of them. This obstacle was of greater relevance to Innovators than Non-Innovators. The proportion of firm citing it as 'not relevant' was lower among Innovators (13.3%) than Non-Innovators (24.6%). Nevertheless, the proportion of firms that cited it as being of 'high' importance was not very different between Innovators (29.3%) and Innovators (32.8 %).

Institutional-related obstacles appear to be of lesser importance. 'Insufficient flexibility of regulations and standards' was cited as being of 'high' importance by about 14 per cent of firms and not relevant by about 38 per cent of them. This obstacle appears to be of greater relevance to Innovators than Non-Innovators. The proportion of firm citing it as 'not relevant' was lower among Innovators (24.3%) than Non-Innovators (54.1%). Nevertheless, the proportion of firms that cited it as being of 'high' importance was higher for Innovators (17.3%) than Innovators (9.8 %).

Organization-related obstacle appears to be the least important obstacle. 'Organizational rigidities' was cited as being of 'high' importance by about 9 per cent of the firms and 'not relevant' by about 41 per cent of them. This obstacle is of greater relevance to Innovators than Non-Innovators. The proportion of firm citing it as 'not relevant' was lower among Innovator (22.7%) than Non-Innovators (55.7%). Nevertheless, the proportion of firms that cited it as being of 'high' importance was not very different between Innovators (9.3%) and Innovators (8.2 %).

To summarize, all the obstacles were generally important for the firms: more than half the firms found each of these to be of 'high' or of 'medium' importance. The firms viewed finance and risk related factors as the most important obstacles. This was followed by information- related factors, labour- and then institutional- and organizational-related obstacles. Both institution- and organization-related obstacles appear to be of lesser importance. The result is consistent with the finding of Mohnen and Rosa (1999) that both organization- and institution- related obstacles are the least important obstacles faced by innovator firms in the Canadian services industry.

If these obstacles hampered innovation activities, then one would expect that the proportion of firms encountering obstacles would be relatively higher among Non-Innovators than Innovators. However, for all the obstacles evaluated, a higher proportion of Innovators consistently found these obstacles to be relevant compared to Non-Innovators. This is similar to the findings of Galia and Legros (2004) in their studies of French manufacturing firms, in which the frequency of encountering obstacles was relatively higher for firms engaged in innovation activities. The result is also consistent with the conclusion reached by Baldwin and Lin (2001) in their study of Canadian manufacturing firms that the more innovative firms face greater obstacles, and is similar to the conclusion reached by Mohnen and Rosa (1999) that the level of perception of obstacles increased with the level of R&D activities.

On the other hand, analysis of the importance of these obstacles to Innovators and Non-Innovators tells a different story. While the overall ranking of obstacles was generally similar, Non-Innovators ranked the availability of the right personnel as being more important than market information. Furthermore, although both Innovators and Non-Innovators found costs, finance and risk to be the most important of obstacles, the proportion of Non-Innovators citing finance and risks as being of 'high' importance was greater than for Innovators. These findings indicate that finance, risk and the availability of skilled personnel are of greater importance to Non-Innovators, while information-related, organizational and institutional factors are of greater importance to Innovators. In other words, the notion that Innovators are more likely to cite obstacles because they experience it is true for those obstacles that are likely to be encountered or evaluated after engaging in the process of innovation. For factors that are important *ex ante* to engaging in innovation, a greater proportion of Non-Innovators are likely to find them obstacles

Complementarities between Obstacles to Innovation

We have so far examined the shortcomings and obstacles faced by firms in their innovation activities. In this section, we examine whether the obstacles are inter-related. This is particularly important because if innovation policy addresses only some of the obstacles in a inter-related set, the policy may not be as successful. Inter-relatedness is measured through complementarity scores. The value of a complementarity score between obstacle *i* and *j* indicates the propensity for obstacle *i* and obstacle *j* to be jointly cited as being of 'high' importance. The average complementarity score for obstacle *i* reflects the average propensity for this obstacle to be combined with all other obstacles. The average of positive scores for obstacle *i* indicates the propensity to be jointly cited as being of 'high' importance while the average of negative values indicates the propensity *not* to be jointly cited as being of 'high' importance. The scores are considered to be high if they exceed approximately 1.64.[2]

Table 7 presents the complementarity scores (SR_{ij}) between all pairs of obstacles to innovation for all firms. The first pattern that can be observed is the high complementarity between costs, finance and risks (economic factors); between lack of information on markets, technology and customers (information-related factors); and inflexibility in regulation and organizational (administrative-related factors). Lack of skilled personnel is an obstacle in a category by itself. Financing, cost and economic risks issues are likely to be related with each other. Perceived economic risks may increase as the innovation cost involved reaches a higher level. High costs of innovation and longer repayment period may be related to high economic risks related to the feasibility and successful of innovation activities. This complementary group of obstacles was also found by Mohnen and Rosa (1999) and by Galia and Legros (2004). These sub-groups further combine into two broad groups, one just the economic factors and the other all the non-economic factors. One possible explanation for such grouping could be due to the relatively importance of economic factors especially costs and financing, that may affect the feasibility and implementation as far as innovation is concerned.

[2] The score is a standardized variable from the hypergeometric distribution. We have assumed $\alpha = 0.10$.

Table 7 : Average Complementarity Score and SR_{ij} for All Pairs, of Obstacles to Innovation for All Firms Which Faced Shortcomings in Innovation Activities

Obstacles to Innovation	COST	RISKS	FINANCE	MARKETS	TECHNOLOGY	CUSTOMER	SKILLED	REGULATION
Innovation costs too high (COST)								
Excessive perceived economic risks (RISKS)	**1.64**							
Lack of appropriate sources of finance (FINANCE)	**2.75**	1.46						
Lack of information on markets (MARKETS)	0.32	-1.56	-0.30					
Lack of information on technology (TECHNOLOGY)	0.65	0.17	0.20	**5.71**				
Lack of customer responsiveness to new products (CUSTOMER)	0.16	0.30	**-1.68**	**3.12**	**1.85**			
Lack of skilled personnel (SKILLED)	-0.12	0.43	-1.38	**2.62**	**2.91**	**3.34**		
Insufficient flexibility of regulations and standards (REGULATION)	0.30	-0.59	0.69	**2.37**	**1.70**	**2.26**	**1.50**	
Organization rigidities (ORGANIZATION)	-0.37	-1.08	0.86	0.70	**2.35**	1.26	**1.87**	**2.80**

Except for cost, technology and skilled, complementarity scores for all obstacles are not skewed and hence mean is representative.

Table 8 shows the average complementarity scores of all obstacles to innovation by type of innovator firm. Only one obstacle, 'lack of information on technology' showed a propensity to be combined with other obstacles. However, there are considerable differences between Innovators and Non-Innovators. No pattern could be observed for the Innovators, whereas for Non-Innovators, a number of obstacles showed a propensity to combine with others. 'Lack of skilled personnel" showed the greatest propensity to be combined with others, followed by information-related obstacles.

Since a number of average scores were small, we examined the average of the positive values, that is, the average of scores showing propensity to be cited jointly as being of 'high' importance. Table 9 shows the average complementarity score for the positive scores. A quick review on the average complementarity scores for positive values shows that for all firms non-economic related obstacles had a higher propensity to be cited jointly with other obstacles as being of 'high" importance. Again, the result showed there are considerable differences between Innovators and Non-Innovators. For Innovators, only 'lack of market information' showed a propensity to be cited jointly

Table 8 : Average Complementarity Scores of Obstacles For All Firms, Innovators and Non-Innovators that Reported Shortcomings in Innovation Activities

Obstacles to Innovation	All Firms	Innovators	Non-Innovators
Innovation costs too high	0.67	0.15	1.12
Excessive perceived economic risks	0.09	-0.37	1.09
Lack of appropriate sources of finance	0.33	-0.61	1.38
Lack of information on markets	1.62	0.89	**1.89**
Lack of information on technology	**1.94**	1.08	**2.07**
Lack of customer responsiveness to new products	1.33	0.83	1.55
Lack of skilled personnel	1.40	0.59	**3.52**
Insufficient flexibility of regulations and standards	1.38	0.41	**2.18**
Organization rigidities	1.05	0.22	1.58

with other obstacles as being of 'high" importance. For Non-Innovators, almost all obstacles with the exception of lack of finance showed a propensity to be cited jointly with other obstacles as being of 'high" importance. The greatest value was for 'lack of skilled personnel'.

Table 9: Average Positive Complementarity Scores of Obstacles For All Firms, Innovators and Non-Innovators that Reported Shortcomings in Innovation Activities

Obstacles to Innovation	All Firms	Innovators	Non-Innovators
Innovation costs too high	0.97 (6)	0.51 (4)	**1.64** (6)
Excessive perceived economic risks	0.80 (5)	0.48 (2)	**1.72** (6)
Lack of appropriate sources of finance	1.19 (5)	0.45 (3)	**1.63** (7)
Lack of information on markets	**2.47** (6)	**1.86** (5)	**2.74** (6)
Lack of information on technology	**1.94** (8)	1.30 (7)	**2.06** (8)
Lack of customer responsiveness to new products	**1.76** (7)	1.38 (6)	**1.82** (7)
Lack of skilled personnel	**2.11** (6)	1.08 (7)	**3.52** (8)
Insufficient flexibility of regulations and standards	**1.66** (7)	0.71 (6)	**2.18** (8)
Organization rigidities	**1.64** (6)	1.18 (4)	**2.31** (6)

Remark : number of obstacles with positive scores in parentheses

The preceding analysis shows that there are indeed complementarities between obstacles. The groupings identified were economic-related factors, information-related factors, labour and administrative-related obstacles. Furthermore, there were complementarities between the latter four non-economic groups of obstacles. An evaluation of average scores showed only one obstacle, lack of information on technology, with propensity to combine with all others. However, there were considerable differences between Innovators and Non-Innovators. No complementarity was observed among Innovators. On the other hand, for Non-Innovators, almost all the obstacles showed a propensity to be jointly cited with other obstacles as being of 'high' importance. Additionally, average positive scores were relatively higher among Non-Innovators than Innovators for all obstacles. This implies that the complementarity between obstacles is greater among Non-Innovators than Innovators, that is, Non-Innovators were more likely to jointly cite a number of obstacles as being of 'high' importance. These results suggest that a package of policies and a more systemic approach is required to encourage non-innovator firms to participate in innovation activities.

Conclusions

Firms encounter various obstacles to innovation during the process of innovation. This study used the Malaysia NSI-3 data to analyze the obstacles faced by firms. The majority of firms in the Malaysian manufacturing sector did not report shortcoming in innovation activities. Among all shortcomings, both delayed and uninitiated innovation activities were more frequently reported. All obstacles identified in NSI-3 were generally important for the firms. Among all, finance and risk related factors were the most important obstacles, followed by information-related factors, labour or manpower and administrative. Obstacles that were external to the firm were clearly more important than internal ones, perhaps because most internal issues can be resolved by a firm that is committed to its innovation activity. In general, two complementary groups were identified for all firms reported shortcoming in innovation activities: economic and non-economic related. One possible explanation is the relative importance of economic factors especially costs and financing, which are more likely to affect the feasibility and initiation of innovation projects.

This study also examined the differences in the obstacles faced by Innovator and Non-Innovator firms. One aim was to ascertain whether non-innovators face more obstacles or whether innovator firms in the process of carrying out innovation activities face more obstacles. The results show clear differences between Innovators and Non-Innovators. First, while one might expect that Non-Innovators would face more shortcomings, the results were the reverse. Innovators were found to be more likely to report at least one shortcoming compared to Non-Innovators. Innovators were more likely to report delayed activities while Non-Innovators were more likely to report uninitiated projects. On the other hand, the ranking of obstacles by 'high' importance was only slightly different between Innovators and Non-Innovators in that the latter ranked manpower as more important than information-related obstacles. Nevertheless, all obstacles appear to be of greater relevance to the Innovators than Non-Innovators. However, it is interesting to note that a greater proportion of Non-Innovators found many of the obstacles, including the economic factors, as being of 'high' importance. This was also seen in the complementarities between obstacles: Non-Innovators were more likely to cite a number of obstacles as being of 'high' importance. For Non-Innovators, labour-related obstacles showed the greatest propensity to be combined with others. Lack of flexibility in regulations, lack of information on technology, and lack of information on markets were more likely to combine with other obstacles. Only the lack of market information showed the greatest propensity to combine with other obstacles amongst Innovators.

It appears that innovator firms face more obstacles, a result is consistent with the findings of previous studies (Baldwin and Lin, 2001; Mohnen and Rosa, 2002; Galia and Legros, 2004). On the other hand, non-innovators face a different set of obstacles at a different intensity from innovators. Non-innovators are more likely to face finance and risks related obstacles, while innovators are more likely to face a high cost of innovations and information-related obstacles. The idea that innovators are more likely to cite obstacles because they experience it is true for those obstacles that are likely to be encountered or evaluated *after* engaging in the process of innovation. Non-innovators are more likely to find obstacles that are *ex ante* to engaging in innovation more important. The way the obstacles combine to hamper innovation is also different between innovators and non-innovators. The propensity for an obstacle to combine with others is greater among non-innovators. This suggests a need for package of policies and a more systemic approach to encourage non-innovator firms to participate in

innovation activities. It also suggests that policies to encourage innovation need to address the different requirements of innovators and non-innovators.

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Appendix

Industry Classification

Firms were classified in this paper into 12 industrial sectors based on the two-digit level code of the International Standard Industrial Classification (ISIC) of all economics activities (United Nations,2002) as follows:

Table A: Classification of Industry Sector

Industry	ISIC (2-digit)	Principal Economic Activities
Food	15-16	Food Products and Beverages; Tobacco Products
Textile	17-19	Textiles; Wearing Apparel; Dressing and Dyeing of Fur; Tanning and Dressing of Leather; Luggage, Handbags, Saddelery, Harness and Footwear
Wood	20	Wood; Products of Woods; Articles of Straw and Plaiting Materials
Paper	21-22	Paper and Paper Products; Publishing, Printing and Reproduction of Recorded Media
Chemicals	23-24	Coke, Refined Petroleum Products and Nuclear Fuel; Chemicals and Chemical Products
Rubber	25	Rubber and Plastic Products
Non-metallic	26	Other Non-Metallic Mineral Products
Metal	27-28	Basic Metals; Fabricated Metal Products except Machinery and Equipment
Machinery	29	Machinery and Equipment N.E.C.
Electronic	30-33	Office, Accounting and Computing Machinery; Electrical Machinery and Apparatus N.E.C.; Radio Television and Communication Equipments; Medical, Precision and Optical Instruments, Watches & Clocks
Transport	34-35	Motor Vehicles, Trailers and Semi Trailers; Other Transport Equipment
Furniture	36-37	Furniture; Manufacturing N.E.C.; Recycling