

Valuation of Knowledge: A Business Performance-Oriented Methodology

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Abstract

For the successful management of knowledge, knowledge needs to be measured. Without valid measurement, it is hard to manage it effectively. However, intangible characteristic of knowledge makes the knowledge measurement a very challenging task. In this paper, we do not measure knowledge directly, but assess how much knowledge contributes to the business performance. KP³ methodology developed in this paper assesses the contribution of knowledge to the business performance by employing product and process as intermediaries between the two.

1. Introduction

Knowledge is considered one of the most important asset in the economy. It is the major source of economic growth of the country and individual corporation's success [3]. The importance of the knowledge become even more emphasized as industrial economies have entered a new epoch, new economies in the 21st century. Regarding the importance of knowledge, Peter Drucker [8] mentioned in his book, *Managing in a Time of Great Change* that "knowledge has become the key economic resource and the dominant – and perhaps even the only-source of comparative advantage."

Because knowledge is difficult to create and imitate [31], it can be the source of sustainable competitive advantage [21, 23, 27]. Therefore it has to be nurtured and managed to achieve sustainable competitive advantage [16, 17, 19].

For the effective knowledge management, it is very important to measure the knowledge. Without valid

and reliable measurement of knowledge, it becomes very difficult to develop a comprehensive theory of knowledge or knowledge asset. Consequently, no clear progress can be made in the efforts to treat knowledge either as a variable to be researched or asset to be managed [10]. However, the inherently intangible characteristic of knowledge makes the measurement difficult. In fact, from the survey of 431 US and European organizations, 43% of the respondents replied that measuring value and performance of knowledge assets is the most difficult thing next to the changing people's behavior [26].

In our paper, we take different approach to "measure" knowledge. That is, we try not to measure knowledge directly which either may not exist or can't be measured. Instead, we assess how much knowledge contributes to the business performance. Using business performance data which is the result of applying knowledge to business operations, the methodology developed in this paper enables to assess the contribution of each individual's different knowledge. Each individual's knowledge contribution to the business performance then can be summed up over different business unit or corporation as a whole. The assessment is not the direct measure of knowledge. However, it is an important understanding of the value of knowledge. The assessment would provide very useful information to evaluate and compensate knowledge workers, to allocate and develop human capital depending on the business needs. As long as we understand, this is the first approach to assess the contribution of knowledge to the business performance. This effort would enhance our understanding for the value of knowledge.

2. Background

Even though knowledge is one of the most important asset and ultimately related to better business performance, the effort to measure knowledge, especially to measure the contribution of knowledge to business performance has been less clear. Despite the fact that many companies recognize the importance of the tie between knowledge and business performance, few if any companies have thus far been able to establish an explicit causal link between them, regardless of how it is measured [5]. It still remains as a major research agenda [28].

In fact, it is not clear whether knowledge can be measured or not [15]. Despite the various researchers trying to develop metrics and models to measure knowledge [7, 9, 14, 15, 25], people think that measurement is one of the most difficult part of the knowledge management activities [26]. Other researchers even argue that knowledge cannot be measured, but the activities or outcomes associated with applying knowledge can be measured [6].

The methodology developed in this paper enables to assess the contribution of each individual's different knowledge to business performance. The methodology, called KP³ methodology, establishes logical links between knowledge and business performance through product and process, and suggest various application areas for improving business performance. A number of linkage matrices were introduced for that purpose. With the help of those linkage matrices, contribution of knowledge to business performance can be assessed.

Because the direct link between knowledge and business performance and its assessment is difficult from the practical implementation point of view, a *two-step* approach was proposed by employing *Product* and *Process* as intermediaries.

One of the major building blocks of the KP³ methodology is knowledge. In fact, knowledge is viewed from many different perspectives. Nonaka [20] suggested two types of knowledge: tacit knowledge and explicit knowledge. Collins [4] related knowledge types to their accessibility: symbol-type knowledge, embodied knowledge, embrained knowledge, and encultured knowledge. There are other views on knowledge type, which include Spek and Spijkervet [30], Quinn et al. [24], etc. In the framework of the KP³ methodology, knowledge helps to achieve business performance through product and process. It's our view that product and process serve as key intermediaries when we want to relate knowledge to performance, and accordingly the associated knowledge should be sepa-

rately managed as *Product knowledge* and *Process knowledge*.

To assess the business performance, organizational performance and financial performance were used in this paper. Incidentally, several research findings in the human resource management area show that human resources increase the organizational and financial performances and source for continuous competitive advantage [1, 12, 13]. In the study of assessing the impact of human resource management practices to the business performance, Harel and Tzafrir [11] used similar performance measures: organizational performance and market performance in relation to its competitors. Because assessing the contribution of knowledge and impact of human resource management practices share the common characteristics of assessing the contribution of human capital, organizational and financial performances are used to measure the contribution to business.

3. The KP³ Methodology

3.1. The approach

Figure 1 shows the overview of the KP³ methodology. The basic building blocks of the KP³ methodology consist of four components: Knowledge, Process, Product, and Performance. Knowledge is further classified into two: Product-related knowledge and Process-related knowledge.

The arrows in Fig. 1 with solid lines represent the fact that the four components are linked together through four linkage matrices: *the Knowledge-Product matrix*, *the Product-Performance matrix*, *the Knowledge-Process matrix*, and *the Process-Performance matrix*. The purpose of the linkage matrices is to link knowledge to business performance through product and process. Specifically, product knowledge is linked to product by the Knowledge-Product matrix and further linked to financial performance by the Product-Performance matrix. On the other hand, process knowledge is linked to process by the Knowledge-Process matrix and further linked to organizational performance by the Process-Performance matrix. Process and organizational performance are indirectly linked to product and financial performance respectively, and the linkages are represented as dotted lines.

It is important that the four components in the KP³ methodology are linked logically. The logical linkage would enable the monitoring of the status of financial and organizational performance, and it would take necessary actions to improve them through knowledge

management activities. The solid line in Fig. 1 represents presumably direct relationships that can be formally stated with logical or mathematical expressions. It means that the contributions of knowledge are possibly quantified and monitored so as to influence them to improve business performance. The dotted line represents indirect relationships that exist but cannot be expressed explicitly. It means that it is hard to measure organizational contribution in monetary terms and their influence is rather indirect.

In the next section, four components of the KP³ methodology (Knowledge, Process, Product, and Performance) and four linkage matrices (*the Product-Performance matrix, the Process-Performance matrix, the Knowledge-Product matrix, and the Knowledge-Process matrix*) are explained in more detail.

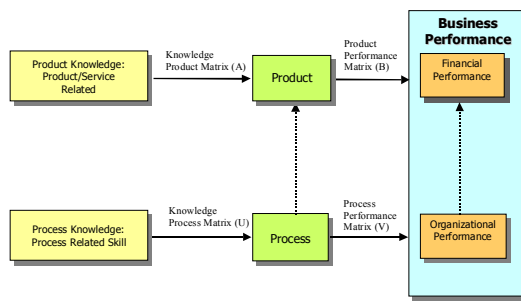


Figure 1: Overview of the KP³ Methodology

3.2. Components of the KP³ Methodology

3.2.1. Knowledge

In the framework of the KP³ methodology developed in this paper, knowledge helps to achieve business performance through product and process. To make a logical link from knowledge to product and process, associated knowledge is viewed separately as *Product knowledge* and *Process knowledge*.

Product knowledge is knowledge directly related to the specific product or service with which a company serves. Specifically, product knowledge can be classified as (1) *Technology related*, (2) *Operations management related*, (3) *Market related*, and (4) *Industry related*. Knowledge would take specific forms if they are to be applied to a specific industry. To distinguish market related and industry related knowledge, market related knowledge is concerned with very specific marketplace. On the other hand, industry related knowledge is concerned with more general and high-level

knowledge on the marketplace. Let's take an example of the Internet shopping mall business. Technology related knowledge could involve encoding techniques for security in payment systems. Operations management related knowledge could involve the expertise in handling product specific inventories such as perishable items. Market-related knowledge could involve the understanding of customer purchasing behavior in the Internet shopping mall. Finally, industry related knowledge could involve the knowledge regarding industry activities for mobile portal solutions.

Process knowledge is the knowledge associated with the activities performed in each stage of a value chain from inbound logistics to customer care. Compared to the product knowledge, which is directly related to the provision of products or services, process knowledge helps and facilitates the achievement of objectives in each value chain activity. Therefore, product knowledge can be regarded as *Know-what* and process knowledge as *Know-how*.

Table 1 shows the individual skill set that is considered important for the evaluation of human capabilities [2]. It is closely related to the individual's capabilities and can be further classified into four groups: (1) *General and personal capability (G)*, (2) *Communications capability (C)*, (3) *Problem-solving capability (P)*, and (4) *Leadership and interpersonal capability (L)*. We employ these four types of capabilities as our four categories of process knowledge.

For the purpose of this paper, we assumed that each individual's knowledge would be defined in such a way that it can be added up across individuals to become the product division's knowledge. To make the knowledge level additive, it is measured from the perspective of the productivity concept. It means that each individual's knowledge could be considered as a knowledge stock to accumulate. For example, suppose that person A has knowledge stock 0.4 and person B has knowledge stock 0.5. Then, they have a total knowledge stock 0.9 as a team and they are regarded as comparable with person C having a knowledge stock 0.9. This is equivalent to saying that person C can perform a specific job with the same level of productivity as person A and B working on the job together. The issue of how we assess the knowledge stock will be discussed later in Section 3.3.1.

Table 1: Individual’s capabilities as process knowledge

Process Knowledge	Category
Motivation	G
Verbal Communications Skill	C
Ambition	G
Personal Fit	G
Decision Making	P
Self Discipline	G
Problem Solving	P
Ability to Organize	L
Work in Teams Well	L
Practical Work Experience	P
Leadership	L
Time Management Skills	G
Creativity	P
Quantitative Skills	P
Writing Ability	C
Selling Skills	C
New Technology Skills	P
Negotiation Skills	C
Foreign Language	C

3.2.2. Product

Products are the output of the value chain activities. If the company or organization in discussion were a service company, product would mean service in that context. For the purpose of this paper, product could mean both the product itself and the product division depending on the context. Because knowledge management activities are executed and evaluated by product division, product and product division are used interchangeably in this paper.

3.2.3. Process

The process of delivering a product or service can be divided into a number of linked activities, each of which adds values for customers [22]. The value chain is a framework for analyzing the contribution of each activity to the business performance. Various activities that make up the value chain are important individually, but they are perhaps even more important in combination. Overall value for customer is created not by individual activities but by groups of activities that come together to form what are known as core processes [18].

Because the core processes are set of critically important activities that produce products and eventually determine the performance of a company, they need to be well managed. Process knowledge would make the core process the most efficient and productive contribu-

tor to both the organizational performance and financial performance. In this paper, five core processes are identified. They are (1) *Corporate development*, (2) *Product and service innovation*, (3) *Technology management*, (4) *Operations management*, and (5) *Customer care*.

3.2.4. Performance

Performance or business performance is both financial and organizational. Financial performance is directly influenced by how the product or service performs in the market. Depending on the characteristics of the product and service, different metrics can be used. The possible monetary metrics for measuring financial performance are revenue, profit, EVA (Economic Value Added), etc.

Meanwhile, organizational performance is usually defined with non-monetary metrics, thus it is relatively difficult to measure. Though it could be measured indirectly using some “intermediate” measures like the number of new ideas, the number of new products, document processing time, service provisioning time and job satisfaction level, the contribution of knowledge management activities to the organizational performance is hard to be translated into tangible benefits. However, the effort to understand the relationship between knowledge and business performance, especially financial performance is quite essential considering the fact that real financial improvement has to be demonstrated before the knowledge management activities is adopted and diffused in the regular business activities.

3.3. Linkage matrices

The four components of the KP³ methodology need to be linked logically. To represent the relationships of knowledge to business performance over product and process, four linkage matrices are employed to link four components of the KP³ methodology. They are *the Knowledge-Product matrix*, *the Product-Performance matrix*, *the Knowledge-Process matrix*, and *the Process-Performance matrix*. Knowledge-Product matrix links from product knowledge to product, Product-Performance matrix links from product to financial performance, Knowledge-Process matrix links from process knowledge to process, and Process-Performance matrix links process to organizational performance. We explain each matrix in detail.

3.3.1. Knowledge-Product matrix

The knowledge in the Knowledge-Product matrix is basically product-related. Let's represent individual p 's Knowledge-Product matrix as $\mathbf{A}(p)$.

Then $\mathbf{A}(p) = [a_{ij}(p)]$, where $a_{ij}(p)$ is defined as the level of product knowledge i employee p has accumulated in association with product j . The value $a_{ij}(p)$ is assessed to be $0 \leq a_{ij}(p) \leq 1$, and $a_{ij}(p) = 1$ if employee p is an expert in product knowledge i related to product j .

Product knowledge can be measured for each individual at a certain point of time and later updated regularly or on an ad-hoc basis. To measure the level of product knowledge, we need to develop an appropriate scale for it. For example, Table 2 illustrates a 7-scale rating that could be used to assess the individual knowledge level. Each level needs to be converted into a numerical scale from 0 to 1 to be used in the Knowledge-Product matrix.

Table 2: 7-scale rating for the knowledge level assessment

Level	Description
Level 1	Very poor and little hope for improvement.
Level 2	Poor and needs significant development.
Level 3	OK with constant guidance, and it could become satisfactory with more experiences
Level 4	Satisfactory and can perform a job requiring the skill satisfactorily with some support from the colleagues having some experience).
Level 5	Good and can do any job requiring the knowledge successfully and independently.
Level 6	Very good and can do any job related to the knowledge successfully, and can do the job not only independently but also can be a leader helping other people who need support.
Level 7	Excellent and expert level which can be a mentor or role model for that knowledge.

Because knowledge level is defined to be additive, we can add individual knowledge to estimate the knowledge stock in any organizational level. If we denote an organization by a set of people Ω , the knowledge stock of the organization Ω for product knowledge i in association with product j is estimated to be

$\sum_{p \in \Omega} a_{ij}(p)$ and the product knowledge stock as a whole is

$$\mathbf{A}(\Omega) = \sum_{p \in \Omega} \mathbf{A}(p) = \left[\sum_{p \in \Omega} a_{ij}(p) \right]$$

3.3.2. Product-Performance matrix

Performance in the Product-Performance matrix means financial performance. Let's represent Product-Performance matrix as \mathbf{B} matrix. Also, let $FP_k(\Omega_j)$ be the actual financial performance k , which the product division Ω_j has achieved for some period of time. Then, $\mathbf{B} = [b_{jk}]$ and the estimate of

$$b_{jk} \text{ are obtained by computing } b_{jk} = \frac{FP_k(\Omega_j)}{\sum_i \sum_{p \in \Omega_j} a_{ij}(p)}$$

The value b_{jk} can be interpreted as the average contribution per "expert" employee in the product division Ω_j to financial performance metric k .

Because many people are involved in the activities of each business division, we elect to use an averaging approach to assess the contribution of the product division to financial performance.

3.3.3. Knowledge-Process matrix

The knowledge in the Knowledge-Process matrix means process-related knowledge. Let's represent individual p 's Knowledge-Process matrix as $\mathbf{U}(p)$. Then, $\mathbf{U}(p) = [u_{lm}(p)]$, where $u_{lm}(p)$ is the level of process knowledge l employee p has accumulated in association with core process m . The value $u_{lm}(p)$ is assessed to be $0 \leq u_{lm}(p) \leq 1$, and $u_{lm}(p) = 1$ if an employee p is an expert in process knowledge l related to the core process m .

The knowledge in the Knowledge-Process matrix can also be assessed as the knowledge stock in any organizational level, team or larger business unit, as well as an individual capability rating for a particular employee. The matrix can be measured and updated in the same way as the Knowledge-Product matrix.

3.3.4. Process-Performance matrix

The performance in the Process-Performance matrix means organizational performance. Let's represent the Process-Performance matrix as \mathbf{V} matrix. Also, let $OP_n(\Omega)$ be the actual organizational performance

metric n , which the functional organization Ω has achieved for some period of time. Then, $\mathbf{V} = [v_{mn}]$ and the estimate of v_{mn} is obtained by computing

$$v_{mn} = \frac{OP_n(\Omega)}{\sum_l \sum_{p \in \Omega} u_{lm}(p)}$$

The value v_{mn} can be interpreted as the average contribution per "expert" employee in the core process m to organizational performance metric n .

This matrix shows how each core process in business activities contributes to organizational performance. Because organizational performance is usually viewed differently for different processes performed in the organization, process-related performance metrics need to be developed for each process depending on the management needs. Note that each process has its own organizational performance metric, as contrasted to the product divisions where the same financial performance metric is used for each product.

Table 3 shows examples of the organizational performance metric.

Table 3: Examples of organizational performance metric

Process \ Performance	Efficiency	Quality
Corporate Development	# of strategic alliance and M&A attempts	# of successful deals
Product/service Innovation	# of new products or new services developed	# of successful launches
Technology Management	Turnover rates of new technologies	Market newness, # of patents and cross-licenses
Operations Management	Service provisioning time	# of automated processes
Customer Care	# of processed customer calls	Customer satisfaction index

3.4. Linking knowledge to business performance

With the components of the KP³ methodology and its linkage matrices defined in Section 3.2 and 3.3 respectively, contribution of product and process knowledge to the financial and organizational performance can be assessed. The estimates are highly valuable information in many management function areas like human resource allocation, knowledge development, employee evaluation and compensation, etc.

3.4.1. Product Knowledge-Financial Performance matrix

Let's represent matrix \mathbf{C} as a matrix showing the relationship between product knowledge and financial performance. That is, $\mathbf{C} = [c_{ik}]$, where c_{ik} is the (potential) contribution of product knowledge i to financial performance metric k . Matrix \mathbf{C} can be defined and estimated in any organizational level as well as for an individual employee.

Given a product knowledge stock $\mathbf{A}(\Omega)$ estimated for an organization Ω , the associated Product Knowledge-Financial Performance matrix $\mathbf{C}(\Omega)$ can be estimated by multiplying matrix $\mathbf{A}(\Omega)$ and \mathbf{B} or summing up $c_{ik}(p)$ over all p in Ω . That is,

$$\mathbf{C}(\Omega) = \mathbf{A}(\Omega)\mathbf{B} \quad \text{or}$$

$$\mathbf{C}(\Omega) = \sum_{p \in \Omega} \mathbf{C}(p) = \sum_{p \in \Omega} \mathbf{A}(p)\mathbf{B}.$$

Note that the matrix multiplication is done in such a way that the financial performance is summed over all products, that is, $c_{ik}(\Omega) = \sum_j a_{ij}(\Omega)b_{jk}$ and $c_{ik}(p) = \sum_j a_{ij}(p)b_{jk}$.

3.4.2. Process Knowledge-Organizational Performance matrix

Let's represent matrix \mathbf{W}^m as a matrix showing the relationship between process knowledge and organizational performance for process m . That is, $\mathbf{W}^m = [w_{ln}^m]$, where w_{ln}^m is the contribution of process knowledge l to the organizational performance metric n for process m . Because the units of organizational performance metrics could be different for each core process, their estimates can not be added over processes as was done in Product Knowledge-Financial Performance matrix.

The matrix \mathbf{W}^m for each process m can be calculated by multiplying corresponding two terms. That is, $w_{ln}^m = u_{lm}v_{mn}$ for a specific m . If we evaluate these measures at the individual employ level, it is obvious that $w_{ln}^m(p) = u_{lm}(p)v_{mn}$. The process knowledge-organization performance matrix in an organizational level, denoted by $\mathbf{W}^m(\Omega)$, is easily obtained by add-

ing each element over all employees in Ω or

$$\mathbf{W}^m(\Omega) = \sum_{p \in \Omega} \mathbf{W}^m(p) = \left[\sum_{p \in \Omega} w_{in}^m(p) \right].$$

4. Conclusions

Technological advances and changes in regulatory conditions are causing the world to become globalized in a fast way. It has become almost impossible to imagine doing business without considering a global market. To be successful in the global market, knowledge should be managed as the most valuable assets of an organization.

For the successful management of knowledge, knowledge has to be measured. However, it is not clear whether we can properly measure the knowledge which either proper measurement may not exist or can't be measured. To address this issue, we assessed how much the knowledge contributes to the business performance, rather than trying to measure the value of knowledge directly.

The KP³ methodology developed in this paper is based on the idea that the contribution of knowledge to business performance can be measured by employing product and process as intermediaries between the two. The methodology developed in this paper is a general approach and it can be applied to any industry with relevant domain knowledge. Possible applications include employee evaluation and compensation, human resource allocation, recruitment and human capital development, knowledge acquisition and administration, project team building, knowledge map development, career planning, etc.

In order to implement the KP³ methodology successfully, several technical and managerial issues should be addressed in more detail. First, simple but effective knowledge classification schemes need to be further refined and measures for expertise or knowledge stock should be empirically validated. In this paper we identified two aspects of knowledge, product knowledge and process knowledge for the first time, and decomposed them into mutually exclusive and collectively exhaustive knowledge components. Though the suggested taxonomy is simple and good enough to be implemented in general business domains, more enhanced industry-specific or company-dependent classification schemes could be developed. Accordingly, various measures should be developed for them, along with the adequate scales. The issue of definition and measurement of knowledge level still needs further attention to make the knowledge level additive. Regard-

ing the measurement of knowledge and its impact, researches in the human resource management area may provide some idea [29, 32].

Second, the proper incentive system for knowledge management activities has to be setup to help people buy into the KP³ methodology. Because extracting and sharing knowledge are not natural human behaviors, employees should be encouraged and motivated by proper incentives. The framework of KP³ methodology will surely serve as an effective tool for the evaluation procedure too.

As the speed of technological development increases and the body of accumulated data and information becomes ever larger, the value of knowledge and the need for knowledge management will continue growing. As long as we understand, KP³ methodology is the first attempt assessing the contribution of knowledge to the business performance through product and process. This approach enables us to relate knowledge to business performance more explicitly and provides valuable insights on how to manage knowledge strategically. It is our belief that the KP³ methodology will provide a sustainable competitive advantage for the company that uses it.

Many theoretical and practical issues for the real-world applications of KP³ methodology still remain to be addressed. The application areas suggested in this paper can be extended and the optimal decisions can be characterized for each application based on the mathematical formulations. Empirical studies on some hypotheses derived from those characterizations will further validate the applicability and the usefulness of the methodology.

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