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A Correlation-Based Impact Analysis of Competence Utilization on Innovation Performance

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Abstract

This paper introduces the concept of competence utilization in the context of innovation. For some time now, its conceptualization has become a preferred foundation for theory building in other fields, but not in the field of innovation. For this reason, an investigative study is proposed to hypothesize, quantify and validate the role of competence utilization in innovation using a correlation-based impact analysis. In particular, the study assesses the impact of competence utilization on innovation performance by testing three hypotheses. Data was collected, over a three-month period, via a survey questionnaire to extract *ex post facto* information from firms in Singapore. The firms were selected from three industry sectors by stratified random sampling. Non-parametric statistics were employed to test the three hypotheses.

The results showed that the impact of competence utilization on innovation performance, as indicated by the extent of availability, utility and desirability, was found to be statistically significant. The research findings are: Firstly, the level of utilization in technology competence, product competence and market competence, as manifested in innovation activities, is positively correlated to the level of innovation performance, as quantified by sales profitability, company growth and organizational effectiveness. Secondly, the impact of competence utilization is the strongest on sales profitability followed by company growth and then organizational effectiveness. Thirdly, in terms of relative effectiveness, as ranked by the impact on innovation performance, technology competence is the most effective while product competence is less effective; and market competence is the least effective. In conclusion, three areas of future research are recommended to further deepen the field of study.

Keywords:
Competence Utilization; Innovation Performance; Correlation Analysis; Technology Competence; Product Competence; Market Competence; Sales Profitability; Company Growth and Organizational Effectiveness.

Introduction

The innovation process is highly complex, haphazard, multi-faceted and prone to failure. Yet, firms frequently engage in innovation activities to maximize business performance. Descriptive evidence has shown that innovation activities constitute growth agents for firms in general, but research has continually produced diverse results (D' Amboise and Muldowney, 1988; Damanpour, 1991). Studies have also revealed that critical factors that result in innovation success tend to be mutually exclusive from those critical factors which cause innovation failure. Interestingly, those factors that lead to innovation success are predominantly internal to firms (Thomas and Evanson, 1987; Shailer, 1989; Kelmar, 1994; Langlois and Foss, 1999). Given that the body of innovation literature is vast and ever growing, the approaches in research have thus shifted toward analyzing the internal factors of a firm. Amongst the internal factors lies the competence concept whose emergence has generated much awareness due to its relevance in understanding the dynamics of inter-firm competition (Wernerfelt, 1995; Teece, Pisano and Shuen, 1997; Hodgson, 1998). While innovation studies continue to be explanatory and prescriptive, the competence concept has at the same time become an attractive and preferred foundation for theory building in other fields of study (Sanchez, Heene and Thomas, 1996; Durand and Guerra-Vieira, 1997; Giget, 1997). Discussions within the field of innovation management have proposed that competence-based research must gain prominence (Henderson and Cockburn, 1994; Verdin and Williamson, 1994). Recent debate has also argued that whether a firm's efforts will actually lead to better innovation performance depends on the extent to which a firm's competencies are utilized (Filion, 1997; Bogner, Thomas and McGee, 1999). Strategy theorists also claim that a firm's competence constitutes a 'strategic resource' as it creates barriers to entry and weakens the potential threat of new entrants to improve innovation performance (Amit and Schoemaker, 1993; Williamson, 1999).

Since few innovation studies have explicitly focused on the theme of establishing any link with competence utilization, examining its role appears to cast the right-size 'conceptual net' to explore the 'sea' of competitive interactions occurring amongst firms (Barney, 1996; Subramanian and Nilakanta, 1996). To establish insights into the role of competence utilization in innovation, the approach of this study falls under the category of concept development, theory exploration and hypothesis generation. Empirically, the study conducts an analysis of measures involving constructs and associated variables to assess the impact of competence utilization on innovation performance. The objective of this study aims to address the following research questions:

1. Which competencies are relevant and applicable to a firm for utilization that may result in innovation success?
2. Is the role of competence utilization, if employed by a firm, important to innovation performance?
3. To what extent does competence utilization influence a firm's innovation performance?
4. Which of the competencies identified in (a), in comparison, are more influential in terms of the impact on a firm's innovation performance?

Literature Review

The apparent lack of competence-based innovation research can be attributed to the Schumpeterian (1965) view of the innovation process – where it exists a perceived

preoccupation with discontinuities and creative destruction due to the perspectives of product life cycles and hence product obsolescence. The conventional view that innovations undergo a finite life cycle leading to eventual obsolescence might have compromised the explanatory power surrounding the role of competence utilization which resides in firms (Grossman and Helpman, 1992). Recently, an idea termed competence utilization stands at the heart of strategic management thinking as it alleges to reflect more accurately the dynamics of competition and the competitive interactions occurring in innovation (Bogner, Thomas and McGee, 1999). Of the contemporary writings relating to competence utilization, three streams of literature seem to capture preliminary insights, namely: (a) the resource-based theory of the firm, (b) organizational learning and knowledge management, and (c) the impact of environmental change.

Firstly, the resource-based theory, which is inherently an internal view of a firm, is concerned with attaining competitive advantage over rival firms. Originally, the theory has its foundations in international trade to explain why and how nations trade because of resource endowments. Subsequently, different thinking approaches, though essentially centred on the resource-based theory, are employed to explain firm growth in relation to resource constraints such as labour and physical inputs and financial capital (Mahoney and Pandian, 1992). Since then, these approaches have broadened to examine the function of internal resources in terms of a firm's competencies to compete effectively (Barney, 1996). On the basis of the resource-based theory, researchers argue that the possession, allocation and deployment of internal resources are linked to competence utilization, whose impact provides distinct value to firms as a form of endogenous capability (Grant, 1991). In addition, the resource-based theory implies that the 'scarcity' of a firm's competencies lead to difficulties for any competitor to imitate, substitute for, or surpass a firm's innovation performance as competence utilization enables the firm to gain a competitive edge.

Secondly, the fields of organizational learning and knowledge management also offered insights into the conceptualization of the competence utilization (Huber, 1991; Helfat, 1994; Grant, 1996). On the one hand, organizational learning allows a firm to maximize its innovation performance from the role of competence utilization, thus giving a firm competitive advantage over rival firms (Fiol and Lyles, 1985; Helleloid and Simonin, 1994; Spender, 1996). So a firm must, to sustain its competitive advantage and hence achieve better innovation performance, continually engage in organizational learning by competence utilization (Nonaka, 1994). On the other hand, knowledge management literature suggests the need to identify the elemental components and interactions of activities involved in innovation; and until and unless they are studied, it remains difficult to know what gives rise to better innovation performance. The elemental component and interaction that both the fields of organizational learning and knowledge management appeared to be mutually common, insofar as competitive advantage was concerned, seems to be competence utilization and its relation to innovation performance (Garud and Nayar, 1994; Helfat, 1994; Spender, 1996).

Thirdly, another stream of literature argues that a firm selects an environmental change which provides it with the opportunity to utilize its competencies and hence able to compete more effectively (Tushman and Anderson, 1986; Meyer, Brooks and Goes, 1990). Basically, there are two kinds of environmental change termed 'competence-enhancing' change and 'competence-destroying' change. The former is continual, gradual whereby evolutionary processes are experienced, while the latter is revolutionary and radical whereby adaptive processes are encountered. Competence-enhancing change results in selection of an environment consistent with existing competencies that a firm already possesses. A change of this nature

gives the firm opportunity what it does best and thus strengthens its competitive advantage. The more an environment presents such opportunities including those to harness the role of competence utilization in the context of innovation, the more a firm will select the environmental change to surpass competitors (Prahalad and Hamel, 1994). The notion of competence-destroying change, in contrast, implies that a firm's environmental change causes its existing competencies to lose effectiveness and hence the firm's competitive advantage. While environmental selection becomes an important factor to remain competitive, a firm's ability to achieve better innovation performance depends ultimately on the environment it competes. Competence utilization strengthens a firm's competitive advantage and for this reason, a firm will naturally select an environmental change with opportunity to utilize its competencies and thereby innovate effectively. A firm will refrain from a change associated with competence-destroying change if it causes the firm to innovate less effectively and thereby loses its competitive advantage over rivals (Gersick, 1991).

Competence Construct

While it is necessary to advance the competence concept in the field of innovation, what actually constitutes a unit of analysis has remained debatable and disagreement abounds over the best quantitative indicator. Given the need to link the competence concept with the dynamics of competition inherently occurring in innovation, the construct has been criticized for 'failures of operationalization' in empirical research (Day, 1994). The competence concept embraces not only all forms of available capabilities, knowledge, know-how and skills in a firm as most literature would suggest, but also assets that contribute to a firm's competitive potential (Sanchez, Heene and Thomas, 1996; Mosakowski and McKelvey, 1997). Although references to a firm's numerous internal resources were frequently made, the concept was also applied with a holistic notion wherein lies acquired expertise or proficiency in executing complex tasks. To illustrate this point based on works that dealt with the body of knowledge, the debate on the competence construct continues to be discursive as stated below:

> Focusing on human characteristic(s) rather than on firms, Boyatzis (1982) defines competence as 'an underlying characteristic of a person whether it may be a motive, trait or an aspect of one's role or a body of knowledge that he or she uses'. Without specifying exactly what a competence is, Woodruffe (1990) provided a narrower definition of competence as 'behavioral dimensions that affect performance' to emphasize the importance of behavioral elements regardless of how and where the dimensions originate from. To make sense of a multitude of the dimensions related to competencies, Spencer and Spencer (1993) suggest a generalized approach of grouping competencies into clusters resulting in a more generic conceptualization.

Other pioneering works championed by an increasing number of authors have consciously referred their works on competence as lying within the confines of a 'capabilities', 'dynamic capabilities' or 'core competencies' (Langlois and Foss, 1999, Williamson, 1999). The decomposition of the competence construct into categories yielded disparate results, due primarily to the fact that it is embedded within a firm's unique routines and is tacit in nature. The competence construct, to a large extent, is difficult to be measured as precise quantitative data, and being multi-dimensional, the problems associated with developing an accurate construct are, in part, a direct result of the generality that the concept connotes. The operationalization of the competence construct hence hinges on the supporting logic to identify dimensions recognizable in practice (Sastry, 1997; Hodgson, 1998).

The actual forms of competence, as allegedly utilized in the implementation of any innovation activity, are widely varied and situation-specific. Specifications of all competencies required in innovation are extensive and diverse. Also, it is less feasible to evaluate analytically, competence by competence, since the critical issue is concerned with how a firm can implement an effective innovation based on a portfolio of competence dimensions. Without the need to embark on a huge undertaking of categorizing all competencies, these dimensions are identifiable and as such, can be characterized broadly. Studies analyzing overly numerous competence dimensions tend to encounter 'causal ambiguity' that produces 'weak theories', especially for insensitive dimensions (Verdin and Williamson, 1994; Hodgson, 1998). Including more competence variables may thus not necessarily be superior for research purpose because all theory building requires some degree of parsimony and the competence construct should be sufficiently generic to develop more complete theories (Durand, 1997; Williamson, 1999). Incorporating myriad variables may result in model over-fitting with substantial multi-collinearity amongst different variables. Although fitting numerous variables within a model can be highly accurate for explaining the sample data, it is less predictive for the population data. On the other hand, having too few variables to represent the competence construct may introduce unintended biases that lead to statistically large generalization error. Despite the need to strike a balance for a practical number of variables, one issue stays unarguably consistent. That is, competence, albeit intangible and intricate to measure, should be linked to innovation performance with its dimensions being causally related to the latter; and the attainment of innovation performance correlates with the measure in these dimensions (Dean and Sharfman, 1996).

Hence, to ensure that the competence concept is theoretically significant and experimentally measurable, this study deliberately refrains from a comprehensive classification but uses an objective treatment of generic dimensions covering most situations based on a practical domain of content (Durand, 1997; Mahoney and Sanchez (1997). To reduce the wide range of competencies to a limited set, the competence dimensions are identified through a literature review by 'distilling' through those that are most relevant, applicable and valid. Paying attention to a 'portfolio' of dimensions that are expected to influence innovation performance, competence utilization seems to be dispersed along three traditionally held dimensions. Using these dimensions as guidelines for variable selection, innovation literature also revealed characteristically three variables: technology competence (TECHCOMP), product competence (PRODCOMP), and market competence (MARKCOMP) for observing the role of competence utilization. These three dimensions are considered as providing a more complete, integrated and synthesized view of a firm's role of competence utilization in innovation and yet applicable for alternate and simultaneous use.

With an appropriate research design, empirical data of competence variables may be collected from multiple firms to offer relative, distinguishable and inter-firm comparisons of measurement. To gather quantifiable data for the competence construct based on managerial experience of firms via a survey instrument, three kinds of questions are posed to identified 'subjects' on: (a) actual utility; (b) availability and usefulness; and (c) desirability. Subjects who replied to the survey instrument subsequently become 'respondents' and the research results are analyzed using data collected from these respondents.

First, the respondents are required to reply as a binary option whether their firms are involved in the role of competence utilization when implementing innovation activities.

Second, respondents are requested to indicate their firm's level of competence utilization ranging from basic to intermediate to advanced levels on a Likert scale, as empirical evidence of availability and usefulness.

Third, respondents are asked to rate the extent of desirability for the three dimensions of the competence construct in terms of, whether it is important for innovation.

Higher scores are associated with higher levels, that is, a greater extent to which a firm experiences, utilizes and desires, in terms of measures, for the three dimensions of competence. Likewise, lower scores are associated with lower levels, to which a firm experiences, utilizes or desires for the measure of a particular competence dimension.

Innovation Performance Construct

The primary objective of competence utilization in any innovation activity is linked to achieving higher levels of innovation performance (Helleloid and Simonin, 1994). Despite the importance of quantifying the innovation performance construct, what constitutes a suitable measure has been a subject of intense debate (Venkatraman and Ramanujam, 1986; Eisenhardt and Bourgeois, 1988). For instance, studies have applied a simple concept of binary indicators (such as success or failure) to quantify the construct. At the same time, opposing views were expressed, offering arguments in conflict with quantifying the innovation performance construct along the same continuum as binary indicators. It was disputed that such a conception for measuring the construct as either success or failure appears to be theoretically fallible because the measure does not present itself at two ends of a continuum. Instead, a multi-factorial approach gives a more representative, reliable and practical measure of the innovation performance construct, implying that it should be at least two-dimensional mathematically (Kelmar, 1994).

Consensus towards a multi-variate measure of innovation performance has become increasingly more apparent. On the one hand, conventional measures employ financial indicators (sales growth, return on investment and sales profits, for example) to rate innovation performance (Venkatraman and Ramanujam, 1986). Yet, on the other hand, cost-based measures alone do not adequately quantify the outcomes attributable to competence utilization (Hart, 1992; Bruns and McKinnon, 1994). Arguments prevail that if one quantifies the innovation performance construct around financial indicators but fails to incorporate parameters that reflect other firms' goals, the 'chain of causality' in hypothesis testing tends to be potentially weak. Hence, this study proposes a broader conceptualization of the innovation performance construct to include indicators other than purely financial ones, taking into account other quantifiable indicators of organizational outcomes (Ramanujam and Venkatraman, 1987; Cooper and Gascon, 1992). Obviously, if a singular variable is employed, then the data measurements must be accurate to a high precision. Otherwise, the results of any analysis based on these data measurements will be less reliable even if the tests are highly rigorous. For this reason, multivariate information of the innovation performance construct should be considered although it is recognized that, in practice, difficulties are often encountered in gathering innovation performance data, given that firms hesitate in providing answers related to a firm's innovation activities. Also, while innovation performance measures seem to be traditionally confined to profitability-related factors, it is also judicious in research to consider both quantitative and qualitative criteria.

Hence, objective and subjective measures of innovation performance should be incorporated even though data precision may be slightly compromised. In this study, the variables for the innovation performance construct are quantified in two ways: firstly, by objective self-reported financial variable(s); and secondly, by subjective self-evaluated satisfaction level concerning non-financial variable(s) to afford greater reliability to the data collected. Selected through a purification process based on validity appearance in innovation literature, the variables for analysis comprise: (a) sales profitability (SALPROF); (b) company growth (COGRWTH); and (c) organizational effectiveness (ORGEFFN).

Hypothesis Development

One important part of this research focuses on the development of hypothesis, which relies on data, to be extracted from firms involved in innovation activities, to draw conclusions. Hypothetically, the study conjectures that a firm's innovation performance may be attributable to the role of competence utilization by assessing statistical consistency on the correlations between measures of competence variables (TECHCOMP, PRODCOMP, MARKCOMP) and measures of innovation performance variables (SALPROF, COGRWTH, ORDEFFN). To evaluate the degree of statistical consistency, hypotheses are tested to determine whether the competence construct is positively correlated to the innovation performance construct. Towards this end, hypothesis testing analyzes the extent to which competence utilization, as evidently manifested in the context of innovation, correlates to a firm's innovation performance. Three hypotheses are developed for testing as follows:

Hypothesis 1 (H1):	Innovation performance (SALPROF, COGRWTH, ORGEFFN) will be higher for those with a higher measure of technology competence, than for those with a lower measure of technology competence (TECHCOMP).
Hypothesis 2 (H2):	Innovation performance (SALPROF, COGRWTH, ORGEFFN) will be higher for those with a higher measure of product competence, than for those with a lower measure of product competence (PRODCOMP).
Hypothesis 3 (H3):	Innovation performance (SALPROF, COGRWTH, ORGEFFN) will be higher for those with a higher measure of market competence, than for those with a lower measure of market competence (MARKCOMP).

Since ordinal data can be used for non-parametric hypothesis testing, measures for both competence variables and innovation performance variables employ rank statistics to satisfy the mathematical requirements of ordinal scaling. Of all the non-parametric statistical tests, the Spearman rank-order correlation test is chosen, as it is one of the most powerful tests developed (Siegel and Castella, 1988). Based on a measure of association between two constructs, a pair-wise comparison between variables is made by calculating the Spearman correlation coefficients using rank statistics of two ordered series of the constructs. Statistical results of hypothesis testing are reported at the conventional 5% level of significance unless otherwise stated.

Proxied by respondents' opinions to a mail survey, responses measured on binary (YES or NO) and 7-point Likert scales are used to quantify empirical data. Responses to the survey questions on innovation performance construct, measured by both objective and subjective self-evaluated data, are reported on a Likert-type

scale to detect variability of measurement. For the analysis of competence variables, items that are selected with a score of four or more on the 7-point Likert scale are considered empirical evidence of 'utilization'. If nominal statistics are required for a construct on an ordinal scale, observed scores on a Likert-type scale may be converted to form categories for a nominal scale (NO or 0 for levels 1 to 3 and YES or 1 for levels 4 to 7, for example). The validity of hypothesized relationship(s) between the competence variables (TECHCOMP, PRODCOMP, MARKCOMP) and the innovation performance variables (SALPROF, COGRWTH, ORGEFFN) is demonstrated by any evidence of statistical support based on the test results of pair-wise correlation test using Spearman rank-order statistics.

Research Methodology

Due to the paucity of established data collection methods in measuring the phenomenon of competence utilization, it becomes apparent that one needs to work on, *inter alia*, an appropriate research methodology to avoid being beleaguered by data problems. To address any inherent weaknesses encountered that may yield less reliable results in hypothesis testing, trade-offs were made to strike a balance amongst factors relating to speed, cost and control. Given that greater immersion of empirical data does not necessarily lead to better results, a three-stage sampling plan is designed to select suitable sample firms, which suit the approach of hypothesis testing, as a representation of the population. The first stage selects the industry sectors to implement a cross-sectional study of firms, and the second stage involves a randomized selection of firms to be studied, while the third stage constitutes the collection of data from selected firms.

To accomplish data collection within several months, it does not make sense to conduct a longitudinal study that involves gathering data from a few subjects and then wait for sufficient data to be accumulated over an extended period of time, which may take some years to complete. Instead, the sampling plan is devised to: (a) strengthen the reliability of the empirical data; (b) improve the homogeneity of the sample firms; (c) enhance the availability of data measures; and (d) enable respondents who are likely to possess the most relevant knowledge to provide answers to the survey. With all firms resident in Singapore as the population base and sampling techniques suggested by Kish (1965) and Tortora (1978), the research methodology covers the following areas: (a) Selection of Industry Sectors, (b) Random Sampling, and (c) Data Collection.

Selection of Industry Sectors

The role of competence utilization is by no means limited to any particular industry sector. It is also ostensibly difficult to distinguish the effects of innovation performance across industry sectors. For example, differences in firm characteristics exist between industry factors such as rate of growth (McGrath and Maxmillan, 1992). However, the loss of prospective respondents, caused by placing unnecessary restrictions on industry sectors, cannot be justified both theoretically and empirically. Firms under study constitute those registered in Singapore with no attempt made to measure industry factors as the contextual elements are principally similar since they are all subject to the same legal, political, social, cultural, economic and demographic environment within a single national economy. Firms are chosen from three industry sectors: (a) electronics and electrical equipment and components; (b) information technology and computer equipment; and (c) multimedia products, as these sectors are widely acknowledged to be experiencing a flourish of new innovations globally including Singapore.

Apart from sampling a cross-section of Singapore registered firms in these three industry sectors, a gestation period is imposed to allow for the effects of the phenomenon under study to be experienced and hence improve the overall reliability of the 'historical data' provided by firms. This gestation period is bounded above and below by the time lengths of venture creation and innovation life cycle. The majority of studies on venture creation, typically, used a three to six year time horizon while most innovation studies uses a three to five year time horizon, especially in the context of the industry sectors identified. To refrain from imposing an overly long gestation period, only data from firms with at least three years of innovation experience are analyzed.

Random Sampling

The sample consists of selected firms resident in Singapore. Ideally, data should be collected exclusively from those firms with direct and actual experience of the phenomenon under study. Nevertheless, firm selection efforts were hindered by the difficulties associated with identifying such firms, for it is impossible to capture solely these firms to the exclusion of others unless one knows exactly how they can be identified within the population. To obtain representative data, random sampling was preferred over census sampling as the former allows a survey to be conducted at a single point in time so that respondents' opinions are comparable. For this reason, stratified random sampling is used because it tends to be less biased and more reliable for drawing conclusions beyond the sampled data.

Stratified random sampling is structured as a two-step process. First, the population firms were compiled from business directories, electronic company guides, industry contacts and networking referrals. They are then short-listed and separated into non-overlapping groups called sampling frames, consisting of potential subjects that represent the three industry sectors identified. To test whether variances across industries are statistically significant, the number of random sampling units for each industry sector is made equal in size. Second, units are randomly selected from these sampling frames to enable data sources not to be unduly predisposed towards certain groups of firms. Randomization was achieved by the use of a random number generator to select the sampling units. Such a method is generally adequate because the chances of being selected are equal for each sampling unit; and it ensures that the differences in sampling probabilities from beginning to the end of sampling process are negligible.

Data Collection

For data collection, a self-administered survey instrument is used to *explicate ex post facto* information required to test hypotheses. In terms of survey questions, extra attention was paid to balance the need for reliable empirical measures and the potential complications that may arise due to managers' sensitivities when releasing firms' information. A pre-test on 'dummy respondents', carried out over a five-week period, was conducted to check the content validity of the survey instrument. To improve interpretation of survey questions, suggestions from these respondents were incorporated to further refine and modify the wordings used. Designed as a five-part structured questionnaire containing twenty questions, the survey instrument is cost-effective and provides better control and consistency across measurement situations since each respondent answer identical questions.

For mail implementation, a cover letter accompanying the questionnaire was addressed personally to the heads of firms such as Chief Executive Officers, Managing Directors or General Managers as they typically possess the most comprehensive and experiential knowledge about their firms and hence could furnish more reliable and relevant information. A self-addressed, postage-paid, return envelope was also provided to all respondents. The protocol for mail implementation, which was carried out over an eight-week period, involved three major mailings with thank-you notes and replacement surveys to a total of 300 firms. The mailings are conducted in succession to generate progressive encouragement to enable more respondents to participate in the survey. Of the 128 returned questionnaires, 104 were usable as the written answers provided the required information for data analysis, yielding a response rate of 34.7%

Test Results

At the core, the three hypotheses under test are concerned with the conjecture about the role of competence utilization, in terms of effectiveness in innovation activity, to be manifested by its impact on innovation performance. To test the hypotheses, a correlation-based analysis is used to establish statistical significance for the hypothesized relationships; and the analysis correlates measures of competence variables with innovation performance variables to reveal any consistency. The level of utilization is represented by ordinal data, and the inputs of the three competence dimensions are measured by rank statistics. Scores in ordinal data are converted to ranks via frequency counts at each level of utilization, and the ranks of innovation performance are similarly determined. The Spearman rank-order correlation test is employed to measure the extent of correlation between the constructs of competence (TECHCOMP, PRODCOMP, MARKCOMP) and innovation performance (SALPROF, COGRWTH, ORGEFFN). The magnitude of the empirical correlation coefficients between variables provides an indication of the effects on innovation performance attributable to competence utilization. A high correlation is interpreted as reflecting that the role of competence utilization was indeed important; and conversely, a low correlation implies that a given competence dimension, even if utilized, does not enable a firm to innovate effectively to produce positive results in innovation performance. Hence, hypotheses may be rejected or accepted by comparing empirical correlation coefficients, for pair-wise variables between the competence and innovation performance constructs, with critical Spearman statistical values. The results of the Spearman rank-order correlation test for the three hypotheses are reported in turn.

Results of Hypothesis 1

H1 states that innovation performance (SALPROF, COGRWTH, ORGEFFN) of a firm, which engages in innovation activity, will be higher for those with a higher level of utilization in technology competence (TECHCOMP), than for those with a lower level of utilization. To test H1 empirically by ordinal data, the Spearman rank-order correlation test is employed. Classified as a non-parametric statistical test, the Spearman coefficient (r_s) is based on a measure of association between two variables using pair-wise comparison, calculated on the basis of the differences in rank between two ordered series. The null hypothesis of H1 states that if the differences between the two ordered series are small, the correlation is positive or close to one; and if the differences between the two ordered series are large, the correlation will be small or close to zero. If the correlation coefficient r_s between any two variables is equal to or greater than the critical correlation coefficient $r_{s(critical)}$ for a

particular level of significance (α), then H1 is accepted at that level of statistical significance; otherwise, H1 is rejected.

The magnitude of Spearman rank-order correlation coefficients measures the relative importance of TECHCOMP in innovation activity. H1 anticipates that higher rank ratings of utilization in TECHCOMP will produce higher rank ratings of innovation performance. Similarly, at the other end of the ordinal scale, lower rank ratings of utilization in TECHCOMP will result in lower rank ratings of innovation performance. The ordered series of TECHCOMP in relation to innovation performance variables (SALPROF, COGRWTH, ORGEEFN) for computing empirical Spearman correlation coefficients based on differences in rank order, with fractional halves denoting ties between ranks at various levels, are displayed in Table 1.

Table 1: Spearman correlation table (TECHCOMP)

Level	TECHCOMP	SALPROF	dI	COGRWTH	dI	ORGEFFN	dI
1	1.5	1.5	0	1.5	0	1	+0.5
2	3	3	0	1.5	+1.5	3	0
3	1.5	1.5	0	3	-1.5	4	-2.5
4	5	6	-1	7	-2	6	-1
5	7	7	0	6	+1	7	0
6	6	5	+1	5	+1	5	+1
7	4	4	0	4	0	2	+2
		Σdi2 = 2.0		Σdi2 = 10.5		Σdi2 = 12.5	
	rs =	0.9636		0.8091		0.7748	

Direct correlations, determined by empirical Spearman rank-order coefficients, between TECHCOMP and the three innovation performance variables were found to be statistical significant at α=5.0%, with values ranging from 0.7748 to 0.9636. By comparing the magnitude of these coefficients with critical correlation coefficient ($r_{s(critical)}$=0.714 at α=5.0% for N=7), the research results confirmed that TECHCOMP was positively correlated with innovation performance, showing the most pronounced impact on SALPROF (r_s=0.9636, α=5.0%), followed by COGRWTH (r_s=0.8091, α=5.0%) and then finally ORGEFFN (r_s=0.7748, α=5.0%). Additionally, the influences of TECHCOMP on SALPROF and COGRWTH except ORGEFFN were also statistically significant at α=2.5%. Of the three innovation performance variables, the correlation with TECHCOMP was the strongest for SALPROF, followed by COGRWTH and the weakest for ORGEFFN. Overall, the results showed that technology competence utilization was positively correlated to innovation performance; and the magnitude of correlation was in a decreasing order of sales profitability, company growth and organizational effectiveness.

Results of Hypothesis 2

Hypothesis 2 (H2) states that a firm employing competence utilization in innovation activity, will attain a higher level of innovation performance (SALPROF, COGRWTH, ORGEFFN) under a higher measure of product competence (PRODCOMP), than under a lower measure of product competence. This hypothesis essentially evaluates the relative importance of yet another competence variable. A statistically significant correlation for PRODCOMP with innovation performance implies a corresponding significance of its role in innovation.

To test H2 by ordinal data, the Spearman rank-order correlation coefficients (r_s) are calculated to evaluate the measure of association between PRODCOMP and innovation performance variables by pair-wise comparison based on rank statistics of two ordered series. If the r_s values of PRODCOMP with any innovation performance variable are greater than the critical correlation coefficient ($r_{s(critical)}$=0.714 at α=5.0% for N=7), then H2 is accepted; or else H2 is rejected at the 5.0% level of statistical significance (α). If r_s is exactly one, it means that the two variables are positively correlated and the correlation is perfectly significant.

The research results are deemed to be statistically significant if they satisfy the conventionally acceptable level of α=5.0% or at lower values of α. Similarly, identifiable results for H2 at a level of statistical significance other than α=0.05 are also reported, if the significance of correlation at higher α values needs to be established. The ordered series of PRODCOMP in relation to the three innovation performance variables, and the results of Spearman rank-order correlation coefficients in comparison with critical r_s values were shown in Table 2.

Table 2: Spearman correlation table (PRODCOMP)

Level	PRODCOMP	SALPROF	di	COGRWTH	DI	ORGEFFN	di
1	1	1.5	-0.5	1.5	-0.5	1	0
2	3	3	0	1.5	+1.5	3	0
3	2	1.5	+0.5	3	-1	4	-2
4	5	6	-1	7	-2	6	-1
5	6	7	-1	6	0	7	-1
6	7	5	+2	5	+2	5	+2
7	4	4	0	4	0	2	+2
		Σdi2 = 6.5		Σdi2 = 11.5		Σdi2 = 14.0	
	rs =	0.8829		0.7928		0.7748	

According to the research results based on empirical values of product competence and innovation performance variables, the magnitude of the Spearman coefficients were compared with the critical correlation coefficient ($r_{s(critical)}$ = 0.714 at α=5.0% for N=7). The research results, based on a two-tailed Spearman rank order test, revealed that PRODCOMP was positively correlated to all the three innovation performance variables, with the largest influence on SALPROF (r_s=0.8829, α=5.0%), followed by COGRWTH (r_s=0.7928, α=5.0%) and the smallest influence on ORGEFFN (r_s=0.7748, α=5.0%). Consistently, the research findings showed that competence utilization in PRODCOMP was positively correlated to innovation performance, in descending order of SALPROF, COGRWTH and ORGEFFN. It was thus concluded that the analysis further provided empirical evidence to support H2, affirming that competence utilization of PRODCOMP was important in innovation activities, whose correlations with the three innovation performance variables were all shown to be statistically significant.

Results of Hypothesis 3

Hypothesis 3 (H3) states that when a firm engages in innovation activity, its innovation performance (SALPROF, COGRWTH, ORGEFFN) will be higher for those with a higher measure of utilization in market competence, than for those with a lower measure of utilization in market competence (MARKCOMP). Similar with the tests of H1 and H2, if the empirical Spearman rank-order correlation coefficients (or r_s values)

between MARKCOMP and innovation performance variables are greater than the critical correlation coefficient ($r_{s(critical)}$=0.714 at α=5.0% for N=7), then H3 is accepted; otherwise, H3 is rejected. Based on pair-wise comparison between two variables, the rank statistics of these variables were computed to determine the magnitude of empirical Spearman rank-order correlation coefficients. The ordered series of MARKCOMP with the three innovation performance variables for calculating Spearman coefficients based on differences in rank order, with fractional halves denoting ties between ranks at various levels were shown in Table 3.

Table 3: Spearman correlation table (MARKCOMP)

Level	MARKCOMP	SALPROF	di	COGRWTH	dI	ORGEFFN	di
1	1	1.5	-0.5	1.5	-0.5	1	0
2	2	3	-1	1.5	+0.5	3	-1
3	3	1.5	+1.5	3	0	4	-1
4	4	6	-2	7	-3	6	-2
5	7	7	0	6	+1	7	0
6	6	5	+1	5	+1	5	+1
7	5	4	+1	4	+1	2	+3
		Σdi2 = 9.5		Σdi2 = 12.5		Σdi2 = 16.0	
	rs =	0.8289		0.7748		0.7143	

According to the magnitude of empirical Spearman rank-order coefficients, MARKCOMP was found to be positively correlated to the innovation performance construct, with the largest impact on SALPROF (r_s=0.8289, α=5.0%), followed by COGRWTH (r_s=0.7748, α=5.0%) and the smallest impact on ORGEFFN (r_s=0.7143, α=5.0%), lending support to H3. Overall, the test results were consistent, indicating a positive correlation between MARKCOMP and innovation performance to manifest the role of market competence utilization in innovation strategy. Furthermore, it was observed that, amongst the innovation performance variables, the correlations of MARKCOMP were in descending order of SALPROF, COGRWTH and ORGEFFN.

The Spearman rank-order correlation coefficients between competence variables and innovation performance variables for the three hypotheses (H1, H2, H3) are summarized in Table 4 as an inter-correlation matrix of pair-wise variables.

Table 4: Spearman rank-order correlation coefficients (r_s) between competence and innovation performance

SPEARMAN RANK-ORDER CORRELATION COEFFICIENT (rs)		INNOVATION PERFORMANCE		
		SALPROF	COGRWTH	ORGEFFN
Competence	TECHCOMP	0.9636	0.8091	0.7748
	PRODCOMP	0.8829	0.7928	0.7500
	MARKCOMP	0.8289	0.7748	0.7143

Note: All the Spearman rank-order correlation coefficients are statistically significant at α=5.0%.

Summary

All nine empirical Spearman rank-order coefficients were found to be statistically significant at α=5.0% affirming that TECHCOMP, PRODCOMP and MARKCOMP constitute competencies, which are relevant and applicable for the implementation of innovation activities. Out of the nine coefficients, the results showed that the extent of correlation between TECHCOMP and SALPROF (r_s=0.9636, α=5.0%) was the strongest, while the extent of correlation between MARKCOMP and ORGEFFN (r_s=0.7143, α=5.0%) was the weakest. Overall, the role of competence utilization was determined to be of importance in the context of innovation.

Of the correlations between TECHCOMP and innovation performance variables, the one with ORGEFFN (r_s=0.7748, α=5.0%), in comparison, demonstrated the lowest measure of association. Two (SALPROF and COGRWTH) of the three Spearman rank-order coefficients were also statistically significant at α=2.5% ($r_{s(critical)}$=0.786 for N=7), with that of ORGEFFN falling short by less than 1.5% of $r_{s(critical)}$, thus lending support for accepting H1. The correlation between TECHCOMP and SALPROF was also statistically significant at α=1.0% ($r_{s(critical)}$=0.893 for N=7).

For PRODCOMP, the Spearman rank-order correlation coefficients with the innovation performance variables ranged from 0.7500 to 0.8829. A similar pattern of correlation in descending order of SALPROF, COGRWTH, ORGEFFN was evident. Besides being statistically significant at α=5.0% since all the three Spearman coefficients exceeded the critical correlation coefficient ($r_{s(critical)}$=0.714 for N=7), the same two innovation performance variables (SALPROF and COGRWTH) were also statistically significant at α=2.5%. The largest Spearman correlation coefficient for PRODCOMP (with SALPROF) was marginally less than the critical r_s of 0.893 ($r_{s(critical)}$ at α=1.0% for N=7) by only 1.2%. No direct correlation between PRODCOMP and any innovation performance variable was reported to be statistically significant at α=1.0%.

In the case of MARKCOMP, with Spearman rank-order coefficients ranging from 0.7143 to 0.8289, all the correlations for the three innovation performance variables were statistically significant at α=5.0%. The same pattern, in decreasing order of correlation from SALPROF to COGRWTH to ORGEFFN, was detected. However, in comparison with TECHCOMP and PRODCOMP, only the correlation with SALPROF exceeded the critical r_s of 0.786 (for N=7) at α=2.5%.

Amongst the innovation performance variables, correlation was the strongest for SALPROF compared with COGRWTH and ORGEFFN. From TECHCOMP to PRODCOMP to MARKCOMP, the correlations with SALPROF were in decreasing order from 0.9636 to 0.8289 and were all statistically significant at α=2.5%, with that of TECHCOMP even achieving statistical significance even at α=1.0%. Following a similar trend, the correlations of COGRWTH with competence dimensions were in decreasing order of TECHCOMP, PRODCOMP, MARKCOMP, dropping from 0.8091 to 0.7748. All the Spearman coefficients for COGRWTH were statistically significant at α=5.0%, with that of TECHCOMP and PRODCOMP attaining statistically significance at α=2.5%. Like the other two innovation performance variables, the correlations of ORGEFFN traced an identical pattern, with values of 0.7748, 0.7500 and 0.7143 for TECHCOMP, PRODCOMP and MARKCOMP respectively and all were statistically significant at α=5.0%. The discernible trend on the role of competence utilization shows an increasing order of impact: MARKCOMP, PRODCOMP and TECHCOMP.

Concluding Remarks

Practitioners and researchers have traditionally viewed the effectiveness of innovation activity from perspectives largely associated to addressing the alignment of various management issues with the external environment. This paper proposes a fresh perspective to the diverse ways in which mainstream concepts on innovation activities have been conceived to challenge the status quo of orthodoxy, and to justify for greater attention to be placed on the role of competence utilization.

To provide a clearer picture, the inference of reasoning is grounded conjecturally on an overriding proposition that a firm's competencies, if utilized in innovation activity, impact on innovation performance. The findings reported that the three hypotheses relating to the proposition about competence utilization were statistically supported at α=5.0%. The positive results confirmed that the competence utilization was positively correlated to innovation performance. Simply put, it means that higher innovation performance was encountered for firms, which employed a higher level of competence utilization. Conversely, since the results were reported as a two-tailed test, it was concluded that lower levels of innovation performance were experienced when firms employed lower levels of competence utilization. The test results conformed closely to theoretical expectations in support of the impact of competence utilization on innovation performance. In reiteration, the empirical evidence suggests that the role of competence utilization should not be trivialized, as opposed to the traditional notion of recognizing the dominant influences of the external environment, but be given due emphasis for effective implementation of innovation.

Additionally, the level of consistency amongst the findings was evidently high. Spearman rank-order tests showed that correlations were significantly positive in ascending order from market competence (MARKCOMP) to product competence (PRODCOMP) to technology competence (TECHCOMP), with relative influences on innovation performance in decreasing order of sales profitability (SALPROF), company growth (COGRWTH) and organizational effectiveness (ORGEFFN). Technology competence utilization was the most effective in innovation activity with the greatest impact on a firm's sales profitability; while in comparison, market competence utilization was the least influential with the lowest impact on a firm's organizational effectiveness.

While this study focuses on the role of competence utilization, it paves the way for exploring other related behavioral activities (e.g. knowledge transfer) that may be of credence. The road to complete understanding may be a long one, but the findings have moved us a step closer. In any case, the prophetic assertion of 'a good theory is one that holds together long enough to get a better theory' places the value of this study in the right perspective. As to how long the findings can endure the test of time depends ultimately on future theory development, which falls outside the scope of this study.

In conclusion, three areas for future research are recommended. Firstly, new approaches in construct identification, data capture and tools of analysis may be designed to contribute towards the ultimate goal of building highly predictive theories. Secondly, the study can be replicated in other countries or industry settings to broaden the range of applicability and generalizability of the results obtained. Thirdly, longitudinal analyses of similar hypotheses may also be conducted by a personal, face-to-face, open-ended, interview methodology, to further consolidate the interpretation of the reported findings.

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