Herman Shah Anuar,
Zulkifli Mohamed Udin

Post-hoc Analysis on the R&D Capabilities of Chemical and Metallurgical Manufacturing

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Summary

The purpose of this paper is to evaluate how internal R&D, external R&D, and patenting affects the behavior of foreign, local, and joint-venture companies operating in manufacturing companies in Malaysia. Different types of manufacturing companies may have different approach in applying their R&D capabilities and patenting activity. The construct of this paper is based on the post-hoc analysis in evaluating how internal R&D, external R&D, and patenting affects the behavior of foreign, local, and joint-venture companies operating in manufacturing companies. This research was conducted using survey questionnaires. 124 companies in chemical and metallurgical manufacturing companies participated in this survey. It was indicated that these three companies behave differently when dealing with internal R&D, external R&D, and patenting. It can be concluded that these three types of companies have a different perspective on applying internal R&D, external R&D, and patenting which is based on their different business strategic direction. It is suggested that in the near future, researchers should concentrate and other types of manufacturing companies or they can involve more sample size in getting better generalization on the behavior of these companies.

Keywords

internal R&D, external R&D, patenting, manufacturing companies

1. Introduction

Intellectual Property Right is a new form of wealth in the economic system based on innovation. More than 50% of the assets in giant companies like Microsoft, Intel, Starbuck, and Sony are in the form of IPR (Kevin, 1998). This includes the outcomes of innovation and creativity, such as patents, copyrights, trademarks, industrial design, etc., that are used in trade and commerce. For non-physical assets, it includes literary and art given to the exclusive rights under the law to the owner to prevent others from doing exploitation.

According to the National Economic Advisory Council Malaysia, (NEAC, 2009), it emphasizes on the Strategic Reform Initiatives 6: Building the knowledge base and infrastructure; that is "to promote an environment for innovation". It has mentioned that in order to implement the initiatives is through applying protection of Intellectual Property Right.

Therefore, it is clearly stated in the policy measures that the government is seriously looking at the successful implementation of R&D for the betterment of the industries in Malaysia. It is believed that the growth and success of R&D, through the efforts undertaken in the private sector, will boost the nation's economy. Furthermore, this will attract more foreign direct investments, which will revitalize the economy and drive Malaysia aggressively to become a developed nation by 2020.

IPR is a new form of wealth in the economic system based on innovation. More than 50% of the assets in giant companies like Microsoft, Intel, Starbuck, and Sony are in the form of IPR (Kevin, 1998). This includes the outcomes of innovation and creativity, such as patents, copyrights, trademarks, industrial design, etc., that are used in trade and commerce. For non-physical assets, it includes literary and art given to the exclusive rights under the law to the owner to prevent others from doing exploitation.

As a matter of fact on 30th April 2012, an announcement was made by the United States Trade Representatives (USTR) regarding Malaysia, which had been removed from a list of countries that violate IPR. The list showed that Malaysia was no longer involved, like many other countries, in committing violations of IPR. Officials to the USTR office mentioned that the announcement is a sign of recognition of Malaysia's seriousness in protecting IPR. This shows that the great effort expended by the Malaysian government in implementing protection and enforcement of IPR has been recognized by the world community. Such policies are compatible with the operation of Malaysia's pharmaceutical data protection and other regulations.

2. Literature Review

Internal R&D or in-house R&D (IRD) is defined as an activity of the company whereby it sets up and fulfils a research project within itself. Nakamura and Odagiri (2005) mentioned that this can be done by employing important resources, such as researchers, research materials, and equipment. It may also be procured as part of the R&D activity from outside. Audretsch, Menkveld and Thurik (1996) and Bonte (2003) often used the terms "internal R&D" and "external R&D" replacing "in-house R&D" and "procured R&D".

IRD, as mention by Cassiman and Veugelers (2002), has several dimensions that contribute to the full function of it. This includes its ability to scan the environment for existing technology, ability to evaluate the technology, integrate the technology, and leverage the productivity of R&D activities (Veugelers, 1997), appropriation capacity, and prior knowledge to effectively absorb external know-how (Cohen & Levinthal, 1990).

Meanwhile, Cassiman and Veugelers (2002) pointed out advantages for implementing IRD includes increasing the complexity of the new product/process, establishing a lead time, and appropriate returns to innovation strategy (Teese, 1986). Sufficient support of the internal network is one of the examples where simultaneous interaction occurs. It is crucial because this support will direct important external network linkage. From another perspective, properly managed external network linkages offer input to R&D sources for internal network.

By implementing IRD, it allows companies to better scan the environment for existing technology. The current technology which is based internally will help the process of equipping R&D capabilities to evaluate the built-in technology (Cassiman & Veugelers, 2002). In the long run, it will give better returns to the firm. IRD can also behave as an appropriation capacity.

External R&D (ERD) as understood by the industry practitioner, academics, and people of the public indicates any external or outsiderinvestigative activities that a business or company chooses to conduct with the intention of making a discovery that can either lead to the development of new products or procedures, or to the improvement of existing products or procedures. By doing R&D, it is one of the ways in which a business or company can enjoy future growth by introducing and developing new inventions, products, or processes in order for the company to grow and expand their business operations.

Nakamura and Odagiri (2005) argued that external R&D may become worthless unless the company makes conscious efforts to procure it. One-way to procure is through making sacrifices in the form of payments or the allocation of its human and other resources. They argued that a company may gain benefit from ERD without paying through spill-over.

According to Cassiman and Veugelers (2002), several reasons that attract companies to implement ERD are companies that have the ability not to take R&D risks at their own expense, company's ability to run away from dealing with financial constraints, and company's opportunities to gain the spill-over effects especially when the new knowledge comes into the company. When these promising gains have come into the mind of top management of the company, then they will evaluate the positive outcome that can be derived from external R&D practice.

Furthermore, Rigby and Zook (2002) found from their case studies that the strategy of opening up the innovation process to external knowledge flows, has the tendency to reduce the cost, improve the quality, and enhance the speed of innovation when the quantity of ideas to choose from increases for those responsible for innovation. Therefore, external knowledge flows have the same effect with ERD, which later on would bring favorable effect by improving the performance of a company.

Intellectual property rights (IPR) are increasingly recognized as "key value driver" (Ghosh, 2003) and plays an important role in the modern economy as compared to the previous era. It can be seen as a new source of wealth. Many have mistakenly understood the function that IP can serve. Greenhalgh and Rogers (2007) highlighted that economist sees IPR as a policy tool to ensure adequate private returns to innovation and creative activities. Companies may use IPR to protect the returns from their investment from being depleted by imitation.

Chiesa and Gilardoni (2004) classify that IPR issues can be seen from three major perspectives namely patent intent, patent strategy, and patent portfolio management. Patent intent covers the reason why a patent is filed and how it will be used. Patent strategy focuses on how a certain technological area is protected. Patent portfolio elaborates more on how a company that holds

strong patent rights manages them in order to generate value.

A study conducted by Hall (1993) highlighted that IPR of patents, trademarks, copyrights, and registered designs are one out of nine elements that is classified as intangible resources. He claimed that intangible resources may be classified as assets or competencies. The other nine elements includes trade secrets, contracts and licenses, databases, information in the public domain, personal and organisational networks, the know-how of employees, professional advisers, suppliers and distributers, the reputation of products and company, and lastly, the culture of the organisation. Intangible resources which are legally protected are patents, trademarks, copyrights, registered designs, contracts and licenses, trade secrets, and databases.

Hall (1993) found that regulatory capabilities through patents ranked the top among other capabilities which are positional capabilities (reputation), functional capabilities (know-how), and cultural capabilities (ability to manage change) in gaining competitive advantage. In other words, the challenge in the business arena is when a product or process is managed to be recognized as patented products, the chance for the product to be marketed is comparatively high as compared to non-patented product. It carries the weight as a quality product, new, has better requirements, and it is very practical to be used.

IPR is a type of property that can generate financial returns which needs to be applied and granted before it can be used. Benefits of owning the property include: owner's work is protected against infringement and owner has the rights over its application. At the same time, the IP owner has the authority to license the work to another person or organization to use these rights.

The license contains terms and conditions on how to use the work. It also includes how much royalty should be paid to the IP owner. The most common types of licensing agreements are exclusive, non-exclusive, compulsory, and cross licensing. Different types of licensing are designed for different requirements that are needed for companies and IP owners to choose from. The IP owner can also benefit from IP rights through technology transfer brokerages, and through the sale or transfer of ownership (Singh, 2007).

IPR is a concept of protecting one's own effort of creating new invention or products that has long been practiced by the world community since 1867. The establishment of the world body that coordinates and become the center of reference for issues pertaining to IPR is the World Intellectual Property Organization (WIPO), which shows how deep is the appreciation of the international community toward IP.

3. Methodology

This study applies the survey method in collecting data. The survey questions were distributed to the respective chemical and metallurgical manufacturing companies throughout Malaysia. This type of manufacturing companies was chosen because this group was on top of the list which obtained the most patented products in the year 2010. The company names were obtained from Intellectual Property Corporations of Malaysia (MyIPO). These companies at the same time also registered with the Federation of Malaysian Manufacturers (FMM). Unit analysis for this study was companies with key R&D/ IP managers or

Multiple Comparisons
M_IRD_DELETEB
Tukey HSD

(I) A6	(J) A6	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
0	100% LOCALLY OWNED	.06681	.25867	.994	-.6071	.7408
	100% FOREIGN INVESTED	-.36852	.27085	.526	-1.0742	.3372
	JOINT VENTURE	-.19394	.30243	.918	-.9819	.5940
100% LOCALLY OWNED	0	-.06681	.25867	.994	-.7408	.6071
	100% FOREIGN INVESTED	-.43533*	.12046	.002	-.7492	-.1215
	JOINT VENTURE	-.26075	.18059	.475	-.7313	.2098
100% FOREIGN INVESTED	0	.36852	.27085	.526	-.3372	1.0742
	100% LOCALLY OWNED	.43533*	.12046	.002	.1215	.7492
	JOINT VENTURE	.17458	.19764	.814	-.3404	.6895
JOINT VENTURE	0	.19394	.30243	.918	-.5940	.9819
	100% LOCALLY OWNED	.26075	.18059	.475	-.2098	.7313
	100% FOREIGN INVESTED	-.17458	.19764	.814	-.6895	.3404

*. The mean difference is significant at the 0.05 level.

executives, or any executive level officer who knows about the R&D / IP department.

For the survey items, it can be divided into five sections, namely: section A (demography), section B (internal R&D), section C (external R&D), section D (intellectual property rights-patent), and section E (operation performance). The number of items for each section were, section A (10 items), section B (22 items), section C (20 items), section D (14 items), and section E (11 items).

The population for this study was 599. Using the confidence level of 95%, confidence interval of 8, sample size needed is 120 (Survey system, 2012). After the surveying question collection was finished, a researcher received 138 responses. Out of this number, only 124 survey responses were usable. The other 14 were unusable due to missing and incomplete data in their survey responses.

4. Analysis

The tool used to evaluate the how internal R&D, external R&D, and patenting affects the behavior of foreign, local, and joint-venture companies operating in manufacturing companies in Malaysiais using One-way ANOVA.The hypothesis,H0: $\mu A=\mu B=\mu C$.

A: Locally owned company
B: Foreign owned company
C: Joint-venture company

One-way analysis of variance is used when you want to compare more than two means. It is a technique that generalizes the two-sample t procedure which compares two means. Like the two-sample t test, it is robust and useful.

Hypotheses:
H0: There are no significant differences between the groups' mean scores.
Ha: There is a significant difference between the groups' mean scores.

4.1. ANOVA A6 to Independent Variable 1 – Internal R&D

The Table 1. show the result of ANOVA for company status behaviour towards Internal R&D.

Table 1 *ANOVA A6 to Independent Variable 1- Internal R&D*

ANOVA
M_IRD_DELETEB

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.323	3	1.441	4.583	.004
Within Groups	37.729	120	.314		
Total	42.052	123			

Testing Hypotheses in One-Way ANOVA for Independent Variable 1 – Internal R&D:

Hypotheses for the Independent Variable 1- Internal R&D is as stated below:

H0 : $\mu A = \mu B = \mu C$

H1a: not all the μA, μB, μC are equal (at least one is different)

From the One-way ANOVA test table 1., it shows that the analysis was significant $F(3, 120)=4.583$, $p=.004$. When comparing to the α level, it was found that $p(.004) \leq .05$, so it rejects H0. A post hoc Tukey test showed that the locally owned company, foreign owned company and joint-venture company differed significantly at $p< .05$. H1a is supported. There is a significant difference between a locally owned company, foreign owned company and a joint - venture company.

4.2. ANOVA A6 to Independent Variable 2 – External R&D

The table 2 below shows the result of ANOVA for company status approach towards External R&D.

Table 2 *ANOVA A6 to Independent Variable 2- External R&D*

ANOVA
M_ERD_DELETEC

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.372	3	1.457	4.169	.008
Within Groups	41.951	120	.350		
Total	46.323	123			

Multiple Comparisons
M_ERD_DELETEC
Tukey HSD

(I) A6	(J) A6	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
0	100% LOCALLY OWNED	.24359	.27276	.808	-.4671	.9542
	100% FOREIGN INVESTED	-.20208	.28561	.894	-.9462	.5420
	JOINT VENTURE	.11932	.31890	.982	-.7116	.9502
100% LOCALLY OWNED	0	-.24359	.27276	.808	-.9542	.4671
	100% FOREIGN INVESTED	-.44567*	.12702	.004	-.7766	-.1147
	JOINT VENTURE	-.12427	.19043	.914	-.6204	.3719
100% FOREIGN INVESTED	0	.20208	.28561	.894	-.5420	.9462
	100% LOCALLY OWNED	.44567*	.12702	.004	.1147	.7766
	JOINT VENTURE	.32140	.20841	.416	-.2216	.8644
JOINT VENTURE	0	-.11932	.31890	.982	-.9502	.7116
	100% LOCALLY OWNED	.12427	.19043	.914	-.3719	.6204
	100% FOREIGN INVESTED	-.32140	.20841	.416	-.8644	.2216

*. The mean difference is significant at the 0.05 level.

Testing Hypotheses in One-Way ANOVA for Independent Variable 2 – External R&D:

Hypotheses for the Independent Variable 2- External R&D is as stated below:

H0 : μA = μB = μC

H1b: not all the μA, μB, μC are equal (at least one is different)

From the One-way ANOVA test table 4.28, it shows that the analysis was significant F(3, 120)= 4.169, *p*=.008. When comparing the P-value to the α level, the output presented *p*(.008)≤ .05, so it rejects H0.A post hoc Tukey test showed that the locally owned company, foreign owned company and joint-venture company differed significantly at *p*< .05. H1B is supported. There was a significant difference between a locally owned company, foreign owned company and a joint - venture company. Table 4.3 below shows the approach of different company status towards independent variables under study.

Table 3 *Approach of Company Status towards Independent Variables with N=124*

Independent Variable	Categories	M	F-value	*p*
IV1- Internal R&D	Locally owned company	4.6332	4.583	.004
	Foreign owned company	5.0685		
	Joint-venture company	4.8939		
IV2- external R&D	Locally owned company	3.5689	4.169	.008
	Foreign owned company	4.0146		
	Joint-venture company	3.6932		

4.3. ANOVA A6 to Dependent Variable – Operational performance

The table 4.4 below shows the result of ANOVA for company status behaviour towards Operational Performance.

Table 4. *ANOVA A6 to Dependent Variable – Operational performance*

ANOVA
M_OP

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.802	3	.267	.641	.590
Within Groups	50.044	120	.417		
Total	50.846	123			

Testing Hypotheses in One-Way ANOVA for Dependent Variable – Operational performance:

Hypotheses for the Dependent Variable – Operational performance is as stated below:

H0 : μA = μB = μC

H3c: not all the μA, μB, μC are equal (at least one is different)

From the One-way ANOVA test table 4.4, it shows that the analysis was not significant F(3,120)= .641, *p*=.590. When comparing with the α level, *p*(.590) ≤ .05, so, it fails to reject H0. A post hoc Tukey test showed that locally owned company, foreign owned company and joint-venture company differed significantly at *p*<.05. H1C is rejected. There were no significant differences between locally owned company, foreign owned company and joint-venture company.

4.4. ANOVA A6 to Moderating Variable – IPR (Patent)

The table 5. below shows the result of ANOVA for company status behaviour towards IPR (Patent).

Table 5. *ANOVA A6 to Moderating Variable-IPR (Patent)*

ANOVA
M_PAT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.263	3	1.088	2.311	.080
Within Groups	56.487	120	.471		
Total	59.751	123			

Testing Hypotheses in One-Way ANOVA for Moderating Variable-IPR (Patent):

Hypotheses for the Moderating Variable-IPR (Patent) are as stated below:

H0 : μA = μB = μC

H1D: not all the μA, μB, μC are equal (at least one is different)

From the One-way ANOVA test table 5, it shows that the analysis was not significant $F(3,120)= 2.311$, $p=.080$. When comparing the value obtained, $p(.08) \leq .05$, so it fails to reject H0. A post hoc Tukey test showed that the locally owned company, foreign owned company and joint-venture company differed significantly at $p<.05$. This indicates that H1D was rejected. There was no significant differences between locally owned company, foreign owned company and joint-venture company.

Results obtained from the ANOVA of company status towards internal R&D and external R&D indicates that locally owned company, foreign owned company, and joint-venture type of company may have their own approach pertaining to implementation of internal and external R&D. Even though all of these companies compete in the same category of industry which is chemical and metallurgy manufacturing, it was found that there is some difference between them.

In order to get to know the differences between these three groups, a post-hoc test were carried out. By using this technique, it would be able to determine which groups differ from each other. ANOVA test will be included in the very beginning. In the Tukey's post-hoc test, the researcher needs to find the differences between the means of all of our groups. The researcher will compare this difference score to a critical value to see if the difference is significant. The critical value in this case is the HSD (honestly significant difference). It is the point when a mean difference becomes honestly significantly different (Pallant, 2001).

Post-hoc comparisons are used to conduct a whole set of comparisons. In this study, the researcher wants to explore the differences between three different status of the company namely locally owned company, foreign owned company and joint-venture type of company. This test consists of two steps which is to look at the overall F ratio that is calculated. This ratio informed the researcher that there were significant differences among the three types of company (Pallant, 2001).

Multiple Comparisons
M_OP
Tukey HSD

(I) A6	(J) A6	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
0	100% LOCALLY OWNED	.15245	.29792	.956	-.6237	.9286
	100% FOREIGN INVESTED	-.00303	.31194	1.000	-.8158	.8097
	JOINT VENTURE	.25289	.34831	.886	-.6546	1.1604
100% LOCALLY OWNED	0	-.15245	.29792	.956	-.9286	.6237
	100% FOREIGN INVESTED	-.15548	.13874	.678	-.5169	.2060
	JOINT VENTURE	.10045	.20799	.963	-.4414	.6423
100% FOREIGN INVESTED	0	.00303	.31194	1.000	-.8097	.8158
	100% LOCALLY OWNED	.15548	.13874	.678	-.2060	.5169
	JOINT VENTURE	.25592	.22763	.675	-.3371	.8490
JOINT VENTURE	0	-.25289	.34831	.886	-1.1604	.6546
	100% LOCALLY OWNED	-.10045	.20799	.963	-.6423	.4414
	100% FOREIGN INVESTED	-.25592	.22763	.675	-.8490	.3371

From this study, it was found that these three categories of companies differ in the way how they react towards patenting. When the post-hoc analysis being done, it indicates that locally owned company and foreign owned company yield significant differences (.002) on the implementation of internal R&D. No significant difference accumulated for joint-venture companies. It means that internal R&D had an influence to the local owned and foreign owned company but not for the joint - venture type of company.

For the external R&D, both foreign owned company and locally owned company showed the same significant difference (.004), whereas there are no significant differences for joint-venture company. This indicates that these companies put serious attention on acquiring external R&D on their business approach as compared to the joint-venture type of company.

5. Findings

Post-hoc analysis was done to evaluate how internal R&D, external R&D, and patenting affects the behaviour of foreign, local, and joint-venture companies. The results indicated that it drew mixed results. For the locally owned company and foreign owned company, both of them yield significant differences (0.002) on the implementation of internal R&D. But, there was no significant difference accumulated for the joint-venture company.

For the external R&D, both foreign owned company and locally owned company showed the same significant differences (.004), whereas, there is no significant difference for joint-venture companies. This indicates that these companies put serious attention on acquiring external R&D on their business approach as compared to the joint-venture companies.

For the intellectual property rights (patent) approach, the three categories showed no significant difference. It is agreed that these companies have minor or no focus on protecting their inventions. In other words, they agree that protecting their inventions is good for the company's future growth but still concentrate on generating revenue through the normal method such as getting profit, increase market share, reduce cost per unit, and many more but not on creating revenue from property rights (patent) or licensing.

6. Conclusion

To conclude, the findings from the post hoc analysis between internal R&D, external R&D, and intellectual property rights (patent), discovered mixed results among local, foreign, and joint-venture companies. It was found that for the local and foreign owned companies, they were being influenced significantly to implement internal and external R&D towards their operational performance, whereas it is the complete opposite for joint-venture companies. For the implementation of intellectual property rights, local, foreign, and joint-venture company, it was not being influenced significantly. Therefore, these three categories of companies only put strong emphasis on the traditional approach of doing R&D where their focus is more towards internal and external R&D rather than implementing protection of intellectual property rights.

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Herman Shah Anuar
Universiti Utara Malaysia
School of Technolog Management and Logistics
06010Kedah
Malaysia
Email:herman@uum.edu.my

Zulkifli Mohamed Udin
Universiti Utara Malaysia
School of Technolog Management and Logistics
06010Kedah
Malaysia
Email:zulkifli@uum.edu.my