The Impacts of NPD Characteristics on Innovation Market Performance and its Survival: The Mediating Role of Collaboration

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Abstract: ***While collaboration has been acknowledged as pertinent to the success of innovation product commercialization, the collaborative effort between the innovation recipient firm and the innovators remains limited. Besides, one of the central questions is how and under what condition the two parties are more likely to engage in a resilient collaborative effort, from the perspective of innovation recipient firms remain unclear. This new perspective requires an understanding of the relationships among new product Development (NPD) characteristics, collaboration, and product innovation market performance and survival within the context of technology transfer. In this paper, we employed transactional cost economic (TCE) theory to explain the relationships between NPD characteristics (innovation uncertainty and asset specificity) and collaboration, and the mediation effect of collaboration on the relationships between NPD and performance. Based on the response of 104 product innovation recipient firms, our findings suggest a positive relationship between NPD characteristics and, collaboration and market performance and innovation survival. This study revealed that, consistent with TCE theory, NPD characteristics influence the pattern of collaboration between the innovation recipient firms and the innovator, acted as an effort to reduce transactional risks. Our findings also concluded that collaboration mediates the relationship between NPD characteristics and market performance and innovation survival.***

Keywords: New Product Development, Market Performance, Innovation Survival, Collaboration

I. INTRODUCTION

New Innovative product is one of the vital sources to gain competitive advantage, thus, companies must be able to develop an innovative product that appeals to customer demand [1]. Particularly in today's market-based economy era, most of the countries have taken some effort to increase their economic value by diffusing their scientific knowledge to a much wider sphere of industrial activities through the process of technology transfer and commercialization.

When it came to the transfer of product innovation from the R&D stage to companies for manufacturing and commercialization, this activity tended to be failed when companies are incapable to successfully link the characteristics of product innovation with the market needs Due to the novelty of the product innovation, firm might be suffering from the liability of newness [2]. As consequences, firm may not have sufficient internal resources to capture the market needs [3]. In this light, research findings on collaboration between innovator and recipient firm could help firm reduced the risk of liability of newness of the innovation.

There is a lack of understanding on the relationships between collaboration and commercialization performance in the transfer of the innovation for commercialization between the innovator and the recipient firm, especially from the perspective of the recipient firm. This was supported by [4], who discovered that cooperation is vital for technology transfer activities. Thus, in the context of technology transfer collaboration in commercializing new product, the present study examines: (1) Whether closed collaboration affected by level of innovation uncertainty and asset specificity; (2) Does closed collaboration between firm and innovation provider result in better commercialization performance; (3) How the collaboration generate commercialization success under high level of innovation uncertainty and high level of asset specificity.

This research theorized that collaboration may play a mediating role in the relationship between the antecedent variables (degree of innovation uncertainty and degree of innovation asset specificity) and the dependent variables (market performance and innovation survival). Four mediation hypotheses were developed to test this proposition. A variable is considered as a mediator when it creates an indirect effect through which the focal independent variable is able to influence the criterion of the variable of interest [5]. According to [6], the mediator variable transmits some of the causal effects of prior variables onto subsequent variables.

Uncertainty is derived from different sources, and in this study, innovation uncertainty, which consists of market uncertainty and technology uncertainty, has been identified. Market uncertainty is defined as the level of ambiguity about competitive behaviour, the composition of customers and their preferences, and substitutes that may appear [7]. Meanwhile, technology uncertainty includes technological evolution, technology discontinuities, and lack of knowledge about the real means to accomplish a project [8].

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Acquired firms that are uncertain about the state of the innovation market and technology will spend more time and resources on technology and market scanning and forecasting than those firms that are more assured that they understand the acquired innovation. However, the market and technology uncertainty may be the highest in the case of an innovation that comes from a research machine. For instance, [9] argued that manufacturers will find it more difficult to plan when demand is more variable. Thus, this will encourage the acquired firm to collaborate with the innovator. This is because in a highly uncertain market with a low uncertainty technology, there is a greater need for interdependency between the acquired firm and the innovation provider to share information, integrate expertise and use their resources [10].

Similarly, the acquired firm would be more conservative in its allocation of scarce and critical resources. An acquired firm would avoid making huge investments and instead, would prefer to collaborate. Collaboration between an acquired firm and the innovation provider would help the former to cope with turbulent markets and technology and be better able to serve changing customers in a timely manner. Thus, an acquired firm will tend to use the NPD experience, technical expertise and resources of the innovation provider to enhance the market performance and survival of the innovation in conditions of high market and technology uncertainties. Accordingly, this study proposed that in situations where high innovation uncertainty exists, commercialization performance (e.g. market performance and innovation survival) will be diminished due to the unpredictable conditions. It is believed that greater collaboration between the acquired firm and the innovation provider can offset this effect. Therefore, this study also posited an indirect effect, and proposed that the degree of innovation uncertainty can be mediated through the use of collaboration.

The second NPD characteristic discussed in this study was the degree of innovation asset specificity. Asset specificity is defined as investments in physical or human assets that are dedicated to a specific exchange relationship and whose relocation involves considerable switching costs [11]. This definition shows that asset specificity encompasses both human and physical assets. Physical assets include plant, machinery and sites, while human assets are reflected in the training of personnel and the acquisition of expertise [12]. For example, the commercialization of an innovation may require a high degree of asset specificity. According to [13], innovation can be based on new scientific breakthroughs, although more commonly it is from re-combinations of existing technologies. Thus, innovation is a knowledge quest and creation process. Therefore, the human asset specificity is higher. As defined by [14], human asset specificity relates to knowledge-specific assets that arise from learning-by-doing and which have limited transferability to other work settings. In addition, it also involves additional investments in laboratory accessories that help the company assess the quality of a bigger proportion of goods [15].

II. DATA AND METHODS

The hypotheses were tested using quantitative research design. The data collected from firms that manufactured and commercialized the acquired technology from outside innovators. This was because the main objective of this study was to understand the commercialization performance when the degree of uncertainty of the acquired innovation product and the degree of asset specificity were high, and whether the governance structure, which in this study is collaboration, influenced these two variables, thus leading to higher performance in the market and product innovation survival. Hence, only those respondents who could provide the required information were selected. The data collection process was conducted over a 10-month period. At the end of data collection period, a total of 104 usable questionnaires via mail survey, online survey and by hand survey, were collected and used for further analysis. In order to determine the desired sample size target for this research, a power analysis using G Power software statistical program with a power of 0.80, with $p < 0.05$, and an anticipated medium effect size of 0.15, was chosen. This 80 percent of power is the minimum power needed for social science research [16]. Therefore, based on the power analysis, the minimum sample size needed was 77 cases. This result indicated that 77 samples were enough to show the power for the effect size of the study. After the data collection, the total sample size for this study was 104, which was well over the minimum number required. All measurement scales for this study were adapted from previous literature. A 7-point scale was used for all dependent, independent, and mediator variable. The anchor points for the independent and mediation items were “strongly disagree” (=1) to “strongly agree” (=7) and “Far below” (=1) to “Far above” (=7) for dependent variable.

Degree of innovation uncertainty. innovation uncertainty was captured by several measures adapted from Buvik & Grùnhaug (2000), Gao, Sirgy, & Bird (2005), Carbonell & Rodriguez (2006), Stock & Tatikonda (2008), Abd Rahman & Bennett (2009), and Pries & Guild (2011) to describe the difficulty and inability to forecast accurately the changes in the market and technology that are related to the innovation manufacturing process. The degree of innovation uncertainty was measured through the use of six items, which captured the uncertainty of market for innovation and uncertainty of innovation form in the context of the technology itself.

Degree of innovation asset specificity. Degree of innovation asset specificity was described as the firm’s physical, human and temporal specificity of a firm that describes the specific investment made by firm in manufacturing and commercializing the innovation that they acquired from the external innovators. The items were referred to Klein, Frazier, Roth, Roth, & Frazier (1990), Burgel & Murray (2000), Artz & Brush (2000), Kwon & Suh (2004), Mithas, Jones, & Mitchell (2008), Chiou & Shen (2006), Chandler, McKelvie, & Davidsson (2009), Lui, Wong, & Liu (2009), and De Vita, Tekaya, & Wang (2010). This research modified the items to be appropriate for use in the context of this study.

Innovation commercialization collaboration

The construct of innovation commercialization collaboration (ICC) consists of seven items that borrowed from previous researches. The variables are information sharing (Lee, 2001; Lages, Lages, & Lages, 2005; Li & Lin,

2006; Wu, 2008; Abd Rahman & Bennett, 2009; Cao & Zhang, 2011; Wang & Wang, 2012)., trust (Sharma & Patterson, 2000; Li, 2005; Ki & Hon, 2007; Wu, 2008; Lin et al., 2009; Wang, Yeung, & Zhang, 2011), business understanding (Lee, 2001; Lee & Kim, 2005; Ki & Hon, 2007; Abd Rahman & Bennett, 2009), communication (Moenaert et al., 1994; Sharma & Patterson, 2000; Santoro & Saparito, 2003; Lages et al., 2005; Hoegl & Wagner, 2005; Massey & Kyriazis, 2007), commitment (Sharma & Patterson, 2000; Abd Rahman & Bennett, 2009; Zillich et al., 2005; Ruppel & Harrington, 2000), decision synchronization (Baggs, 1994; Hurley & Hult, 1998; Vachon & Klassen, 2008; and Cao & Zhang, 2011)., and resource sharing (Rajagopal, Zailani, & Sulaiman, 2009; Cao & Zhang, 2011). The selection of these variables was based on the frequencies of the measurement of collaborations by authors. A 42-item scale was used to measure ICC in this research.

Market performance

Market performance was measured using five items. The studies carried out by Luca & Atuahene-Gima (2007), Lin et al., (2009) and Lai et al., (2012) were referred to, where they utilized two items to measure market performance, namely market share and sales volume. In addition, Cousin & Lawson (2007) added time as one of the items for measuring market performance. A sample of the items for customer acceptance was adapted from Lai et al., (2012) and Barczak et al., (2008). These two authors also included customer satisfaction as one more item for measuring market performance, and this item was also adapted from another author, Lin et al., (2009). One additional author, Yao et al., also used sales goal as one of the items of measurement.

Innovation survival

In this research, innovation survival was defined as how long the innovation was sustained in the market. This definition was based on the study by Astebro & Michela (2005). According to their study, the success of innovation can be measured by whether the product reaches the market (commercialization), how long the product remains on the market (survival), and any yearly profit. This study measured innovation survival using 3 dimensions taken from a study done by Astebro & Michela (2005). All constructs in this study employed seven-point Likert scale, ranging from 1 strongly disagree to 7 strongly agree. The rational of applying the seven-point scale is to overcome the central tendency error (Cooper & Schindler, 2003).

Validity and Reliability Test

A conformity factor analysis was employed to assess the reliability (Cronbach's α and composite reliability) and validity (convergent and discriminant) of the model. Following the procedures recommended by [17], the assessment of the reliability test for the measurement model was conducted which included all the reflective constructs and their associated manifest indicators. Results of calculations of the item loadings, composite reliability, and average variance extracted (AVE) indicated satisfactory reliability at the construct level, using the conventional threshold criteria of 0.5, 0.6, 0.7 and 0.708 for loadings, 0.7 for composite reliability and 0.5 for AVE [18], [19]. These results showed a strong and consistent relationship between each set of items and their latent variable. The PLS generated factor loadings for each scale indicator, which could be used to assess the measurement model. The matrix shows that most of the factor loadings were greater than 0.5, 0.6, 0.7 and 0.708 as recommended by [19]. The factor loading must exceed 0.708 for the factor to account for fifty percent of the variance of the variable. [19], suggested that when the loading is below 0.4, the item should be deleted. From the result, two items were deleted. For this case, the composite reliability and AVE were above the suggested threshold value of 0.5. Therefore, all these items were retained for the hypothesis testing. It can be concluded that all the constructs exhibited good internal consistency based on loading, composite reliability and AVE.

The second method was proposed by [18], and is a more stringent approach to assessing discriminant validity. They recommended that the square root of the AVE of each construct should be greater than its highest correlation with any other construct. The results of AVEs were higher than the squared inter-construct correlations, which suggested satisfactory discriminant validity for all the reflective constructs.

Table. 1 AVE and CR Results

Construct	Average Variance Extracted (AVE)	Composite Reliability
Degree of Innovation Uncertainty	0.620	0.863
Degree of Innovation Asset Specificity	0.552	0.860
Collaboration	0.768	0.959
Market Performance	0.781	0.947
Innovation Survival	0.596	0.935

III. RESULT

The criteria used for the assessment of the structural model in this study were, estimation of path coefficient (β), coefficient of determination (R^2) and blindfolding [19]–[21].

Table. 2 Hypotheses Results

Relationship	Std Beta	Std Error	t-value
Degree of Innovation Uncertainty -> Collaboration -> Market Performance	0.313	0.065	4.832**
Degree of Innovation Asset Specificity -> Collaboration-> Market Performance	0.228	0.055	4.123**
Degree of Innovation Uncertainty -> Collaboration -> Innovation Survival	0.324	0.072	4.527**
Degree of Innovation Asset Specificity -> Collaboration -> Innovation Survival	0.236	0.058	4.097**

Based on the analysis, its shows clearly in Table 2 that collaboration was influenced directly by the degree of innovation uncertainty (β = 0.350, t = 4.976) and the degree of innovation asset specificity (β=0.479, t=5.356). As a result, hypothesis 1 and hypothesis 2 were supported. The results also indicate that market performance and innovation survival were influenced directly by the innovation commercialization performance, where (β=0.340, t=3.296) and (β=0.653, t=8.367). Thus, hypotheses 3 and 4 were supported.

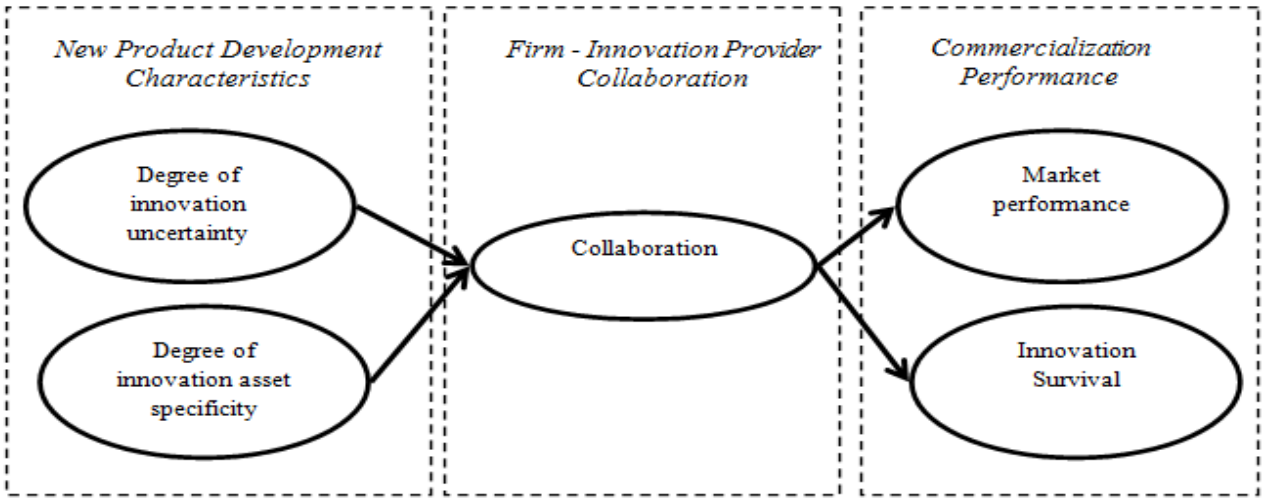

Fig. 1 Conceptual Framework

For the next research objective, the mediating effect of collaboration, the bootstrapping method of the indirect effect by [22], [23] was applied. The bootstrapping analysis illustrated in Table 3 shows that the indirect effect of H5, β = 0.313 (0.479*0.653) was significant with a t-value of 4.832; H6, β = 0.228 (0.350*0.653) was significant with a t-value 4.123; H7, β = 0.324 (0.479*0.340) was significant with a t-value of 4.527 and ultimately H8, β= 0.236 (0.350*0.340) was significant with a t-value of 4.097.

Hypotheses	Relationship	Std Beta	Std Error	t-value
H1	Degree of Innovation Uncertainty -> Collaboration	0.35	0.07	4.98**
H2	Degree of Innovation Asset Specificity -> Collaboration	0.48	0.09	5.36**
H3	Collaboration -> Market Performance	0.65	0.10	8.37**
H4	Collaboration -> Innovation Survival	0.34	0.08	3.30**

Table. 3 Summary of Mediating Analysis

Also, as indicated by Preacher and Hayes [22], the results shows all relationships did not straddle a zero in between, indicating there was mediation. For H5, the results indicated the indirect effect of 0.313, with 95 per cent, Boot CI: [LL = 0.145, UL = 0.413]; for H6, 0.028, 95 per cent, Boot CI: [LL = 0.134, UL = 0.353]; for H7, 0.324, 95 per cent, Boot CI: [LL = 0.136, UL = 0.430]; and for H8, 0.236, 95 per cent Boot CI: [LL = 0.139, UL = 0.369]. Therefore, it could be concluded that the mediation effect was statistically significant, thus indicating that hypotheses H5, H6, H7 and H8 were supported.

Table. 4 Confident Interval Bias Correlated

Relationship	Std Beta	2.50%	97.50%
Degree of Innovation Uncertainty -> Market Performance	0.313	0.145	0.413
Degree of Innovation Asset Specificity -> Market Performance	0.228	0.134	0.353
Degree of Innovation Uncertainty -> Innovation Survival	0.324	0.136	0.430
Degree of Innovation Asset Specificity -> Innovation Survival	0.236	0.139	0.369

III. DISCUSSION

The goal of this study was to investigate the commercialization performance benefit of the involving innovation provider in the commercialization process. This study found that a high degree of innovation market and technological uncertainties had a significant influence on the decision of Malaysian firms regarding the collaboration governance structure. This situation may be affected when the firms are more uncertain about the manufacturing process of the acquired innovation, as the original design came from the innovator, and about the user demand for the innovation since the product is new. Therefore, firms are more likely to collaborate with the innovation provider. Since most of

these companies are SMEs and 58 per cent of new products are new to the existing market, it is obvious that these firms intend to secure themselves and assume lower risks by choosing to collaborate with the innovation provider to protect their needs and limit their exposure to risks.

The next objective of this study was to examine the relationship between innovation asset specificity and collaboration. For SMEs specifically, and also some of the large companies, a certain amount of investment is made purposely to set up new equipment and facilities as the innovation, which is totally new to the existing market, is the most important and influential consideration when it is acquired. Other important specific assets which are also considered as important are the new skills, training and staff that are needed in order for the firm to protect itself from the risk of failure. Therefore, all these specific assets apparently impact the decisions of Malaysian companies on the collaboration governance structure. Being SMEs, most of the companies in operation are small-sized firms with a small number of employees, whose skills with regard to the newly-acquired innovation are still limited, where they need training and support from the innovation provider. Collaboration was one of the governance structures adopted from the transactional cost economics (TCE) theory. The final results showed that collaboration has a positive significant effect on market performance. This result provides some insights into how the innovator collaboration structure affects the new product market. Effective collaboration between the firm and the innovator is the key factor for manufacturers to achieve market performance.

As shown by the total effects, collaboration had a positive significant effect on innovation survival. From the systematic literature review on prior researches [24], no empirical tests were conducted to test the relationship between these two variables. However, based on an article written by [25], it was claimed that innovation success outcomes are not only about market performance and yearly profits. There are other success outcomes which have not been explored much in empirical terms. Therefore, considering how long the products will survive in the market will give some new insights to the research field of innovation commercialization. Additionally, these authors also explained the benefits of using these success criteria separately. One such benefit is that the researcher can learn more about the drivers of total returns. Based on the benefits and the opportunities for contribution, this study confidently states that it was worthwhile to study the relationship.

Four hypotheses were developed to test whether collaboration mediates the relationship between the latent variable of new product development (NPD) characteristics (degree of innovation uncertainty and degree of innovation asset specificity) and commercialization performance (market performance and innovation survival). All four hypotheses were tested and confirmed. When the indirect effects of the degree of innovation uncertainty and the degree of innovation asset specificity through collaboration were included, the total indirect effects showed positive significant results. This suggested that collaboration mediated the relationship between degree of innovation uncertainty and degree of innovation asset specificity towards market performance as well as innovation survival.

IV. CONCLUSION

This study was aimed at addressing antecedence and consequence of collaboration by developing and testing a structural model of collaboration towards commercialization performance. Collaboration between the innovation provider and firm that acquired the innovation was observed to have had a significant impact on commercialization performance (i.e., market performance and innovation survival). Even though previous studies have shown that collaboration has a significant effect on innovation performance, however, this study extended the research by developing a new measure for collaboration and by considering innovation survival as a commercialization performance item. Under the lens of TCE theory, this study suggest that when the technology and market uncertainties are high, collaboration with innovator can help to ensure that their designed product is manufactured and commercialized in the right manner. Similarly, large firms that have acquired new products which are unfamiliar to the market still have to incur some transaction costs in terms of investments in the acquired innovation. Thus, by collaborating with the innovation provider, they can lower the risk in terms of their investments and low asset specificity. Within the context of technology transfer between the innovation acquiring firms and the innovator, one of the important findings from this study is that collaboration facilitate the relationship between NPD (innovation uncertainty and innovation specificity) with both market performance and innovation survival. Having the innovation provider together at this stage could help firms to continuously improve their acquired innovation. For instance, when the innovator shares all the information concerning the innovation, this can reduce the failure rate of the product when it comes to the manufacturing and commercialization process. Continuous communication from time to time between the firm and the innovator can also improve the quality of the product by identifying problems regarding the product design or safety. Thus, the chances of the product surviving in the market are higher.

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APPENDIX 1

Item		Loadings
Indicate your level of agreement with the following statement related to New Product Development (NPD) characteristics *(1=Strongly disagree.... 7=Strongly Agree)*		
Degree of Innovation Uncertainty	We were confident that this innovation was done to how it should be done	0.925
	We were confident that this innovation would perform as it was originally designed	0.925
	This innovation was well understood by our firm	0.605
	We were very confident that this innovation would meet user demands	0.635
Degree of Innovation Asset Specificity	We have made major investments in production equipment specifically for this innovation	0.804
	The innovation obtained require unique technical skills	0.772
	If the innovators were to switch to one of our competitors, it would be a big loss to us	0.661
	Innovation obtained takes time, training and energy for worker to gain basic knowledge about the innovation	0.699
	We have recruited additional staff for the sole purpose of managing the new acquired innovation	0.769
COLLABORATION		
Indicate your level of agreement with the following statement related to Collaboration between Innovator and Firm *(1=Strongly disagree.... 7=Strongly Agree)*		
Information Sharing	The innovator openly shared confidential information with us	0.683
	The innovator openly shared true information with us	0.785
	The innovator openly shared complete information with us	0.661

	We rely on innovator for innovation information	0.748
	We inform the innovator in advance of changing needs	0.828
	Innovator frequently shares existing reports and official documents (e.g., manual, models and methodologies) about the innovation with us.	0.847
	Our firm and innovator exchange timely information	0.835
Trust	The innovators are dependable	0.916
	The innovator always keep their word	0.889
	We never worry that the innovator will take advantage with us	0.666
	The innovator act with high transparency and never act opportunistically	0.853
Business Understanding	We understand each other's objectives and process each other	0.841
	The innovator really listen to what we have to say	0.879
	We share the benefits and risks that can be occurred in the process of commercialization	0.763
	The innovator has a good grasp of our organization manufacturing process	0.867
	The innovation provider has a good grasp of our organization manufacturing performance	0.846
Communication	The innovator had continuous interaction during manufacturing of innovation and commercialization process	0.934
	There was extensive formal and informal communication within our organization and innovator	0.934
	The innovator always responded to us and never hesitates to give us as much information as we like to have	0.921
	The innovator provided us with a lot of feedback	0.892
	The innovator and our organization exchanged mail frequently	0.861
	Our communication during NPD manufacturing stage was mainly limited to an interaction at the top-level of our company	0.508
Commitment	The innovator committed to the relationship with our organization	0.894
	The innovator committed to help our firm to increase the efficiency of manufacturing of new innovation	0.892
	The innovator committed to provide after sales service and technical support which has allowed us to manufacture the innovation successfully	0.894
	The innovator was committed to spent time trying to learn how they can help us provide better product	0.657
Decision Synchronization	We jointly planning to anticipate and resolve NPD manufacturing and commercialization-related problems	0.945
	We jointly decide about ways to increase the commercialization performance of the innovation	0.949
	Decision are made based on open discussion and debate of facts	0.903
	The decision making responsibilities for the innovation were shared between us	0.935
	Decision making for this innovation was co-ordinated between us	0.937
Resource Sharing	We use cross-organizational teams frequently for process design and improvement	0.710
	We share technical supports	0.795
	We share equipments (e.g. computers, networks, machine)	0.583
	We pool financial and non-financial resources (e.g. time, money, training)	0.685

	We are allowed to work as a team to resolve problem	0.865
	We are engaged early in the product development phase	0.680
Indicate your level of agreement with the following statement related to commercialization performance *(1=Far below.... 7=Far above)*		
Innovation Survival	The innovation solve a problem, fill a need or satisfy a want for the customer?	0.864
	The demand for the innovation expected to be long term?	0.797
	Customer easily can learn the correct use of the innovation?	0.862
	The appearance of innovation demonstrates desired qualities?	0.892
	This innovation work better than alternatives?	0.833
	This innovation require less servicing or less costly servicing than alternatives?	0.604
	This innovation have a price advantage over its competitors?	0.741
	Innovation may face new competition in the market from other innovation which must be expected to be threatening its market value?	0.760
	The cost and effort of promotion to achieve market acceptance of the innovation in line with expected earnings?	0.730
	The difficulties will be to develop or access distribution channels for the innovation?	0.563
Market Performance	Sales goals	0.860
	Profit goals	0.892
	Customer acceptance	0.926
	Customer satisfaction	0.877
	Market share goals	0.862

APPENDIX 2

COLLABORATION	Loadings
Information Sharing	0.889
Trust	0.729
Business Understanding	0.899
Communication	0.912
Commitment	0.876
Decision Synchronization	0.872
Resource Sharing	0.891