INNOVATION IN ENGINEERING CONSULTANCY: A CASE FOR COMPETITIVE ADVANTAGE

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ABSTRACT

The internationalisation of the engineering consultancy services brings new challenges to its competitiveness. Service innovation is the way to enhance competitiveness. Although competitive innovation in the 1990s was achieved by information and communication technologies adoption, it is no longer sustainable without the combination of entrepreneurship, learning, sharing, knowledge and creativity, and by using information and communication technologies as a tool. The firm and the individual face challenges from external perceptions, internal beliefs, institutional legacies and organisation cultural misalignments. This paper proposes a knowledge-based model for re-engineering the firm with a learning culture. If engineering consultancy is a knowledge-based business whose asset is the employees, then the firm has to manage knowledge in an organisational learning and sharing context for the innovation purpose. Knowledge management with a human resource strategy for learning is a means to leverage the know-how, experience and judgment of the pool of highly qualified labour to achieve the innovation objective by replacing irrelevant work routines with dynamic ones.

Keywords : *Engineering Consultancy, Business Process Re-engineering, Knowledge Management, Innovation, Competitiveness*

INTRODUCTION

The Malaysian engineering consultancy sector is a respected and reliable provider of technical services in design and supervision of buildings and infrastructures. In the 1990s, it faced challenges brought about by the pressure of globalisation, the restructured economy with the emerged petrochemical and environment sectors, the change in project procurement and implementation process due to privatisation and the proliferation of information and communication technologies (ICT) in all sectors of the economy. The dearth of construction projects post the 1997 financial crisis, brought to focus the question of how the engineering consultancy business could be sustained during industry stagnation. The changed market also brought in external pressures to work at higher levels of competition and at a technically more demanding level requiring integration in the project, of cost-effective designs with construction aspects. The convenient route to sustainability is to hitch on the back of globalisation to export the consultancy services overseas. Armed with the knowledge and experience gained from previous domestic project work, the sector sought to gain entry into the more open and competitive overseas market by first supporting Malaysian clients who have secured overseas projects.

Due to ICT proliferation, the tradability of services in the international market has increased and with it, the emergence of the competitive division of labour paradigm. It opens up new opportunities for competent and innovative service providers anywhere in the world to be sourced and makes engineering consultancy a new component of the cross-border trade. This situation creates opportunity for firms to act in collaboration with foreign consultants or act as design contractors to foreign clients without physically relocating from home if they are highly ICT-enabled in their production and delivery processes for interaction across borders and time zones [1]. Design services could be provided at the point of production with minimal local presence [2] if they are aided by the virtualisation of the interaction process via video conferencing facilities. This option conveniently avoids the external cultural, linguistic and regulatory barriers imposed by physical location of the project team in the client's country.

The strategy addresses the firm's immediate sustenance but not its long-term competitiveness. Getting entry into the overseas market will make competitiveness and flexibility the more central issues, while threatening the survival of the bureaucratic, inflexible and non-creative [3]. To survive, the business has to be sustainable. To be sustainable, it has to be competitive. However, the strategy does not answer the question of how the competitive edge of Malaysian engineering consultancy firms in an international market can be sharpened in the long-term apart from it being just ICT-driven to facilitate delivery and diffusion of information.

For services to be competitive, firms have to be creative and innovative by continually acquiring new knowledge and enhancing existing knowledge and capabilities to meet the changing requirements of the international market. Combined with the competitive nature of the business, innovation is a means of service diversification and enrichment. When the market can no longer differentiate on the basis of technical advantage, price differentiation dominates.

Engineering consultancy is a component of the larger category of Knowledge Intensive Business Services (KIBS). Innovation in engineering consultancy services can be

defined as the transformation of new scientific and technical possibilities into new service products [2]. While a comprehensive theory of innovation in engineering consultancy waits to be developed, this paper is motivated by the immediate need to fit innovation into the firm's operations in an international setting. The firm needs to respond to the pressures of competition in a globalised environment as well as a stagnating domestic market. First, it justifies the need for innovation to achieve economic performance. It argues that innovation is derived from a combination of entrepreneurship, learning, sharing, creativity and knowledge but relies on ICT as a tool. It then determines the current position of engineering consultancy service innovation development and examines the barriers to innovation. To overcome them, a model for re-engineering the firm is proposed. A learning culture is needed in the firm's realignment with market conditions. With it, structural change is made in the organisation for innovation by a knowledge management (KM) infrastructure. It is suggested that irrelevant work routines is replaced by dynamic ones. This paper then draws some conclusions.

PRODUCTIVITY INCREASE

Although there have been few studies on innovation in services, robust empirical evidence of the important role of innovation as a competitive factor in services has emerged recently from an Italian empirical study [4] which concluded that innovating firms out-performed non-innovating ones in productivity growth. Investments in ICT exerted the strongest impact on productivity. The analysis of Italian 1990s firm-level data [4] also pointed to "the crucial importance of ICT as a key driver of firms' economic performance" in the 1990s. Similar conclusions were also drawn from an earlier Dutch study [5] using firm-level data. Similar phenomenon was observed in local consultancy firms, which through capital investment embraced ICT as an innovation in its production and delivery processes in the 1990s. ICT was then an indispensable component of service differentiation because of its early-mover advantage. It speeded up the delivery process, enhanced the design analysis and drafting with software, provided a reliable and compact means of storage and enriched project communications. All these translated to productivity increase. Indeed the pervasiveness of ICT has permanently made it an important factor of production. It is now so closely linked to services that the distinction between ICT and service innovation has sometimes become quite blur. But can service innovation derived from adopting ICT alone sustain the competitive edge? Does it have a significant role for developing competitive strategies?

The Italian study [4] also gave indication that in the R&D and consultancy sub-sector, increasing resource spending in ICT alone does not necessarily increase productivity. One of the conclusions of the Dutch study [5] was that ICT innovation was linked to lower employment growth rates and that non-technical changes were required in order to reap the benefits of innovation. Thus, there must be stronger underlying factors for competitivity in services apart from investing in ICT.

INNOVATION WITH KNOWLEDGE

Consultancy service is knowledge-intensive, technology-based and primarily devoted to change [2]. Knowledge is the result of giving meaning to information through interpretation in a particular context. It comprises a codifiable explicit component and a tacit component [6]. The codified component is stored in knowledge bases. Tacit knowledge is the whole body of cognition and skill that is embodied in individuals [7]. It is not reproducible in information systems. Learning is the acquisition, communication and exploitation of knowledge. Innovation follows by using problem-solving skills and knowledge learned to produce new solutions during the process of applying new technologies into the service product. Competitive advantage exists when the service can be positively differentiated from that of a competitor. Service differentiation comes from the provision of superior service that has elements of technology or methods, which are of great value to the project that the competition could not provide. The application of new technology and methods in the design and construction of a project is thus a strategic asset. Unlike traditional manufacturing innovation, which is derived from formal R&D, engineering consultancy service innovation is the application of new knowledge to a service.

Innovation results from the use of knowledge, technologies and skill-intensive inputs in response to client requirements, usually in a trust-based interactive client-consultant relationship. It is still very much client-driven [1,2] for quality and productivity. Project interactions determine the need for innovation. The service output is an extensively customised piece of work manifested in two forms. One is the physical manifestation of the service, the service product, which is the project itself and also the documents that eventually govern the project's physical realisation. The other is the intangible value created in the customisation process to implement the project in its own unique way, satisfying specific objectives, consolidating and building long-term service relationships and at the same time, reducing informational asymmetry [8] by evolving and accumulating the project knowledge base for all participating parties. They are much more than the product of ICT alone because they are developed by knowledge processing and by the evolution of ideas that came from information exchange among the parties in the project. There exists a distinct process of knowledge creation with new technologies followed by their translation into project features through design and are then deeply embedded in the project by construction. They are thus, innovations in their own right.

When ICT was a decisive factor in service delivery in the 1990s, the competitive edge came from its users' early-mover advantage. When ICT proliferation diminishes this advantage, the firm more crucially needs the entrepreneur's

will, creativity and an accumulation of new knowledge in the existing knowledge stock through a learning process [9] to raise the innovativeness of the firm. It requires a strong supportive learning culture to focus on the application of new knowledge in the design process and to make learning and innovation more central to the consultant's work. Thus, embracing ICT cannot be equated to innovation. ICT's role is to support idea and knowledge creation by processing, transferring and organising information. It acts as a medium for knowledge transport, storage and accumulation [8]. Engineering consultancy service innovation is about innovation with knowledge, which has several distinct characteristics (predominantly tacit, heavily context-dependent, cumulative) that distinguish it from information [8]. Knowledge is elicited from information through interpretation from another viewpoint. It is a factor of innovation and is central to value creation and success.

INNOVATION DEVELOPMENT PHASE

Before proceeding further, the position of the innovation process in relation to ICT commoditisation needs to be clarified. Barras [10] examined how technology transmission created out-of-phase life cycles in the capital goods sector and the consumer goods/service sector. His argument suggested that new service activities were based on information technology (IT) as a capital good. While IT innovation goes through the normal product cycle, he postulated that service innovation goes through a "reverse product cycle". Each phase of IT innovation affects service innovation. The correct placement of engineering consultancy service innovation in the reverse product cycle aids the firm in its use of Venkatraman's IT-strategy alignment model [11,12].

According to Barras, the reverse product cycle starts when the medium of service is replaced with ICT to increase the efficiency of existing service production and delivery [1]. In engineering consultancy, it substituted the mechanical and manual work processes with computers and software to improve existing services during the period of rapid computerisation from the 1980s into the 1990s. In the Italian [4] and Dutch [5] studies, this phase of IT adoption improved productivity through the rapid rate of capital investment in the new technology. It commanded a competitive edge by Venkatraman's localised exploitation [11,12] (automation) by computer-aided drafting, design software, word-processing and other software. It was tantamount to competitive innovation. Now ICT underpins the operation of the firm to provide the vital speed for efficient delivery. Its proliferation also leads to the end of the ICT adoption phase.

The second phase of the reverse product cycle begins when much of IT's use has been standardised. Its cost decreases, making it an affordable commodity. The Internet as a global information infrastructure allows fast exchange of data and information. From the firm's strategic standpoint, ICT's earlier position as an innovation for speedy delivery has been diminished by its commoditisation. Because it is ubiquitous, it can no longer command the competitive edge that it originally did [13]. The opportunities for individual advantage are largely gone when it becomes a common resource for all businesses thus, nullifying its original role in service differentiation. This compels the firm into a transitional phase in which it re-examines its processes to improve service quality through more radical changes aimed at effectiveness rather than efficiency [1,2]. This phase uses ICT as a tool for Venkatraman's internal integration [11,12]. It demands superior insight into how hardware, software and communications could be used to support all business processes. Value is added by employing ICT as a medium to create new knowledge and to innovate. With ICT's role redefined, knowledge and specialised competencies will emerge as the primary resource for innovation. Organisational and technical system integration using ICT then brings a new kind of dynamism into the work routine [1] in which information flow and its utilisation reach a higher level so that knowledge becomes an even larger component in the service. Process innovation to improve service quality is the emphasis.

The next phase is driven by advanced and maturing ICT to produce broadband communications, specialised information systems and databases, which are intended to revolutionise service production and delivery [11,12]. The business moves beyond its original boundary to face wider possibilities that could be found in emerging generic technologies such as groupware, decision support systems, expert systems and knowledge technology. When their impacts threaten business viability by making the old business assumptions no longer valid, Venkatraman [11,12] suggested that survival requires a fundamental overhaul of the business from business process re-design to business scope re-definition.

ICT-enabled engineering consultancy is in the transitional phase but should be ready to move into the third phase of the reverse product cycle. In the context of the construction industry, the firm in reality has little opportunity to totally transform a project into a new product of innovation. Although project problems are complex and often dynamic in nature, they tend to appear as new patterns and interactions among elements/sub-systems of the project. It is difficult for innovation development to move out of the transitional phase by client-led incremental innovations at the subsystem level [2]. To do so requires re-engineering the business [11,12] by removing any bureaucratic culture, moving to multi-dimensional work methods and changing the managerial behaviour [14]. Having identified the current position of innovation in the reverse product cycle, what are the barriers to innovation and competitiveness?.

BARRIERS TO INNOVATION

In general, engineering consultants do not normally look for new ways to innovate unless there is an immediate purpose for it [2]. The new delivery methods using ICT more often

originated from external demand for speedier delivery of designs and specifications than from internal motivation to change. If there was any change in the service production process, it came from the need to streamline project work so as to save on manpower and increase productivity to compensate for the lower fee earned. Thus, from an external perspective, engineering consultants are seen as consumers of innovation and as "passive" elements in the innovation process. They have long been perceived as innovation "laggards" who reacted to or at best, supported the technology push, especially if viewed in the context of the manufacturing innovation paradigm [15], whose dominance is still shaping corporate thinking, the service organisation culture and management style/traits.

There are a number of factors that are barriers to innovation. The first is that the sector has been traditionally viewed by the public as a conservative one with low rate of innovation [2]. Such thinking guided by the manufacturing innovation paradigm, equates low service innovation rate with low rate of explicit, formal R&D activities [15]. Contrary to perception, innovations though not radical, have always been buried deep in the design process. They are integrated into projects as part of the solutions to design problems but are seldom revealed explicitly. Thus, there is less recognition from the public, who seldom could see the innovations that are hidden from view.

Secondly, there has been relatively little detail and comprehensive analysis of the innovation patterns in design because engineers themselves do not devote much of their time in reporting on such activities or differentiate innovative routines from normal work routines [3]. Since innovations are perceived as normal work, they are seldom recognised or acknowledged as innovations by engineers themselves [2]. The manufacturing innovation paradigm still has a stronghold on the consulting engineer's thinking, thus creating a blind spot to innovation routines. Yet at the same time, engineers believe that engineering design is a creative activity. Perhaps, the lack of a system in the organisation that could clarify innovation, remove blind spots and consolidate knowledge for innovation has allowed this perception to persist. But regardless of the external perception and the internal dichotomy, engineers have been trained with the ability to be innovators. Their creativity has to be leveraged. The missing ingredient that the consulting engineer has to have is the entrepreneurial orientation, which will provide the motivation for self-initiated innovation so that it is not client-driven all the time.

Thirdly at the organisational level, there is in general a lack of deliberate and systematic management of knowledge. While forward-looking managers look for options for self-motivation, the firm's entrepreneurial orientation has to be kept alive so as not to extinguish at any spark of enthusiasm for innovation. In an environment of change, the ability to explore emerging opportunities by launching learning strategies [9] is actually crucial to survival. But a passive (knowing-but-not-doing [18]) culture coupled with strong enforcement of conformity, rules standardisation, routine behaviour, risk (uncertainty) avoidance [19] (these are symptoms of a static, bureaucratic or tayloristic firm) and short-term thinking, can stop learning and hinder the development of specialised technical as well as managerial competencies. Indiscriminate downsizing can result in considerable loss in organisational knowledge and competitiveness. These cultural factors threaten the business by their dogmas and outmoded practices.

The fourth factor is the institutional framework under which Malaysian engineers operate. The traditional division of labour separates the consulting engineer who is only permitted to design from the contractor who only builds [16]. This fragmentation does not promote integration of design and construction for cost effectiveness. Traditionally, the heavy design liabilities have made them take a risk-averse attitude when it comes to the introduction of new technology. It tends to promote the use of safe and proven technology and well-tried methods, which when taken to the extreme, may kill the innovative spirit. In the presence of outdated codes of practice, new technologies take time to be accepted. Their diffusion and application are slowed down by this institutional legacy. The petrochemical sector's project execution method, which allows consulting engineers to act as designers for contractors, is a refreshing change.

Finally while one may think that client demands can force the engineer to innovate under pressing project requirements, price competition when it becomes overly intense, may inhibit the innovation process because it costs too much time and effort. When fees do not commensurate with effort, the situation is not conducive for innovation. It can be improved if new ideas embedded in projects are not traded at zero prices so that the innovator can recoup the cost of innovation. New ideas have a larger positive lower bound price as they are more costly to transmit, learn and implement in projects than well-used and standardised ones that only incur low replication costs [17].

The misguided perception can be corrected if the public understands that service innovation differs from manufacturing innovation. But more importantly, the consulting engineer has to build self-confidence by keeping up with advances in her field, be equipped with new knowledge/methods to tackle emerging problems and find improvements in design to maintain the competitive edge initially driven by new client demands but eventually by a self-awareness of new opportunities. Business sustainability needs the influence of entrepreneurship, an internal supportive learning and sharing culture and management system, and an external driver that creates a demand for it in an emerging knowledge market so that the innovative spirit can flourish. This external driver could exist in a strong institutional framework that promotes innovation in the market which acknowledges that it has to pay a fair price for a new innovation. On the part of the firm, it has to realign its business processes to overcome some of the problems.

RE-ENGINEERING THE FIRM

The firm's innovation initiative requires an internal social/behavioural shift initiated at the organisation and individual levels to change the myopic view and its misalignment. The "manufacturing paradigm" must seize in management thinking. For re-engineering the firm's processes, this paper proposes a holistic model of the firm as depicted in Figure 1. It is an adaptation of the technology-driven model in [20] for consultancy services by addressing cultural issues, goals and strategies, organisational and process infrastructures in the context of external market forces. The firm's people reside in three layers distinguished by dark to light shades in Figure 1, the founder/CEO and top management in the innermost layer, managers in the middle layer and project teams in the outermost layer. The outermost layer has the most intense interaction with the external environment. In it resides the clients, regulations & standards, partners in the project, other fellow consultants involved in the project, contractors, technology & project characteristics and the competitors. The influence diagram of Figure 2 shows how the firm's culture, organisational infrastructure and management systems are strategically realigned in response to external (shaded) interactions for innovation to achieve its business objective.

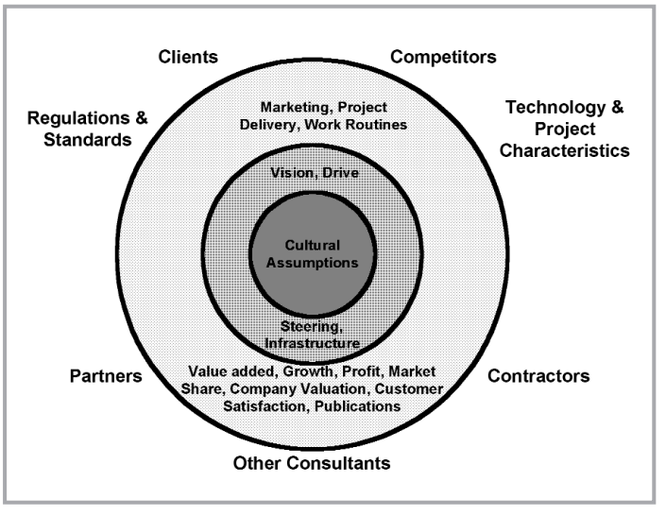

Figure 1: Holistic model of the engineering consultancy firm

Cultural Change

The basis of how the firm develops its innovation strategies, infrastructures and work routines, comes from its innermost layer of the founder's/CEO's cultural assumptions, values and beliefs [20]. They are the sources of the organisation's work habits for converting its energies to revenue and at the same time, shaping its competencies as well as its rigidities. Culture plays such a crucial role in shaping organisational behaviour that it has to be aligned with the right shared values and beliefs. Its role is also to remove change inhibitors [21] that undermine attempts to establish an innovation initiative by threatening innovation actions downstream of the organisation structure, and prevent the building of the right infrastructure and work routines for a learning culture to exist. New market requirements shift the market and misalign the culture formed from old values, beliefs and underlying assumptions. But there is reluctance to change brought about by past successes, which give rise to a competency trap, a resistance to try new ways of doing the business by giving the excuse that older methods have proven to be so successful so many times in the past. The entrepreneurial instinct is needed to trigger a re-examination of the cultural assumptions, values and beliefs on the basis that past proven routines may not fit well into the new paradigm. This trigger is formed by the organisation's innermost layer interacting with the external environment as feedback is received from the outermost layer where intense interactions with the external environment occur. The model proposes a learning and innovation culture as the basis for the firm to accumulate knowledge. Knowledge is a basic resource for innovation and innovation contributes new knowledge. Cultural shift has to exhibit clarity of purpose and vision. The vision has to come alive in the people through a set of shared core values. This takes effort and time but it is the management's initiative and commitment to change that drive the organisation's renewal by actively cultivating trust, openness, communication and skills, and encouraging an innovative mindset, learning-by-doing and sharing of knowledge. Success hinges on a free flow of information, team learning and experimentation (thus, risk-taking) that flourish in a dynamic and entrepreneurial climate in which the head of the business has to be a committed champion to lead and to close the "knowing-but-not-doing gap". Problem-solving skills is an asset that has to be constantly cultivated.

Learning and Innovation Culture

Change leads to learning and learning is a prerequisite for knowledge acquisition and utilisation. Senge [22] defines a learning organisation as "an organisation that is continually expanding its capacity to create its future". A learning organisation leverages learning and information in order to adapt to the market. Learning in his context does not mean acquiring more information but expanding the ability to produce the results people truly want. While learning is a vital process that leads to innovation, the object of learning should distinguish between what is relevant for the firm and what is not. Learning should not be blindly equated to the ability to innovate. At times, individual learning could mean replicating a particular skill or knowledge that already exists in another part of the organisation. Such learning does not contribute to increase in the existing knowledge stock and may remain unutilised because of its irrelevance. The learning that is useful for innovation has to be the kind that positively changes the firm's knowledge base, creates collective frames of reference, grows the firm's competence to solve problems and adds new value to the firm's services [14]. Senge [22] contends that the only construct within the grasp of the firm to produce lasting competitive advantage

is the usable knowledge produced from purposeful, well-orchestrated learning by all employees. The firm has to be a learning organism that has pragmatic social structures and processes that support collaboration and sharing. Therin's empirical study [9] concluded that the presence of organisational learning strongly influences innovation performance but it is affected by the strategic orientation of the firm of which many researchers believe should be built in a supportive and participative organisational culture developed under quality leadership. To learn involves some risk-taking but it should not be overruled by the sclerosis of not engaging in learning at all.

The right cultural change brings new vision and energy to the firm. The innovation purpose when combined with the firm's capabilities, give rise to productive opportunities [23] under a new business framework. Agrawal et al's [19] had found that the success/failure of business process re-engineering is affected by behavioural and the re-engineering process factors. Thus, the vision statement has to guide people to think about learning and innovation aspects. The shared goals have to be translated into learning and innovation terms at the operational context and communicated at high visibility. The full learning organisation has five distinct sub-systems – learning culture, organisation structure, people, knowledge and technology. Learning with the appropriate structure facilitates innovation. Cultural change shown at the bottom of Figure 2 leads to structural change.

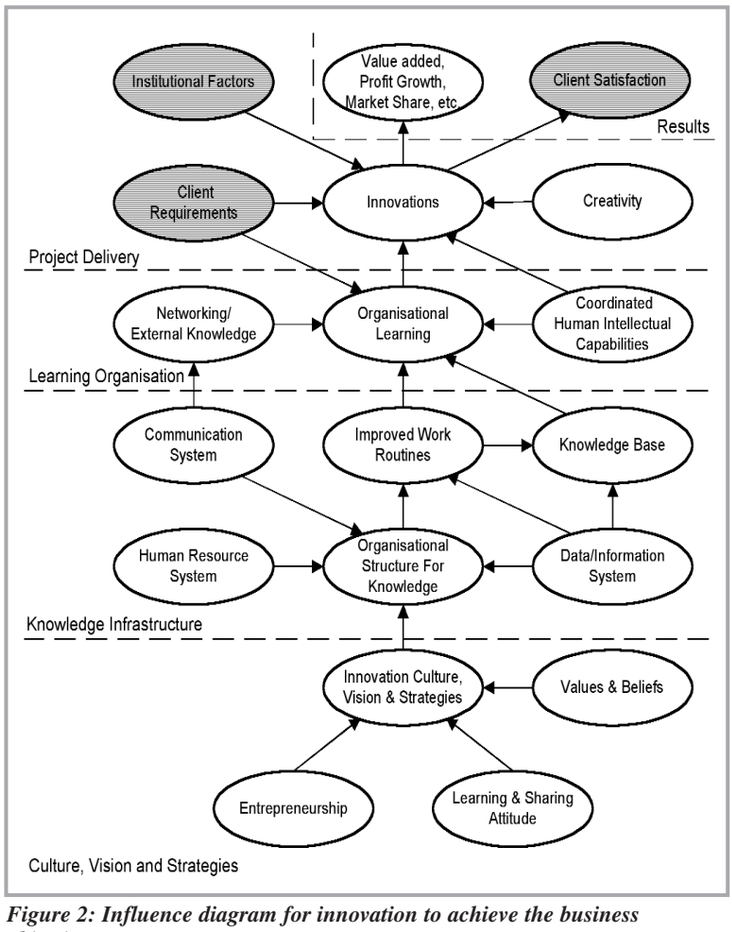

Figure 2: Influence diagram for innovation to achieve the business objective

Infrastructure Change

In the middle layer of the model, existing mechanisms for motivation, coordination and control, which need management's will to implement, are adjusted. The purpose of structural change is to facilitate the building of the new culture and to achieve the innovation objective. A learning culture is best supported by the appropriate organisational and technological infrastructure such as a knowledge system, human resource (HR) and ICT as well as steering mechanisms such as new strategies for developing a learning and knowledge-sharing organisation with an innovation purpose. The managers operationalise the firm's vision and business concepts into management systems. The project managers as knowledge engineers synthesise the tacit knowledge into new technologies and services. Since the firm's stock of tacit knowledge is embodied in its employees, human resource management is critically important in enhancing the learning culture. First, it has to restructure itself for bundling the collective inter-dependent capabilities from top management downwards [23]. In capacity formation, the learning and innovative spirit in the people for advance skill development to meet the changed work content has to be cultivated. ICT and HR have to be positioned strategically for condensing data /information using the IT system in a strong communication network (Internet and intranet).

From the realignment of HR, IT and communications, the firm's knowledge infrastructure is built with a knowledge system. It is represented by the knowledge base and work routines as shown in Figure 2.

Work Routine Change

The outermost layer focuses on the marketing effort, project execution and project delivery. Revalidation of existing work routines (patterns of work and behaviour) to meet the new requirements leads to the replacement of irrelevant routines with ones that better serve the web of interactions between the outermost layer and the external environment. The infrastructure and steering mechanism changes of the middle layer also provide the support for changing the existing work routines. Most importantly, the new routines at the engineering level stabilises the interactions with the client, which without the change creates tension arising from the differences between clients' idiosyncratic requirements and the old order of service provision.

Learning Organisation

With resource re-allocation and learning, a knowledge structure with effective ICT support as shown in Figure 2, can enhance the coordinated cognitive processes using a codified knowledge base to realise a collection of usable knowledge [7]. The success of the

structural change is seen in the growth of a learning organisation. It is measured by how effectively and readily the human intellectual capabilities and external knowledge are exploited in projects.

Innovation

In the project stage of Figure 2, a new idea is created to satisfy client requirements. Influenced by institutional factors, an applicable innovation results when it is translated into a unique physical product by design and construction. When the same idea has the possibility of use in another project, the engineer investigates how by refinement and adjustment, it could again be used. Its implementation results in another specific and unique solution tailored to the project. Initially, there is little replication of a previous solution. But after some use of the idea, the many different solutions may find repeatable applications (as static routines) in other projects. They would eventually appear as the firm's standard designs for replication in which no innovation effort is required.

The innovation aspects of the model can be explained by Baark's conceptual framework for engineering consultancy innovation [16]. It relates the interactions between the external environment with the outermost and middle layers of the model. He suggested that three key factors shape the innovation process, namely the institutional context represented by regulations & standards, the organisational framework represented by technology & project characteristics and nature of the service interactions with the client, and knowledge management (KM) represented as one of the firm's infrastructure. While the institutional context for engineering consultancy provides an environment that encourages learning and innovation, the operating structures of the firm streamline the intellectual knowledge processes in response to project characteristics in the service delivery. He suggested KM as the organisational infrastructure for facilitating the innovation process. It obviates static operation routines from eventually dominating the service provision and leading it to market irrelevance and inflexibility under the guise of stability. It also protects the firm from the dogma on the application of proven knowledge using outdated standards through age-old approaches.

Innovation Features

Baark [16] went further to summarise the relationship of the key features of innovation with the characteristics found in the three factors as shown in Figure 3. Innovation is client/demand-led and is incremental because of its contingent nature. It is driven by clients who require some idiosyncratic and complex enhancements to be embedded in the projects. To meet this requirement, the engineer would have to embark on a learning process within the project duration, which at times could be ad-hoc. Since the use of tacit and explicit knowledge produces innovation, knowledge as the key competitive asset, has to be enhanced by establishing links in the global network. Entry into the international market brings the firm into collaboration with overseas consultants. The multi-lateral network of partners with distributed capabilities [23] working together enables a complex project that requires diverse expertise to be implemented. It is this inter-organisational cooperation that is strategic to building external knowledge links for knowledge extension [23] in an international setting. Similar to open innovation in manufacturing [26], they contribute to the innovation process by revealing opportunities through the adoption of external ideas.

Thus as shown in Figure 2, the influence of institutional factors, client requirements combined with the acceptance of the "no free lunch" principle, and the creative by the application of problem-solving skills with new knowledge using relevant routines result in innovation, which the client sees as value being accrued in the project. At the same time for the consultant, competencies are extended. The project delivery process becomes innovation-centred.

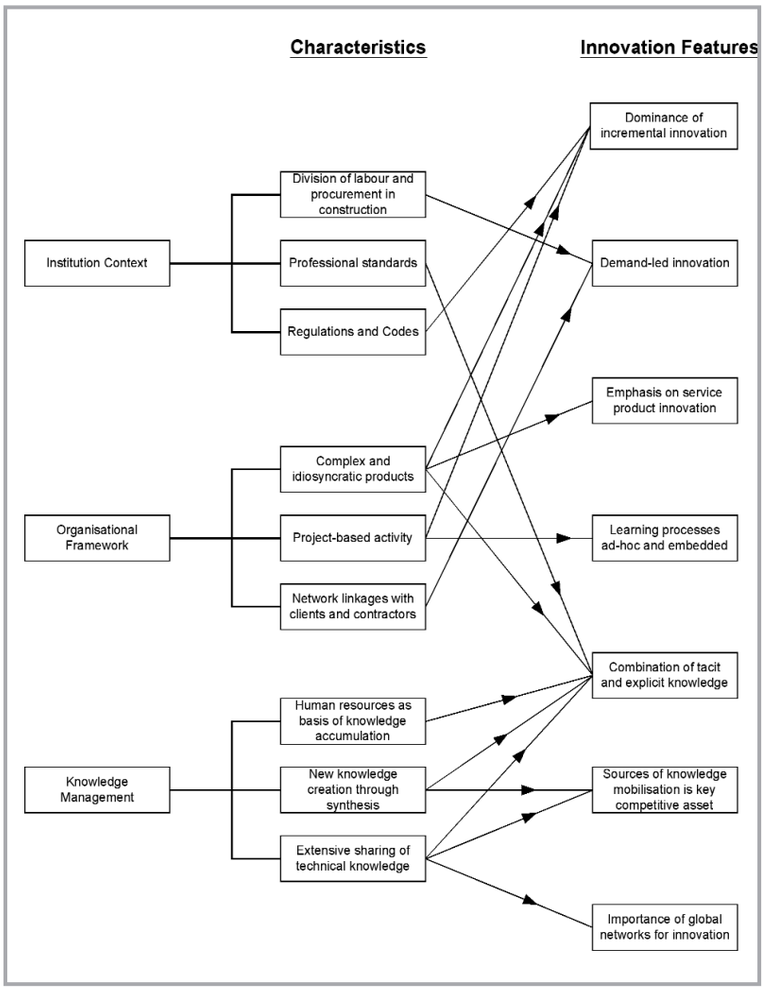

Figure 3: The three factors of design innovation and their characteristics from Baark [16]

Accrued Project Values and Results

The results shown in Figures 1 and 2 are measured by performance indicators such as value added, growth, profit, market share, firm's valuation, customer satisfaction and technical publications. Perhaps, the most appropriate measure of the firm's value creation is its economic value added determined from the return on invested capital less the weighted average of the cost of capital [24]. For the client, it is the innovative features incorporated in the project that gives the satisfaction of value being added to the project.

KNOWLEDGE MANAGEMENT

The model adopts KM as a management system to facilitate the learning process so that innovation can take place. In the race to develop expertise, knowledge loses its value rapidly by efficient diffusion and thus, it has to be fostered and maintained systematically. Knowledge is created by the interpretation and evaluation of information from an individual's contextual mental model [27]. To protect the long-term competitive advantage, KM manages the intellectual assets and develops organisational competence through creative mining of information. Tacit knowledge, which constitutes a large proportion of the body of knowledge, is stored in the minds of employees as a unique asset that is difficult to communicate and disseminate and thus, is hard to copy by other firms. It is the conversion of tacit knowledge to explicit knowledge that is crucial to the knowledge management initiative. This characteristic has to be exploited for competitive advantage [27]. Although KM's aim is to build knowledge by accumulation and to disseminate by internal conversion of tacit to explicit knowledge, it is the key employees who are central and virtually irreplaceable knowledge bearers. Trust is a crucial factor for them to share knowledge. The much-used slogan that says every employee is not indispensable, displays the fragile corporate ego that is counter-productive to the KM initiative. KM has to be embedded in what they do [25] as a means to leverage the existing know-how, experience and judgment of the pool of highly qualified labour to achieve the innovation objective. It has to strategically include the human factor when structuring its systems. Tactically, HR has to include basic rules in psychology for retention of key employees, seeking their collaboration, structuring meaningful career development ladders with an attractive reward system. KM's output is the organisational knowledge comprising individual and collective knowledge assets. The explicit accumulation includes the data and information that are used to build knowledge, the theories, practical, everyday rules and instructions for action. The tacit part is embodied in the employees as competencies. IT supports KM by augmenting the accumulation and interconnecting people and resources. To be effective, KM works synergically with HR and ICT. Thus, people, process and technology are the 3 key elements of KM success [28].

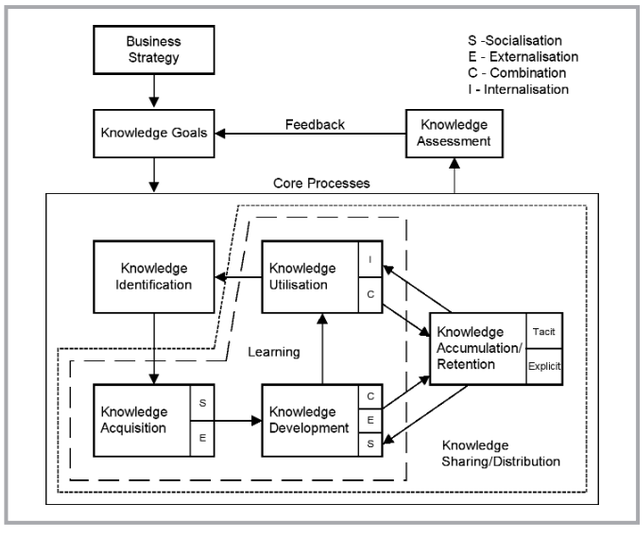

Figure 4: Project knowledge management process

Definition and Structure

The definition of KM adopted here comes from [28]: "An ability of an organisation to use its collective knowledge through a process of knowledge generation, sharing and exploitation enabled by technology to achieve its objectives". A review of research literature points to several proposals of the KM structure. A comprehensive and pragmatic one used by Probst et al's is found in their book [7]. For engineering consultancy, Figure 4 is an adaptation of their core processes of KM in the context of Nonaka and Takeuchi's theory of knowledge creation [29]. The process flow is non-linear. Learning and sharing are portrayed as crucial overlaying activities that tie the other processes together. The KM processes shown in Figure 4 exist in a context-sharing and relationship-building "place" called Ba [6,29] where knowledge conversion occurs yielding the four patterns: socialisation (S) – tacit to tacit, externalisation (E) – tacit to explicit, combination (C) – explicit to explicit, internalisation (I) – explicit to tacit [29].

KM Processes

Defining the firm's knowledge goals gives direction for identifying the kind of knowledge needed for innovation [21,27]. It leads to a continuous process of taking stock of the internal capabilities, resident data and information and identifying external data, information and skills required in the course of a project.

The knowledge gap revealed initiates knowledge acquisition by either recruitment or other methods that rely on networking, searching through external knowledge repositories or in site visit observations and data collection leading to knowledge creation by the SECI model [29], which is fitted into the management process described below.

In the knowledge development phase, the information acquired (socialisation and externalisation) is filtered, interpreted, analysed, organised and developed through interaction of the project's tacit and implicit components between individuals in a collaborative setting (socialisation). This is when the sharing experience occurs.

With trust and motivation [28], a portion of the tacit knowledge is articulated and translated to explicit knowledge (externalisation), which leads to their utilisation straight away by connecting pieces of explicit knowledge together (combination). The psychology inputs in HR are essential for existing knowledge to be made easily accessible for new knowledge creation. It is organised (part of combination) in IT form of a knowledge base by codification, indexing and aggregation [21,27].

Knowledge sharing is an activity that facilitates the two-way transfer of the organisation's knowledge for development and utilisation with feedback. The knowledge is shared/distributed initially in the project team through formal and informal meetings, project discussions, emails and other means of communication available in the ICT infrastructure [21]. The success of KM depends on the people's motivation, their willingness and ability to share knowledge. Trust is the foundation on which this activity is built. Again, psychology inputs in HR are essential. Future knowledge diffusion within the organisation may be in the form of documents created in the project, technical publications and seminars organised to disseminate the project knowledge gained.

In knowledge utilisation, the project team uses the codified knowledge and its own tacit component (combination) gained through the learning-by-doing [18] feedback loop (internalisation) to create new solutions to project problems and for decision-making. This is when further learning occurs with the aid of specialised software. Competencies are embodied from the new project experience (internalisation). This constitutes the innovation process, which transforms the service via the project processes and via solution features embedded in the project itself. In this way, new tacit knowledge is accumulated in the project team and explicit knowledge in the organisation's knowledge base.

The knowledge gained is continually retained by storing the data/information in documents and other IT-based storage media that permits the knowledge base to be retrieved and continually updated and expanded until project completion. Retention actually has a wider organisation scope with the embodiment of the organisation's tacit knowledge in memories, processes, practices and culture. The HR process for employee retention is thus, crucial to knowledge retention.

An assessment of the whole process [18] in achieving the knowledge objective will act as a feedback for defining future knowledge goals for repeating the process in a knowledge spiral [29]. The result of the effort is measured by the added value to the client's project [18] as well as the economic value added to the firm [24] and how effective are organisational learning and knowledge creation increasing.

KM in Services

No specific research of KM in engineering consultancy has been reported. The closest are the recent case studies of Apostolou & Mentzas [21,25] and that of Sarvary [30] of large management consultancy firms. Some indications of the effects of KM on the innovation of new services can be derived from Storey and Kelly's empirical study [31]. Their findings from factor analysis on a conceptual model comprising knowledge creation, knowledge transfer and knowledge storage, suggested that KM has positive effect on innovation in services, particularly in new service development. For knowledge creation to flourish, there has to be a right learning climate, entrepreneurial climate, organisational creativity and a shared vision. A firm's innovativeness is very much influenced by management action. Knowledge transfer requires collaborative working effort, rich communications, empowerment and sharing of knowledge. Success in any innovation endeavour was found to be very strongly determined by the sharing of knowledge, which requires extensive personal interaction and collaboration. Knowledge storage practices depend on knowledge systems, decision systems and documentation.

KM vs QA

KM is not another "change and continuous improvement" initiative. It is a more effective method of sustaining the competitive advantage than quality assurance (QA) because it deals directly with the factors that matter in knowledge innovation. It provides a means of channelling knowledge (knowledge spiral) to refine the service with high quality ideas and to ultimately raise the service quality level by innovation with new technologies. While some of the QA processes and characteristics are designed to achieve similar results as KM, QA implementation exhibits stronger emphasis on procedures for quality maintenance and for closing quality gaps found in repeat work. It has a role in the firm but its potentially rigid orientation tends to restrict the freedom to innovate. How does one enforce "do-things-right-the-first-time" when experimentation, innovation and invention are conducted heuristically and their outcomes are uncertain? Certainly there are commonalities of purpose between KM and QA, each approaching the business objective from different points and directions, and with different routes dictated by their assumptions, basis and intents. Considering the differences discussed here, it is doubtful that existing implementations of QA in engineering consultancy can be as effective as KM in sustaining the competitive advantage.

DYNAMIC WORK ROUTINES

Finally, the KM infrastructure provides the means to review the existing work routines in the light of the innovation initiative. Firms attempting to innovate cannot rely on static, repeatable routines of the past to run their organisation just on account of past successes. Their relevance has to be re-examined with the view of innovating services and moving away from static routines that dominate in the traditional management system by the information-processing paradigm. Static routines are triggered by the recognition of the applicability of a known solution to a problem. Innovation/dynamic routines are

triggered by unknown solution to a problem, thus initiating heuristics to find it [3]. When QA indiscriminately promotes static routines with the purpose for ensuring conformity and uniformity by extensive time-consuming paperwork, it becomes an obstacle to creative work [3]. There is a role for relevant static routines, which is to maintain stability and predictability of operations but dynamic routines must dominate in the innovative environment. Dynamic routines customise the services and are at odds with mass-production methods. The competitive asset lies in their dynamic ability to generate new ideas from the knowledge and skills of the individual professionals and the project teams and to translate them into solutions unique to each project. Cooperative dynamic routines, which suit the contingent nature of service innovation, are heuristic and stochastically mutative. They evolve with changing requirements thus, inherently promotes relevant changes. They provide the flexible means for in-house science-based technology innovation. The extensiveness of dynamic routines will define the organisation's capability of undertaking innovation by technology adaptation and combination.

CONCLUSION

The pressure of globalisation and the domestic market conditions have started to internationalise the Malaysian engineering consultancy services. For success, a firm's competitiveness plays a crucial role. Apart from price advantage, technical competency and innovativeness are crucial factors. Engineering consultancy should innovate with knowledge by tapping into the creativity and problem-solving skills of engineers. In many instances, it is the client's interest to create value in the project coupled with the entrepreneur's pursuit of profit that drives the firm to innovate. Innovation has to play a central role in the engineer's work while ICT should support the innovation initiative.

Barriers to innovation abound. The misguided external perception that engineering consultants are non-innovative needs correction but engineers themselves also has to recognise that they are innovative since their design work calls for creativity. Constraints also come from institutional legacies and from the firm's core rigidities built from self-reinforcing experiences and its lack of new initiatives in the areas where cost and less-than-supportive attitudes rule by over-administration in a tayloristic culture. Many of the innovation initiatives are client-driven and incremental in nature. Firms now have to shift from myopic concerns with the exploitation of tangible assets to a holistic interest in leveraging intangible assets as well. Learning, knowledge and creativity are the main ingredients for innovation and competitive advantage.

The use of ICT and the shift to a knowledge-based view of the firm help in the formulation of the business re-engineering process in the context of market conditions. The co-evolution of the firm's IT development and business realignment is a strategic imperative in the dynamic setting but it has to be business-driven by which the founder/CEO has to lead and cultivate the right culture based on learning and sharing of knowledge for innovation. The proposed knowledge-based model of the firm, the related influence diagram and the KM model represent different aspects of the re-engineering exercise aimed at creating a learning culture and for integrating KM with HR and ICT. They present comprehensive descriptions of all the key factors and strategies that can be adopted. The model proposes that the firm should adopt knowledge management as a means to systematise the way knowledge is managed. Under a strong learning and sharing culture, it can leverage the knowledge, skills and cognitive abilities of the highly qualified employees. By combining with advance technological resources, it enhances the innovation process while avoiding pitfalls. The replacement of irrelevant work routines of the past by dynamic ones would best serve the customisation of services. A HR strategy that promotes learning, sharing and knowledge retention is crucial to success. The model offers more than an incremental approach to business process re-engineering, which is characterised by changes from culture and management style to structures and work routines.

Competition is a beneficial mechanism for innovation through the application of knowledge with creativity. Its prevalence in the international market is a driving force for evolving the business. The future of engineering consultancy services should be seen through the lens of the knowledge economy. The internationalisation of engineering consultancy services has to fully exploit the benefits of establishing knowledge links in the widening international network by using advanced, high-speed communications for accessing resources and knowledge anywhere in the world. Innovation calls for the acquisition of specialised knowledge and skills in emerging technologies that have the potential to invent and re-invent the business. The future lies in the ability to integrate the business under the design-and-build paradigm and the exploitation of advanced and specialised features of ICT. A knowledge-based client relationship using common project data and knowledge bases that can be shared seamlessly is a step toward inter-operability. It has the potential to enhance client-consultant interaction. ■

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