Factor Analysis Between Internal and External R&D with Operational Performance moderated by Intellectual Property Rights

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Abstract- *This paper elaborates the findings from factor analysis in investigating intellectual property rights (IPR) (patent) having a moderating effect on the relationship between internal and external R&D towards operational performance of chemical and metallurgical manufacturing firms in Malaysia. The results of this paper were based on statistical output derived from the Statistical Package for Social Sciences version 19. The survey method was used for the study, focusing on chemical and metallurgical firms in Malaysia as the unit of analysis. It was revealed that IPR policy pertaining patents should become part of a firm's business strategy. Implementing IPR will safeguard firm's new invention, innovation, or process in the long run. Furthermore, firms may gain benefits in creating new business opportunities during various patenting stages. Strict enforcement of IPR could yield better incentives for innovation. In the long run, revenue obtained from IPR can be used to finance innovation and R&D activities. Implementation of IPR has tendencies to stimulate more research and innovation. Applying innovative and creative ideas by protecting it through IPR is able to help firm's long term success. The paper reveals that the relationship between internal R&D towards operational performance was exist in the study (H1A); relationship between external R&D towards operational performance was exist in the study (H1B); and higher level of IPR has a significant positive impact on operational performance (H1C).*

Keywords- *internal R&; external R&D; intellectual property rights; patents; operational performance.*

1. INTRODUCTION

Intellectual property rights (IPR) have become a common phrase among the main players in the industrial community. The common argument is whether to apply protection for patent, copyright, trademark, trade secret, or any other type of intellectual property (IP) protection. In this millennium, research and development (R&D) and IP managers try to cope with better information exchange, shared resources that promotes win-win relationships among the members of the department, fully utilize the usage of technology, and generates an efficient teamwork spirit and effective processes that create value to customers and organizations which later on could result in formal IP protection. When IP protection is guaranteed, this will contribute to the long lasting funds for another invention that would potentially benefit the organization, industry, and society as a whole.

As mentioned by Burrone and Jaya (2004), protecting one's invention, new product, or process carries along with its long lasting advantages. This includes getting and achieving access to new markets with protected goods. The reputation of a firm can be enhanced as a technology leader through access to, or ownership of that protected goods. At the same time, the technology used to produce the product can be patented. Corporate identity can be established through trademark and efficient branding strategy. Products with IP protection would be able to reach wide market segments when different target designs are used on different customer groups.

In addition, protected products can increase the bargaining power of the enterprise vis-à-vis business partners or investors. Firms would be able to avoid wasteful investments in R&D by consulting patent databases. This can be done when a firm learns about and practices recent technological developments. In another perspective, firms may also establish strategic alliances, joint ventures, or other types of partnerships with other companies with complementary assets.

Furthermore, many firms operating in Malaysia are through foreign direct investments, which entails many issues and challenges that are faced by companies operating in this environment (Anuar, Zulhumadi, & Udin, 2012). It is expected that these companies are involved in patenting based on the approach from their parent companies to the domestic companies. When patenting occurs, Malaysia would be able to upgrade its knowledge, which in turn leads to achieving Vision 2020. In addition, the manufacturing sector remains the leading sector in Foreign Direct Investment (FDI), and it provides most of the employment in the country. Not only that, domestic direct investment (DDI) is also another channel of investment that could spur the national economic well-being.

Product, process, or a new invention with IP protection is guaranteed to be value-added to customer responsiveness, on-time delivery, shorter order fulfillment lead times, reduced inventory costs, better asset utilization, quality purchased materials, higher product quality, enhanced capability to handle contingencies, faster product innovation, and reinforce strategic relationships among the business channels.

Firm's operational performance can be more successful when it applies protection on IPR as part of their business strategy. This firm operational performance can be measured in terms of quality, cost, flexibility, delivery, and innovation to customers. The research question for this paper is to investigate the levels of Operational Performance between Internal R&D, External R&D, and IPR. In this paper, internal R&D and external R&D will behave as independent variable, intellectual property rights as the moderating variable and operation performance as the dependent variable.

The objectives of this paper are to study the relationship of the levels of Operational Performance between Internal R&D, External R&D and IPR. Hypotheses of the research are as follows:

H1A: There is a positive relationship between the levels of Operational Performance and Internal R&D.

H1B: There is a positive relationship between the levels of Operational Performance and External R&D.

H1C: There is a positive relationship between the levels of Operational Performance and IPR (patent).

Reliability Test

The purpose of reliability analysis is to ensure internal consistency of measurements of the items. The scale internal consistency becomes an issue when the items that make up the scale hang together or not (Pallant, 2001). The most common indicator of internal consistency is Cronbach's Alpha coefficient. Ideally, the Cronbach's Alpha of a scale should be 0.7 (Nunnaly, 1978). The table 4.6 below shows the Cronbach's Alpha for each variable under study.

Cronbach's Alpha for Each Variable Under Study Variables	**No. of items**	**Cronbach's Alpha**
Dependent variable-Operational Performance (OP)	11	.929
Moderating variable-Intellectual Property rights (Patent)	14	.938
Independence variables – Internal R&D (IRD) External R&D (ERD)	22 20	.926 .916

As shown in the table above, all of the variables have fulfill the requirement when the value of Cronbach's Alpha for each dimension is more than .7. This indicates that all of the items in this study are reliable

2. METHODOLOGY

Previously, a complete survey was done in Malaysia particularly looking at the implementation of IPR among chemical and metallurgy manufacturers. The survey was designed to determine the effectiveness of R&D capabilities toward the operational performance of a firm.

The process of sampling began with the identification of the population. The population refers to a whole group of people or organization that is of interest to the researcher (Sekaran, 2005). The size of the sample depends on the accuracy required, the heterogeneity of the sample, the number of variables in the research, and the statistical tools that are appropriate (Hussey & Hussey, 1997; Neuman, 1997). The sample was chosen from the population of chemical and metallurgical manufacturing companies.

The population for the chemical and metallurgy manufacturers was 599 and it was obtained from the Intellectual Property Corporation of Malaysia (MyIPO, 2010) and the Federation of Malaysia Manufacturers (FMM). According to a statistical table produced by Krejcie and Morgan (1970), a population of 600, with the margin error of 5%, requires a minimum sample size required to be 234. However, with the confidence level of 95%, confidence interval 8, the sample size needs to be greater than 120 (Survey system, 2012). In this study, the returned survey questionnaire was 138, but only 125 were usable, as the rest were incomplete due to lots of missing data.

A confidence interval is also known as margin of error, a real-life example of which is where there is a plus-or-minus figures usually being mentioned in a newspaper or television opinion poll results. For example, if we use a confidence interval of 8 and 50% of our sample picks an answer, we can be "sure" that if we asked the questions of the entire relevant population between 42% (50-8) and 58% (50+8) would have picked the expected answer (Survey System, 2012).

Meanwhile, confidence level will inform us on how sure we can be. The unit for this is represented as a percentage and shows how often the true percentage of the population would pick an answer in the range within the confidence interval. For a 95% confidence level, this means that the researcher can have a 95% certainty; while 99% confidence level means we can be 99% certain of the correct response. In most cases, researchers prefer to use the 95% confidence level (Survey system, 2012).

The manufacturing sector has been a major engine of growth for the Malaysian economy since its Independence in 1957. In 2010 alone, the manufacturing sector contributed more than 60.2% of the nation's GDP. According to the statistic provided by the Intellectual Property Corporation of Malaysia (MyIPO) in 2010, the manufacturing class that filed and granted many patents originated from the chemical and metallurgical manufacturing companies with 28%. Therefore, this sector is a logical consideration as the population used for this study.

According to the literature review, quality of respondents is an important factor that determines whether the required data can be obtained or otherwise. Not all individuals in the company know about the IPR strategy, even if they work in the same organization. Particularly when discussing about IPR, not all managerial levels know about it comprehensively. Hence, the survey targets R&D department personnel starting from executive level and above. For larger companies, the IPR unit would be the best to represent the company in the survey.

The sampling frame can be defined as a list of population elements from which a sample can be drawn. There are four basic criteria that an appropriate sampling frame should meet, which are (Cooper & Schindler, 1998):

- the frame contains a list of member defined population,
- the frame should be up-to-date and complete,
- the frame element is unique and not repetitive, and
- the frame should contain information to stratify the sample.

The latest copy obtained from the Intellectual Property Corporation of Malaysia (MyIPO) in 2011 for this research contains information that is reliable and up-to-date. It provides the organization name and address required for the survey purpose. From a literature review of manufacturing research done in the Southeast Asian context (Boon-it & Paul, 2006; Thi, 2006), the average successful response rate is relatively low, between 15% and 22%.

Based on these past experiences, the study included the entire 599 companies in the chemical and metallurgical industry. The objective is to involve all the companies and to ensure sufficient amount of data is collected to meet the criteria of good sampling frame and sufficient amount of data to run statistical analyses (Bryman & Bell, 2003).

Multi-item scales adopted from prior studies for the measurement of the construct was used to test the hypotheses above. A five-point Likert scale with end points of strongly disagree (1) and strongly agree (5) was used to measure the 67 items. The survey sought data on many components of internal R&D, external R&D, IPR (patent), and operational performance.

Canny (2006) highlighted the importance of 5-points, since it provides the neutral rating, the 3-point value. When respondents are provided with a neutral midpoint, it will avoid the respondents to be biased when deciding to choose between more positive or more negative response. In some cases, respondents will draw attention to the negative according to their previous experiences. It is important to address here that survey respondents might truly feel neutral when being given certain topic of interest. Therefore, a scale with a neutral midpoint helps respondents not to be biased.

3. DATA ANALYSIS

3.1 Dependent Variable – Operational Performance (OP)

The total items measuring these dimensions were 11 items. However, after considering all the criteria discussed before, the factor analysis produced only one factor. None was deleted because they meet the criteria mentioned above. From the analysis all items had factor loadings above .50 on one factor and .35 or lower on the other factor.

From the factor analysis, it indicates that all the variable fall under one factor. No reduction of items can be done because every item fulfills the requirement of .5. This shows that all the items are valid and reliable. The factor was defined by 11 items related to operational performance. It includes customer delivery, reliable delivery, customer order fulfillment, customer service level, respond to urgent customer request, introduction of new products in the market, readiness to offer more products, offers higher quality products, reduce inventory cost, lower costs associated with order entry, follow-up and invoicing, and provides better competitive cost to support profit margin.

3.2 Independent Variable – Internal R&D (IRD)

After performing the factor analysis on the first independent variable (Internal R&D), it produced one dimension. The total number of items measuring internal R&D was 22 items. This dimension was analyzed using factor analysis to check for its validity. Using most of the criteria discussed before, the analysis extracted one dimension. In the process of getting this one dimension, four items had to be removed due to low communality value. Appendix 7.2 presents the result of factor analysis for this independent variable of the study.

The items in this dimension includes good R&D strategy, strong financial resources, pool of skilled R&D personnel, strong infrastructure support for R&D, strong support by the top management, top management does not interfere with process details of R&D activities, has no problem pertaining to delays in making decisions by the

management, good knowledge on R&D management know-how, good knowledge on analytical techniques, adequate market research, ability to scan the environment for existing technology, ability to evaluate the technology, ability to integrate the technology, ability to leverage the productivity of R&D activities, prior knowledge on internal R&D, absorb external know-how, ability to increase the complexity of new products/processes, to increase product lead time, better deals in getting appropriate returns to innovation strategy, important source for companies internal R&D, emphasises on the short-term profitability, and the importance of R&D for long term benefit.
From the factor analysis table, it indicates that four factors should be deleted because the factor loading was less than .5. These factors were B6, B7, B18, and B21. The eigen values for factor was greater than one. The Kaiser-Meyer-Olkin (KMO) value was .92 and Bartlett's test of sphericity was significant. The one factor extracted from the factor analysis was named internal R&D (IRD).

3.3 Independent Variable – External R&D (ERD)

The second independent variable was external R&D and consisted of 20 items. These items include better technology capability, knows how to reduce labour cost, knows how to utilise insufficient government incentives, efficient in reducing capital costs, enough R&D personnel with requisite expertise, enough personnel in various departments, strong physical infrastructural support, protection of intellectual property rights is guaranteed, manages to get licensing agreement, manages to obtain high number of R&D contracts, manages to obtain high of outsourcing activities, has a high degree of customer-supplier relationships, obtains big number of strategic alliances, has countless of organisational modules, patent is easy to apply, improvement in R&D increase competition in the industry, good consultancy services, able to cope with technology advances, receives better government incentives, and faces less number of government regulations.
From the factor analysis table in Appendix 7.3, it can be observed that four factors should be deleted due to the factor loading of less than .5. These factors were C15, C16, C19, and C20. The eigen values for factor external R&D was greater than one. The Kaiser-Meyer-Olkin (KMO) value was .906 and Bartlett's test of sphericity was significant. The one factor extracted from the factor analysis was named external R&D (ERD).

3.4 Moderating Variable – Intellectual Property Rights (Patent)

Appendix 7.4 shows the results of factor analysis for IPR (patent). At the beginning, the moderating variable was measured by 14 items in three dimensions, which were subjected to principal component analysis (PCA) using SPSS Version 19.
Total items for the moderating variables were 14 items. These includes no issue on scope of patentability, optimal priority of inventor-ship rule, chance to provide adequacy of written description and enabling disclosure in patents, difficulty of challenging patents in infringement cases, the risk of a technology in an infringement case, aware on multiplicity of patents affecting product development, licensing practices of patent holders, impact of broad blocking patents, scope of the research exemption, patentability of new products or inventions, knows how to apply the novelty requirement, knows to apply the utility requirement, manages to apply for the non-obviousness requirement, and wide breadth of claims.
The Kaiser-Meyer-Olkin (KMO) for factor IPR (patent), measure of sampling adequacy of 0.881 exceeds the bench mark value of 0.60, which implies that the sample size is adequate for factor analysis to be conducted. Also, the ratio of the sample size to the number of items is sufficient for factorability. On the other hand, the Bartlett's test of sphericity is statistically significant, supporting the factorability of the correlation matrix, since the p-value is 0.00. This indicates the adequacy of applying the factor analysis.

3.5 Factor Analysis Summary

The reliability test for each dimension emerged after factor analysis was performed. Table 3.1 shows the results of reliability test. Cronbach's alpha coefficient is a widely adopted as a measure of reliability. A value of 0.7 in the Cronbach's alpha is considered adequate to ensure reliability of the internal consistency of the questionnaire (Nunnally, 1978). Therefore, the scales were satisfactory for subsequent analysis. Note that there were a few items that had been deleted. These items were B6, B7, B18, B21, C15, C16, C19, and C20, which are listed as follows:

B6	Firm's top management does not interfere with process details of R&D activities
B7	Firm has no problem pertaining to delays in making decisions by the management
B18	Firm manage to increase product lead time
B21	Firm emphasises on the short term profitability
C15	Firm agrees that patent is easy to apply
C16	Firm realises that improvement in R&D increase competition in the industry
C19	Firm receives better government incentives
C20	Firm faces less number of government regulations

The reason for deletion was that the instrument of this study would have achieved a higher reliability.
For the dependent variable of operational performance, factor analysis was performed to verify the suitability for all the factors listed. The total items measuring these dimensions were 11 items. However, after considering all the criteria discussed before, factor analysis produced only one factor. None of the factors were deleted because they met the criteria. The total items remaining were 11 items.

As shown in Appendix 7.1, all items had factor loadings above .50 on one factor, and .35 or lower on the other factors.

The eigen values for operational performance factor was greater than one. All factors have a factor loading of more than .5, which means all factors fulfilled the requirement. There were no factors eligible to be deleted. The Kaiser-Meyer-Olkin (KMO) value was .914 and Bartlett's test of sphericity was significant. The one factor extracted from the factor analysis was named operational performance (OP).

The factor was defined by 11 items related to operational performance. It includes customer delivery, reliable delivery, customer order fulfilment, customer service level, respond to urgent customer request, introduction of new products in market, readiness to offer more products, offers higher quality products, reduce inventory cost, lower costs associated with order entry, follow-up and invoicing, and provides better competitive cost to support profit margin.

Finally, the hypotheses testing results are as below:

Hypotheses	Statements of hypotheses	Remarks
H1A	Higher level of IRD has a significant positive impact on OP.	Supported H1A hypotheses
H1B	Higher level of ERD has a significant positive impact on OP.	Supported H1B hypotheses
H1C	Higher level of IPR has a significant positive impact on OP.	Supported H1C hypotheses

Variables	Operational Performance	Remarks
IRD	β= .251, t=2.496, p=0.014	H1A supported
ERD	β= .520, t=5.173, p=0.000	H1B supported
IPR	β= .664, t=9.815, p=0.000	H1C supported

4. CONCLUSION

As a conclusion, the variables discussed above best matched the research framework. Therefore, the research variable fulfilled its validity and reliability criteria. Although there have been previous work on R&D capabilities, operational performance, and IPR to develop the scales and a relationship of certain operational dimensions, this current research has developed a comprehensive measurement model that links R&D capabilities, operational performance, and intellectual property rights.

The empirical findings by validating the variables simultaneously has culminated in a comprehensive framework from the conceptual models to a managerial framework of operational performance involving internal R&D, external R&D, and intellectual property rights (patent), thus potentially providing practitioners the ability to become more flexible in meeting customer and business requirements. When a product gets IPR protection, this creates value-added characteristics of the product. At the same time, IPR protection would be able to improve its marketability. The positive result of relationship of external R&D toward operational performance moderated by IPR (patent) signals a different role played by patents in that relationship. Thus it is expected that there is some mechanism that could yield in better company performance from patents within that relationship.

Secondly, from the survey, the finding has added to the body of knowledge by providing empirical evidences according to the research framework, which is supported by the hypothesized conceptual models. Since the empirical evidence was acquired from companies in the Malaysian chemical and metallurgy manufacturing industry, this model can be replicated and tested on other discrete manufacturing sectors such as in electric and electronics, food beverages, pharmaceuticals, automotive, wood-furniture, apparel industry, or any other industry. This adds value to future researchers as a foundation and insights for further study of intellectual property rights.

Thirdly, the measurement instruments has been rigorously tested and validated. The instrument developed in this research captures three important aspects, namely internal R&D that captures company internal R&D practices that could evolve into R&D capabilities, external R&D that capture company approach in getting external support for R&D activities, intellectual property rights (patent) practices that foresee how it creates value to its products and processes, and company operational performance.

One key contribution from this research is the combined dimensions of the two R&D capabilities namely internal R&D and external R&D that offers a new perspective to the field of R&D management. Future researchers in R&D management can leverage these measurement tools for strategic management or R&D management studies, complementing the earlier problem statement on the Malaysian intellectual property rights dilemma.

5. DISCUSSION

In general, the relationship between internal R&D towards operational performance was exist in the study (H1A); relationship between external R&D towards operational performance was exist in the study (H1B); higher level of IPR has a significant positive impact on operational performance (hypotheses H1C was supported). Therefore, it is suggested that firms should improve the relationship between internal and external R&D, intellectual property rights and operation performance. Even in this study, the population was only from chemical and metallurgical manufacturing companies,it is suggested that this findings could be generalized to the other industries as well.

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Appendix

Appendix 7.1

Result of the Factor Analysis for Operational Performance

Factor Matrix[a]	
	Factor
	1
E4CS	.865
E5	.826
E1CD	.824
E2RD	.818
E3LT	.809
E11	.756
E9	.728
E8	.726
E10	.692
E6	.633
E7	.521

Extraction Method: Principal Axis Factoring.
a. 1 factor extracted. 4 iterations required.

Appendix 7.2

Result of the Factor Analysis for Internal R&D

Factor Matrix[a]				
	Factor			
	1	2	3	4
B16	.813			
B19	.795			
B15	.786			
B14	.782			
B8	.778			
B1	.760	.301		
B22	.748			
B12	.739	-.354		-.337
B11	.732			
B17	.727	-.359		
B9	.725			
B20	.723			
B4	.719	.407		
B13	.709	-.417	.477	
B10	.666			
B3	.663	.369		
B5	.595			
B2	.566			
B18	.462			
B7	.364			.325
B21				
B6				

Extraction Method: Principal Axis Factoring.
a. Attempted to extract 4 factors. More than 25 iterations required. (Convergence=.005). Extraction was terminated.

Appendix 7.3

Result of the Factor Analysis for External R&D

Factor Matrix[a]					
	Factor				
	1	2	3	4	5
C7	.752				
C18	.741				-.361
C1	.730	-.300			
C4	.727		-.478		
C12	.719				
C5	.704			-.302	
C14	.690	.379			
C8	.680	-.354	.313		
C9	.671				
C13	.666		-.324		
C6	.634				
C3	.576				
C2	.540				
C10	.532				
C11	.518	.417			
C17	.505				
C20	.498	.357		.311	
C19	.455	.430	.436		
C15	.407	.347			
C16	.317				

Extraction Method: Principal Axis Factoring.
a. 5 factors extracted. 15 iterations required.

Appendix 7.4

Result of the Factor Analysis for Intellectual Property Rights (Patent)

Factor Matrix[a]		
	Factor	
	1	2
D22	.808	
D23	.804	
D25	.797	-.303
D21	.790	
D15	.776	
D24	.764	-.310
D14	.726	
D19	.725	
D17	.724	.538
D18	.710	.453
D13	.709	
D16	.641	.343
D12	.623	
D11	.554	

Extraction Method: Principal Axis Factoring.
a. 2 factors extracted. 9 iterations required.