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A value-based framework for the assessment of knowledge workers

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Abstract

Purpose – The purpose of this paper is to propose a new framework to assess the value of a knowledge worker (KWr) in his/her organization.

Design/methodology/approach – The proposed framework determines the value of each KWr based on his/her contribution to organizational value-added. The framework includes two steps: the contribution of each work process to the total organizational value-added is determined using Knowledge Value Added method; and the value of each KWr is obtained based on the contribution of his/her operational knowledge to the value-added of the processes.

Findings – This article elaborates on how KWrs' contribution to organizational value-added can be used to assess them. A new framework is designed to serve this purpose. A case study was also carried out in a marketing department of a detergent manufacturing company to test the practical usability of the framework. The statistical analysis of the results confirms the validity of the framework.

Practical implications – The results of this research can be discussed in terms of two main issues. First, this study highlights the imperative role of KWrs in achieving success for organizations in today's knowledge-based economy. This research urges managers of organizations to fully recognize and measure the importance and value of KWrs and recommends that the mechanisms of human resource management (such as compensation and rewarding systems, hiring process and training and development) can be modified with respect to this value measurement. Second, an applicable framework with specific and clearly defined steps is introduced in this paper, which can be used by organizations to determine the value of KWrs based on their contribution to organizational value-added. The proposed framework has two important characteristics which previous models and frameworks failed to deliver: this new framework contains detailed items and procedures that could be easily obtained and fully understood by practitioners and researchers; and the proposed framework provides the ability to compare all types of KWrs. The results obtained by implementation of this framework give insight into the appropriate managerial approaches to reach personal and organizational goals simultaneously.

Originality/value – Due to the differences between knowledge work (KW) and manual work, the management of KWrs requires its own methods and techniques. In this article, a brand new framework for KWrs' value assessment is developed based on the characteristics of KW.

Keywords Knowledge worker, Knowledge value added, Assessment, Contribution to value-added

Paper type Research paper

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1. Introduction

In today's world, work processes are very complicated and considerably knowledge-intensive in many industries (Eppler *et al.*, 1999), and knowledge workers (KWrs) play a crucial role in maintaining the competitive advantage of organizations (Baker, 1992). Machlup and Drucker were the first researchers who defined the concept of knowledge work (KW) (Cortada, 1998; Pyoria, 2005). Drucker (1959) described KWrs as people who apply knowledge, rather than manual skill or muscle, to work (Nickols, 2000).

The study of business environment shows more increase in demand for KWrs compared to that for manual workers (Drucker, 1995; Lavoie *et al.*, 2002). According to the literature, the number of KWrs is rising in different countries. Moreover, in a knowledge economy, the value of human capital far outweighs more traditional, tangible forms, such as plant and equipment (Murray and Greenes, 2007), and there is an important relationship between issues related to the KWrs and the key performance indicators of organizations. Some key performance indicators are realization of goals and objectives, growth and profitability (Baker, 1992; Lind and Sulek, 2000; Sveiby and Simons, 2002; Smith and Rupp, 2004; Adelstein, 2007; Pan *et al.*, 2008). Aldag and Reschke (1997) stated that in the past, technology created competitive advantage. Now, due to ease of access, technology is having an equalizing effect, leaving employees as the key to competitive advantage. KWrs are important and key strategic resources in modern learning organizations; they are value creators and value adders whose major contributions come from their abilities to process and apply knowledge and information to completing essential tasks, making decisions and solving problems (McFarlane, 2008).

Considering KWrs' impact on a company's profit and overall financial performance and the fact that not all KWrs generate the same level of value and not all have the same impact on wealth creation (Brelade and Harman, 2007), it is extremely important to find a way to measure their value (Eustace, 2003). North and Gueldenberg (2011) tried to shed light on the importance of this measurement in their own way. They consider "How much is the value of a KWr in an organization?" a challenging question that organizations and KWrs need to resolve to achieve success.

The result of the measurement can play a critical role in provision of appropriate practices for KWrs' management. Generally, it can be applied to develop human resource systems (Wang, 2008). At a strategic level, this provides aggregate data for workforce planning and modeling. This is analogous to the way marketing departments customize products or marketing communications to individual customers (Mulhern, 2007).

Several authors have emphasized the importance of KWrs' value in the development of efficient compensation and rewarding systems (MacLean, 2007; Blickenstaff, 2012; Mulhern, 2007; Heneman and LeBlanc, 2002; Ahn and Chang, 2004). Traditionally, the market value of a particular job sets the rate for which an individual is compensated. This, overlooks the value of the specific and unique set of skills and competencies that an individual brings to that endeavor (MacLean, 2007). The compensation system fails when a bland, homogenized model is implemented, and it is necessary to consider that different KWrs have the potential for different impacts (Heneman and LeBlanc, 2002). In addition, employee value is closely linked to retention. Understanding the current and potential value of employees is vital for building up a long-term relationship with employees (Mulhern, 2007).

Patalas-Maliszewska (2013) and Farrell and LaMotta (2008) spotlighted the importance of KWrs' value in the hiring process. They concluded that value assessment can help managers to select new employees based on real requirements and decrease time for investigating job applicants. Furthermore, value assessment can be a guideline for the development of KWrs (Mulhern, 2007). KWrs should make themselves more valuable to their organizations by acquiring right competencies (Cripe and Mansfield, 2002) and organizations can assist them by providing feedback.

Hence, organizations need a framework to assess the value of their KWrs. However, academics and practitioners rarely consider this fact. Besides, few proposed models and frameworks lack two important characteristics:

(1) detailed items and procedures that could be easily obtained and fully understood by practitioners and researchers; and

(2) providing opportunity to compare all types KWrs.

In this article, a framework for KWrs' value assessment is proposed. The value of each KWr is determined based on his/her contribution to organizational value-added. Each step of the framework is properly explained, and all the necessary concepts related to the application of the framework are described. To test the applicability and validity of the framework, we undertook a case study in the marketing department of a detergent manufacturing company.

The rest of the article is organized as follows. The research background is presented in Section 2. Knowledge Value Added (KVA) method is explained in Section 3. Section 4 provides the detailed description of the proposed framework. The case study and the validation procedure are demonstrated in Section 5. Section 6 concludes this paper and offers guidelines for further research.

2. Research background

2.1 Models for KWrs' value assessment

To explain the models specifically designed for the KWrs' value assessment, it is first necessary to outline the differences between these models and other assessment models.

As it can be seen in Figure 1, assessment models can be categorized into performance assessment models and value assessment models. The main goal of value assessment models is to determine the output value derived from the work done by the individual for

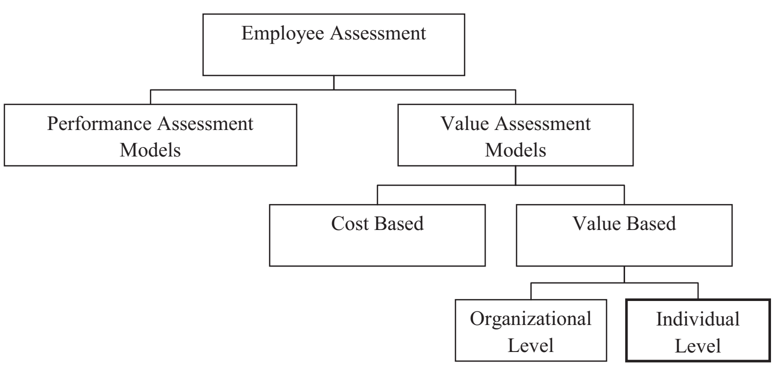

Figure 1. Categorization of the assessment models for workers

his/her organization. On the other hand, the primary goal of performance assessment models is to evaluate to what extent an assigned job is done flawlessly by the job incumbent (Drucker, 1999). As an example, consider a research institute. The performance assessment may lead to the same result for a researcher and an employee in the administrative office; however, it is evident that these two have different values for the institute.

Two aspects of performance assessment models cannot be found in value assessment models. First, these models are highly focused on the efficiency of KWrs and do not take the relationship between KWrs and major organizational key performance indicators into consideration. Second, in most of the cases, the performance assessment models have been developed for a specific type of KWrs and, therefore, not all KWrs can be compared to each other (Ramirez and Nembhard, 2004). Although there is nothing wrong with designing a performance assessment model for a specific type of KWrs (Davenport *et al.*, 2002), a value assessment model must be applicable to all types of KWrs to maintain intended functionality and provide the ability of comparing all KWrs against each other.

Based on what they assess, value assessment models fall into value-based models and cost-based models. Most of the developed models in the human resource accounting area (HRA area) belong to cost-based models. The general approach of the developed models in the HRA area is to consider costs incurred by workers (such as training costs) as an index to determine the value. Such an approach is in marked contrast to the concept of KWrs' value assessment that considers KWrs' value as the index/criterion that guides managers to supervise costs incurred by workers (Cascio, 1991).

Value-based measurement includes two main approaches: value measurement at the organizational level and value measurement at the individual level. According to the literature, some metrics such as human capital value added, human economic value added, human capital revenue factor and intellectual capital-based measures are meant to measure employee value at the organizational level (Fitz-enz, 2009). Moreover, some models in the HRA area (such as present value of future earnings) belong to this group where measurement is performed at the organizational level and average indices are used (Cascio, 1991). Measurement at the organizational level cannot provide appropriate results that fulfill the expectations.

In this paper, we consider value-based measurement at the individual level (bold box in Figure 1) and our developed framework belongs to this group. Few papers in the literature focus directly on this issue. Despite the advances in formal accounting systems and methods that measure people, the measurement of employee value has drawn little attention from academics and practitioners (Mulhern, 2007). Wang (2008) proposed a model based on the rough set theory to assess the value of KWrs. The model involves 14 characteristics. A variable that takes its value from the interval of [0,1] makes the basis for the measurement of each characteristic. The final value of a KWr is calculated using the rough set theory. This study does not clearly establish the relationship between the 14 characteristics and the major organizational factor.

Kreft (2001, 2005) presented a mathematical method to calculate a highly crucial value, which is the human potential. In his method, the compensation of an employee can be a function of his/her evaluated skills and abilities with which he/she contributes to the company's profit. Consequently, the evaluated competences add up to the revenue per employee.

Another study revolves around the application of the KP3 method for the assessment of KWrs (Ahn and Chang, 2004). In this method, the contribution of knowledge to business performance is assessed by using product and process as intermediaries between them. KWrs' assessment is mentioned as one of the applications of the KP3 method and a model is designed.

These two studies lack an appropriate framework for the application of the proposed models; thus, the applicability of the models remains undetermined.

The Employee Life Time Value model (ELTV model) was proposed by Mulhern (2007). The ELTV model calculates a dollar return to an organization attributable to an employee. The model rests on the assumption that investments in a workforce will yield future cash in-flows (Mulhern, 2007). In this model, cash in-flows and out-flows (investments on an employee) are first allocated to each employee. Then, net present value of the expected employee's cash flow is calculated based on the designated period in the employee – organization relationship. Finally, the ELTV results from subtracting costs of recruitment, hiring and other discrete costs related to the employee from the net present value of the expected employee's cash flow. The model lacks a method for determining cash in-flows and out-flows of employees and it is only applicable to cases where management can link financial in-flows to individual employees (e.g. sales workforces).

Table I shows the summary of the reviewed models, what they measure and how they perform the measurement.

The study of these models reveals that the model proposed by Wang (2008) belongs mostly to performance assessment models. The other three models fall short in terms of demonstrating two basic characteristics of a value assessment model:

(1) providing the ability to compare all types of KWrs; thus, the model must be applicable to all types of KWrs; and

(2) applicability in real situations and following clear procedures for practical use.

2.2 The definition of KWr value

How much is the value of a KWr in his/her organization? This is the question that North and Gueldenberg (2011) put before KWrs and organizations in today's competitive business environment. They believe that there is a direct relationship between the value

Model	What is measured	How the measurement is performed
Wang (2008)	14 characteristics that represent KWrs' value	Each characteristic is measured based on a variable from the interval of [0,1] Rough set theory is used to determine the final value of KWrs
Kreft (2001, 2005)	Human potential (human skills and abilities)	The Shannon formula is used to calculate the human potential
Ahn and Chang (2004)	Contribution of KWrs' knowledge to organizational performance	A model (KP3) is proposed to assess the organizational knowledge Results obtained from KP3 model and KWrs' knowledge level are used to determine KWrs' value
ELTV Mulhern (2007)	Net present value of cash flows attributable to an employee	Cash in-flows and out-flows (investments on an employee) are allocated to each employee Net present value of KWr's cash flow is considered as his/her ELTV

Table I. A summary of the reviewed models of a KWr and his/her contribution to organizational value-added and recommend this contribution to be an indicator of KWr value. In addition, Strassmann (1999a) stated that it is not salaries and wages that determine the worth of a worker, but how much economic value-added they create as an organized body in excess of the sum of their compensation, and Aldag and Reschke (1997) believed that the notion of employee value-added is intended to provide a richer and more useful measure of the human side of a business than traditional measures, to enable organizations to focus on employee worth. This view on KWrs' value can be seen in other researchers' works (McFarlane, 2008; Fitz-enz, 2009; Cripe and Mansfield, 2002; Blickenstaff, 2012; Mulhern, 2007). It can be concluded from the reviewed literature that researchers have reached a fair consensus on the concept of KWr value in an organization. KWr value can be defined as his/her contribution to organizational value-added. In this paper, we adopt the same approach to KWr value (Figure 2).

To perform KWr value assessment in an organization, we need to determine the KWr's contribution to organizational value-added, which is discussed in the following sections of this paper.

2.3 KWrs' contribution to value-added

Considering the concept of KW, It is obvious that knowledge is the most important factor of value addition (North and Gueldenberg, 2011) and value creation rests on cause-and-effect chains activated by the development of organizational knowledge resources (Schiuma *et al.*, 2012). Hence, KWrs are value creators and value adders that their major role is the process, and application of knowledge and information to completing essential tasks, making decisions and solving problems (McFarlane, 2008). Their value addition refers to the extent to which they contribute to the team/organization in terms of knowledge to create products and services (Kannan and Akhilesh, 2002).

With respect to this notion, KWrs' contribution to value-added should be seen through lens of the knowledge that they apply to accomplish their tasks, and in a broader view, value-added evaluation of KWrs' knowledge is a method to assess their value (Bogdanowicz and Bailey, 2002; Strassmann, 1999b).

Therefore, the calculation of KWrs' value-added requires a framework to determine the contribution of KWrs' knowledge to organizational value-added. To design a framework, which is able to calculate this contribution correctly, the two following questions must be answered:

2.3.1 How can value-added of knowledge be measured? In the literature, knowledge evaluation is addressed in various ways and there are different evaluation practices (López *et al.*, 2013). Skyrme (2005) divided the knowledge evaluation methods into five main categories:

(1) value-based methods (asset focus);

(2) performance measures (action focus);

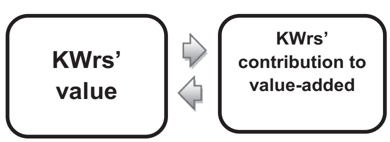

Figure 2.
KWrs' value is equal to KWrs' contribution to value-added

(3) knowledge management benefits measure;
(4) knowledge management assessment tools (baseline focus); and
(5) intellectual capital measurement models.

Based on the approach that we have taken, it seems that methods of the first category are appropriate. It should be noted that the desired method must be able to determine the value of knowledge applied to each organizational process. Moreover, the detailed items and procedures of the chosen method must be available and its applicability must be verified. These two characteristics are essential for the design of a framework that fills the research gaps mentioned earlier.

The reviewed literature led us to the KVA method. Housel and Kanevsky (1995) developed the KVA method to measure the value of organizational knowledge asset. Several articles, books and dissertations have addressed the implementation of the KVA method along with its applications and case studies. In addition, due to substantial theoretical background and practical usability of the KVA method, it is recognized as a valid measurement tool and used by many companies to assess their processes (Kannan and Akhilesh, 2002). Furthermore, there are software packages that support this method (e.g. GAUSS developed by GaussSoft, Inc. and ProcessEdge).

The KVA method has the necessary characteristics, and we use it to develop our framework. The detailed information on the KVA method and how we used it to develop our proposed framework is described in Section 3.

2.3.2 How are knowledge domains and KWrs' operational knowledge level in each of them determined? Different knowledge domains are brought into play to accomplish a process. KWrs perform the process by applying their operational knowledge in these domains. KWrs go through different education and training periods and have different amounts of experience; thus, each of them is familiar with different knowledge and has his/her own level of expertise in each knowledge domain. This fact plays an important role in determining the contribution of KWrs' knowledge to value-added and must be considered for the design of the framework. In the proposed framework, appropriate steps are considered to cover this issue.

3. KVA method

The KVA method was introduced to lead reengineering activities effectively. This method was utilized to monitor the realization of goals pursued during process reengineering (Housel and Kanevsky, 1995). The KVA method provides a means to count the amount of corporate knowledge, in equivalent units, required to produce the outputs of business processes and can be used to measure the value of knowledge assets deployed in core processes objectively.

KVA theory was developed from the complexity theoretic concept of the fundamental unit of change, i.e. unit of complexity. The information bit was theoretically the best way to describe a unit of Kolmogorov complexity. However, to make the implementation of the KVA method more practical, a knowledge-based metaphor was used as a means to describe units of change in terms of the knowledge required to make the changes (Housel and Nelson, 2005). If "P" is considered as a business process which has "a" as its input and "b" as its output, underlying assumptions of KVA are:

- If "a" is equal to "b", no value has been added by process "P".
- If "a" is changed by process "P" to "b", value has been added and it is proportionate to the change.
- Change can be measured by amount of knowledge required to make the change (Housel and Kanevsky, 1995).

So, value-added of a process is proportionate to the amount of knowledge applied to accomplish it.

To determine the amount of knowledge, Housel and Kanevsky proposed three approaches:

(1) the time needed to learn the process;
(2) the number of process instructions; and
(3) the sequence length of binary questions (i.e. bits) required to complete the process (Housel and Nelson, 2005).

Once the corresponding amount of knowledge for each process is determined based on the same unit, the contribution of each process to organizational value-added (revenue or profit) will be equal to the ratio of its corresponding knowledge to the total knowledge deployed in organizational processes multiplied by total organizational value-added.

The brief description of KVA method is as follows (Housel and Bell, 2001):

- *Step 1:* Identify the core processes and their sub-processes.
- *Step 2:* Elect an appropriate approach to knowledge measurement. Based on the chosen approach, make decision on a proper unit.
- *Step 3:* Calculate the amount of knowledge in all sub-processes.
- *Step 4:* Designate a suitable period for sampling which is long enough to capture a representative sample of the core process's final product/service output.
- *Step 5:* Multiply the learning time/number of process instructions/length of the yes–no string for each sub-process, by the number of times the sub-processes are executed during the designated period.
- *Step 6:* Allocate revenue to sub-processes in proportion to the values obtained in Step 5 and calculate costs related to each sub-process.
- *Step 7:* Calculate the return of knowledge and interpret the results.

In this paper, the first six steps of KVA are performed to determine the contribution to organizational value-added for each process. Indeed, the sub-steps of the first step of our framework are similar to these six steps. Because the learning time of each process was used as the basis for the calculation of the amount of knowledge, Step 2 was ignored. Moreover, there was no need to calculate process cost, thus it was excluded from Step 6. Then, Step 5 and Step 6 were integrated into the fourth sub-step of Step 1 of the proposed framework. Detailed description of the steps will be given in Section 4.

4. The proposed framework

The general overview of the proposed framework is depicted in Figure 3.

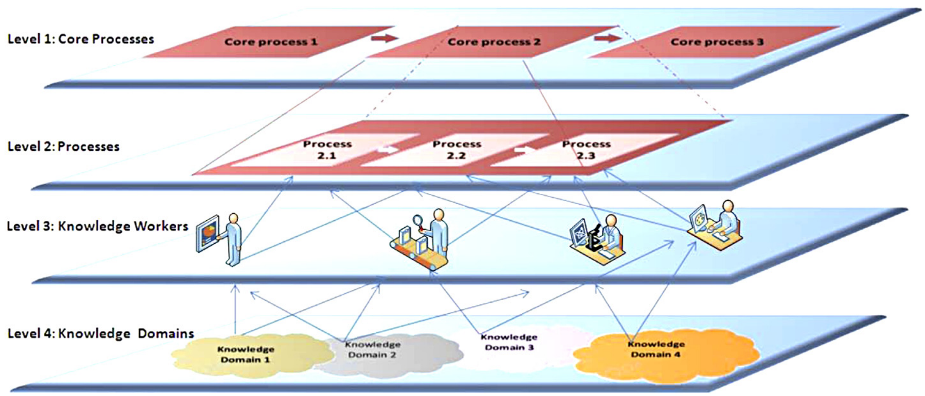

Figure 3.
General overview of the framework

The developed framework has four levels. At the first level, an organization creates value for its clients through a set of core processes. The second level is about sub-processes that form each core process. Indeed, the first two levels show the breakdown structure of common organizational processes. For example, the American Productivity and Quality Center has classified organizational processes into four levels: category, process group, process and activity. To avoid ambiguity in the proposed framework, we use *layer* to mention an organizational level. Moreover, it is assumed that at the second level of the framework, organizational sub-processes extend from the highest layer to the lowest layer. Figure 3 depicts just one layer, but it is possible that several layers exist between the highest and the lowest layers. Based on this assumption, the value-added of each process equals the sum of the value-added of its sub-processes at lower layers. Level 3 is the place where KWrs of an organization perform their functions or tasks using their knowledge, skills and abilities (each task is a part of sub-processes at the lowest layer). At this level, they operate different equipment, interact with people and analyze information (Heidary *et al.*, 2011). We have knowledge domains at the fourth level. The major determinant factor of an individual's contribution to the created value is his/her operational knowledge level in knowledge domains related to each process.

The knowledge of a KWr can be divided into four categories which are formal knowledge (declarative knowledge), procedural knowledge, meta knowledge and impressionistic knowledge (Davis and Naumann, 1997). With these categories in mind, the operational knowledge of each KWr is defined as follows (Davies and Naumann, 1997):

Knowledge of how to do something. It is mostly informal and cannot be easily conveyed through lecture or textbook. It is the ability to effectively use the most appropriate tools and techniques available. It tends to be associated with specifications of work tasks or activities.

Given the above, the framework for KWrs value assessment is composed of two steps:

- *Step 1.* Measuring the value-added of each core process and its sub-processes.
- *Step 2.* Measuring the contribution to value-added for each KWr.

Detailed description of each step and its main sub-steps is provided in the following sub-sections.

4.1 Measuring the value-added of each core process and its sub-processes

Based on the KVA method, the value-added of each organizational core process and its sub-processes is measured in this step of the framework. Figure 4 shows the sub-steps that must be followed.

4.1.1 Identifying core processes and their sub-processes. This sub-step requires an organizational process map. To determine the number of layers that each core needs to be broken into, we should bear in mind that:

- At the lowest layer, knowledge domains of sub-processes need to be identifiable.
- At the lowest layer, the learning time of sub-processes must be measurable.

4.1.2 Determining the learning time of each process. As it was mentioned in Section 3, there are three common approaches used for measuring the amount of knowledge for each process in the KVA method. In this article, we use the first approach to estimate the amount of knowledge in each process. In this approach, the amount of knowledge needed for each process is directly proportional to the learning time of that process. The learning time can be defined as the necessary amount of time needed for an ordinary person to learn how to accomplish the process correctly (Housel and Bell, 2001).

Measuring the learning time of processes begins with sub-processes at the lowest layer. Learning time of upper-layer processes is calculated based on the total learning time of their sub-processes. To obtain these learning times, the following steps must be taken:

- *Expert selection:* It is necessary to select one or more experts for each process. The experts must be able to provide an actual estimate of learning time needed for a given process based on formal and informal training times, job experience, interviews with employees and training manuals and programs.

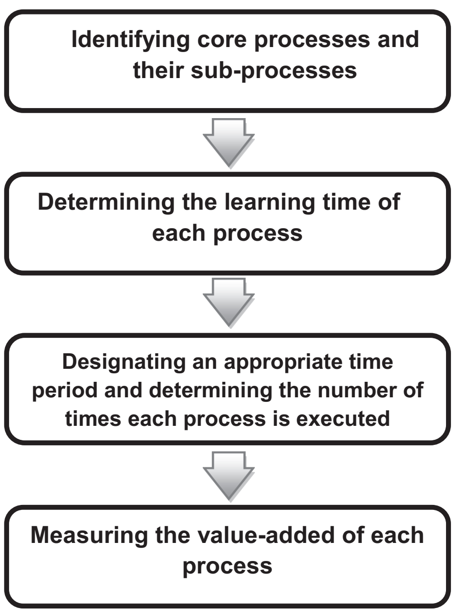

Figure 4.
Sub-steps for measuring value-added of each process

- *Providing the experts with the definition of learning time:* At this point, a common definition of learning time is presented to the chosen experts. It is essential to define a general reference for the learning time of process and present it to the experts. If, for example, a company has already got some training experience regarding a process, the time being spent on training could be used as the reference to determine the learning time. Furthermore, it is also important to estimate the learning time of knowledge of information system. The learning time of knowledge of information system is defined as follows: "The time required for an average trainee being taught to produce the information system outputs" (Housel and Bell, 2001).
- *Determining the learning time of processes:* Now, the experts must estimate the learning time of processes. The estimation of learning time consists of two parts: estimation of process learning time and estimation of learning time of knowledge of information systems.

Each process learning time needs to be verified after estimation. Verification is performed through comparison among learning times of processes to detect likely inaccuracies and errors in estimated values. For example, devoting excessive time to one particular task is one of the most common sources of inaccuracy.

4.1.3 Designating an appropriate period and determining the number of times each process is executed. In this sub-step, an appropriate period must be chosen. Processes at the lowest layer need to be accomplished at least once during that period. Thus, the number of repetitions of each process can be determined during the period.

4.1.4 Determining the value-added of each process. To obtain the value-added of each process, a forward and backward calculation is used. As shown in Figure 4, the knowledge embedded in each process performed at the lowest layer is first calculated by equation (1) (Housel and Bell, 2001):

$$\begin{aligned} PKA_i = {} & \text{number of repetitions of process } i \times \text{learning time of process } i \\ & + \text{learning time of knowledge of information systems regarding process } i \end{aligned} \tag{1}$$

where PKA_i is the amount of knowledge in process i.

Then, the amount of knowledge (PKA) is calculated for the processes at upper layers based on the total knowledge of sub-processes. Finally, the amount of knowledge in each core process is determined.

To determine the contribution of each process to value-added, the reverse direction is followed (according to Figure 5).

To obtain the contribution to value-added, the knowledge contribution of each core process to total knowledge of core processes is first calculated by equation (2):

$$PR_j = \frac{PKA_j}{\sum_n PKA_n} \tag{2}$$

where PR_j is the ratio of knowledge of core process j to total knowledge of core processes.

Then, the value-added of each core process is calculated by equation (3):

$$qp_j = PR_j \times total\ value - added \quad (3)$$

where qp_j and *total value-added* are core process *j*'s contribution to value-added and total value-added of organization which could be based on either revenue or profit, respectively.

The exact calculation can be done for all processes at lower layers, but PKA_i is defined as the amount of knowledge in process *i* in equation (2) and denominator is replaced by the knowledge of upper-layer process. In equation (3), qp_i is defined as process *i*'s contribution to value-added and total value-added is replaced by *qp* of its upper-layer process. This calculation must be done for all processes extending from the highest layer to the lowest layer.

4.2 Measuring the contribution to value-added for each KWr

The value-added is created through KWr participation in corporate activities (carrying out processes). Each KWr can play an effective role in performing his/her tasks based on his/her operational knowledge level in different knowledge domains of a process. Therefore, KWr's contribution to value-added can be measured based on his/her level in each knowledge domain.

Figure 6 shows the sub-steps for measuring the contribution of each KWr to value-added.

KWr's contribution to organizational value-added or process value-added can be obtained through these sub-steps. In what follows, it is assumed that the calculation is done for a specific process which its KWrs are considered for the assessment.

4.2.1 Determining the knowledge domains at the lowest layer and their importance. In this sub-step, processes at the lowest layer are first considered and their corresponding knowledge domains are specified. Then, the importance of each knowledge domain to execution of the process is determined according to experts' opinion. The importance of each knowledge domain is indicated by a number ranging from 0 to 1.

4.2.2 Determining the KWrs' operational knowledge level in each knowledge domain. To determine the operational knowledge level of KWrs in each knowledge domain of the process, we use the 11-scale rating for the knowledge-level assessment (Table II) introduced by Ahn and Chang (2004).

To evaluate KWr's level in each knowledge domain, managers and experts are consulted.

4.2.3 Calculating the value-added of each KWr. KWr's value-added is given by equation (4):

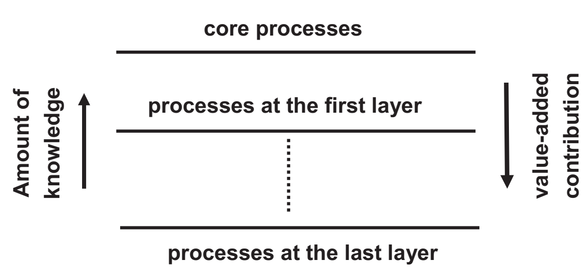

Figure 5.
A forward and backward calculation to obtain value-added

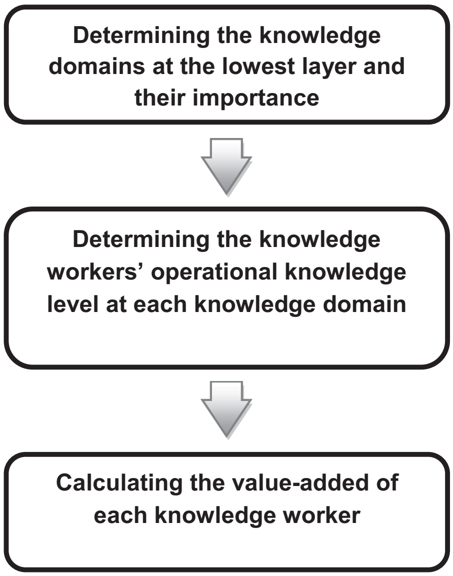

Figure 6. Sub-steps for measuring the contribution of each KWr to value-added

Rating	Description
0	Complete ignorance
1	Needs fundamental education and constant supervision
2	Very poor and little hope for improvement
3	Poor and needs significant development
4	OK with constant guidance, and it could become satisfactory with more experiences
5	Satisfactory and can perform a job requiring the skill satisfactorily with some support from the colleagues
6	Having some experience
7	Good and can do any job requiring the knowledge successfully and independently
8	Very good and can do any job related to knowledge-intensive work successfully
9	Can perform know-intensive job not only independently but also can be a leader helping other people who need support
10	Excellent and expert-equivalent level which can be a mentor or role model for the knowledge-related works
11	World-class expert on the domain

Source: Ahn and Chang (2004)

Table II. Eleven-scale rating for the assessment of knowledge level

$$VA_l = \sum_{k=1}^{n_l} \sum_{j=1}^{m_k} \left(\frac{r_{lj}}{\sum_i r_{ij}} \times d_{jk} \times qp_k \right) \quad (4)$$

Where the parameters are defined as follows:

VA_l: The value-added of the lth KWr.

r_{ij} : The knowledge level of the ith KWr in jth knowledge domain.

d_{jk} : The importance of the knowledge domain j in execution of the process k.
n_i : The number of processes to which the ith KWr contributes.
m_k : The number of knowledge domains related to the process k.
qp_k : Process k's contribution to value-added.

5. Case study

To implement the proposed framework, a detergent manufacturing company was chosen with 600 employees, of which 200 are specialists and managers. They can be considered as KWrs. Due to the time and resource constraints, the framework was implemented in the marketing department with 17 KWrs. Marketing process is recognized as the core process. A description of the framework's steps is presented in the following sub-sections.

5.1 Identifying core processes and their sub-processes

The quality management system is carried out based on ISO9001:2008 in the detergent manufacturing company. The process map has three layers and it was created by IDEF0 notation. As controls and mechanisms were also determined by IDEF0 notation, useful information on procedures and execution of processes could be obtained.

We identified five core processes:

(1) production;
(2) distribution;
(3) marketing;
(4) planning and inventory control; and
(5) procurement.

We also considered the second layer of the process map for estimation of the learning time. The reason that we chose this layer is that there was a process improvement team for each process at the second layer. Each team had a supervisor of its own, thus it was possible to gather different information on different aspects of each process. After consulting these supervisors, it became clear that there was a possibility for the collection of information on the learning time and identification of knowledge domains at the second layer. For example, the marketing process, as a core process, is composed of the following sub-processes:

- identifying the key consumer market;
- creating the public identity or image of the company or brand;
- monitoring current market trends; and
- building and maintaining customer relationship.

5.2 Determining the learning time of each process

The output of this sub-step is the learning time of each process. To evaluate the learning time of processes at the second layer (the lowest layer considered), it was decided to consult the supervisor of each process improvement team. Supervisors were given a booklet containing a brief description of the framework, explanation of the learning time of process and information system. Then, all supervisors were invited to attend a meeting. We first tried to establish a common concept of learning time. The process of preparing monthly report, which all participants were familiar with, was set as the reference. Afterward, each person made comment on the learning time of this process. Finally, a consensus was reached and all evaluations could be conducted based on a common ground. Then, each supervisor mentioned the corresponding learning time of the process he/she was responsible for and the related information system. The learning time of each process was addressed based on a common reference in the presence of all supervisors, thus no outlier data were given.

5.3 Designating an appropriate period and determining the number of times each process is executed

To designate an appropriate period, we asked each supervisor to provide an estimated time needed to complete the process he/she was responsible for. Eventually the longest period, that was a year, was identified and the number of times each process was executed within that period was obtained.

5.4 Measuring the value-added of each process

As mentioned before, a forward and backward calculation needs to performed in this sub-step. By applying equation (1) and using the learning time of process and information system along with the number of times each process is executed at the second layer, the amount of knowledge is obtained for each of these processes. The amount of knowledge in each core process equals the sum of corresponding values of knowledge amount in related sub-processes at the second layer. As an example, Table III shows the amount of knowledge in sub-processes of the marketing process at the second layer. Based on the following calculation, the amount of knowledge in the marketing process is 3,600.

$$PKA_{marketing} = PKA_{Identifying\ the\ key\ consumer} + PKA_{Creating\ the\ public\ identity} + PKA_{Monitoring\ current\ market\ trends} + PKA_{Building\ and\ maintaining\ customer\ relationship} \quad (5)$$

$$\Rightarrow PKA_{marketing} = (400 \times 2 + 100) + (500 \times 2 + 150) + (450 \times 2 + 100) + (400 \times 1 + 150) = 3600 \quad (6)$$

Similar calculations were made on the related information regarding the sub-processes of other core processes to obtain the amount of knowledge in each core process. The first column of Table IV shows the obtained values.

When it comes to the backward calculation, we first obtain the knowledge contribution of each core process to total knowledge of core processes (*PR*) using equation (2) (Table IV). Due to the confidentiality of information regarding income and interest, we used 100,000 as the total value-added in equation (3) to determine the contribution of each core process to value-added (*qp*). As the ratio of the obtained values would be used for later calculations, using 100,000 as total value-added would not affect the validity of results. The calculation for marketing as the core process is as follows:

Table III.
The amount of knowledge in sub-processes of the marketing process

Sub-processes	Learning time of process	The number of times each process is executed	Learning time of information system	Amount of knowledge in process (*PKA*)
Identifying the key consumer market	400	2	100	900
Creating the public identity or image of the company or brand	500	2	150	1150
Monitoring current market trends	450	2	100	1000
Building and maintaining customer relationship	400	1	150	550

$$PR_{marketing} = \frac{PKA_{marketing}}{PKA_{Production} + PKA_{Sale} + PKA_{Marketing} + PKA_{Planning\ and\ inventory\ control} + PKA_{Procurement}} = \frac{3600}{16950} = 0.21 \tag{7}$$

$$qp_{Marketing} = PR_{Marketing} \times total\ value - added = 0.21 \times 100000 = 21000 \tag{8}$$

Analogous calculations were also performed on the related information of sub-processes of marketing process. For example, the corresponding calculation for the sub-process "identifying the key consumer market" is as follows:

$$PR_{identifying\ the\ key\ consumer} = \frac{PKA_{identifying\ the\ key\ consumer}}{PKA_{Marketing}} = \frac{900}{3600} = 0.25 \tag{9}$$

$$qp_{identifying\ the\ key\ consumer} = PR_{identifying\ the\ key\ consumer} \times qp_{Marketing} = 0.25 \times 21000 = 5250 \tag{10}$$

Obtained results are shown in Table V.

Table IV.
The amount of knowledge and contribution to value-added in each core process

Core processes	Amount of knowledge in each core process (*PAK*)	Knowledge contribution of each core process to total knowledge of core processes (*PR*)	Contribution to value-added (*qp*)
Production	4500	0.26	26000
Sale	3000	0.18	18000
Marketing	3600	0.21	21000
Planning and inventory control	3300	0.19	19000
Procurement	2550	0.16	16000

5.5 Determining the knowledge domains at the lowest layer and their importance

Knowledge domains related to each sub-process of marketing and their importance to the execution of processes must be determined in this sub-step. Seventeen job descriptions were first provided by the KWrs under study. The job description standard model in the detergent manufacturing company includes requirements regarding knowledge, skill and ability, which define qualifications for each job or task. The available information on knowledge, skills and abilities served as a proper basis for the identification of knowledge domains. Having scrutinized each job description, we made an initial list of requirements. Then, the similar requirements were combined. To finalize the list, we consulted four supervisors of process improvement teams. We also asked them to evaluate the importance of each knowledge domain using a number ranging from 0 to 1 and took the average of the given values. Identified knowledge domains and their importance (rounded average of the given values) are shown in Table VI.

Sub-processes	Amount of knowledge in each sub-process (*PAK*)	Knowledge contribution of each sub-process to total knowledge of sub-processes (*PR*)	Contribution to value-added (*qp*)
Identifying the key consumer market	900	0.25	5250
Creating the public identity or image of the company or brand	1150	0.32	6720
Monitoring current market trends	1000	0.28	5880
Building and maintaining customer relationship	550	0.15	3150

Table V. The amount of knowledge and contribution to value-added in sub-processes of the marketing

Sub-processes Knowledge domains	Identifying the key consumer market	Creating the public identity or image of the company or brand	Monitoring current market trends	Building and maintaining customer relationship
Banking	0.1	–	–	–
Customer behavior analysis	0.15	–	0.4	0.4
Financial audit		0.15	–	–
Financial management	0.1	0.25	0.3	–
International marketing		0.15	0.15	–
Macro economy	0.1	–	–	–
Marketing	0.2	–	–	–
Micro economy	–	0.25	–	–
Production management	–	–	0.1	0.15
Procurement and distribution systems	0.05	–	–	0.35
Statistics	0.05	–	0.05	0.1
Strategic management	0.2	0.2		
Technical language	0.05	–	–	–

Table VI. Importance of the knowledge domains to execution of processes

5.6 Determining the KWrs' operational knowledge level in each knowledge domain

Operational knowledge of each KWr in knowledge domains related to his/her tasks is determined in this sub-step. We provided each KWr with a questionnaire that contained the definition of operational knowledge along with the 11-scale rating for the assessment of knowledge level (Table II). Moreover, we asked them to determine their operational knowledge in knowledge domains related to the sub-processes to which they contributed with respect to the provided rating. We also asked supervisors to evaluate the knowledge level of the 17 KWrs in related knowledge domains. Questionnaires were compared and, in most of the cases, no significant difference was found between the ones filled out by KWrs and the ones filled out by supervisors. In case of slight difference, the average value was considered. Knowledge levels of each KWr in knowledge domains of the sub-processes are shown in Tables AI–AIV in Appendix 1.

5.7 Calculating the value-added of each KWr

In this step, we calculate the contribution to organizational value-added for each KWr based on equation (4). The target values were obtained using the gathered information and Microsoft Excel. For example, we took the following steps for KWr 2:

As it can be seen in Tables AI and AIV (Appendix 1), KWr2 is involved in "creating the public identity" and "building and maintaining customer relationship" processes, thus:

$$VA_{KWr2} = \sum_{k \in \{Creating\ the\ public\ identity,\ Building\ and\ maintaining\ customer\ relationship\}} \sum_{j=1}^{m_k} \left(\frac{r_{KWr2,j}}{\sum_i r_{ij}} \times d_{jk} \times qp_k \right) \tag{11}$$

According to Table AI, knowledge domains related to the sub-process "creating the public identity" are strategic management, financial management, international marketing, financial audit and micro economy. Furthermore, four KWrs (KWr1, KWr2, KWr14 and KWr17) are involved in this sub-process. Table AIV shows that the sub-process "building and maintaining customer relationship" includes customer behavior, production management, statistics, procurement and distribution systems as knowledge domains. In addition, six KWrs (KWr1, KWr2, KWr7, KWr9, KWr13 and KW16) are involved in this sub-process.

$$\begin{aligned} VA_{KWr2} = & \sum_{j \in \{Strategic\ management,\ Financial\ management,\ International\ marketing,\ Financial\ audit,\ Micro\ economy\}} \\ & + \left(\frac{r_{KWr2j}}{\sum_{i \in \{KWr1, KWr2, KWr14, KWr17\}} r_{ij}} \times d_{j,\,Creating\ the\ public\ identity} \times qp_{Creating\ the\ public\ identity} \right) \\ & + \sum_{j \in \{Customer\ behavior,\ Production\ management,\ Statistics,\ Procurement\ and\ distribution\ systems\}} \\ & \left(\frac{r_{KWr2j}}{\sum_{i \in \{KWr1, KWr2, KWr7, KWr9, KWr13, KW16\}} r_{ij}} \times d_{j,\,maintaining\ customer\ relationship} \times qp_{maintaining\ customer\ relationship} \right) \end{aligned} \tag{12}$$

Considering the values of parameters, the value of VA_{KWr2} would be 2,144. Table VII shows the obtained values.

Managers in the detergent manufacturing company found out that the obtained results could be used as the basis for decision making on promotions and financial rewards. Traditionally, promotions and financial rewards were determined based on the job experience and the organizational level at which an employee worked. This approach had resulted in dissatisfaction among employees. For example, an inventory supervisor with considerable job experience could receive better financial rewards compared to a highly educated engineer with little job experience. Top managers of the company found it essential to implement our proposed framework and use the obtained results as the basis for decision making on promotions and financial rewards. It became evident that job experience and organizational level are not the only appropriate bases to determine promotions and financial rewards, and KWrs value must be taken into account too.

5.8 Results and validation procedure

We could not expect managers and decision makers of the detergent manufacturing company to quantify the contribution of each KWr to value-added and compare it with the one provided by the framework. To validate the results, it seemed logical to ask them to provide us with a ranking for each KWr's relative contribution to process/organizational value-added and, then, compare the results with the ones given by the framework. Thus, we asked seven supervisors from marketing and sales departments to recommend rankings for the 17 KWrs under study.

Table VII. Contribution to value-added for each KWr

KWr	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Contribution to value-added	4894	2144	1034	850	925	1042	493	833	379	1071	1130	917	544	1508	980	648	1607

Table VIII. Information regarding the data entered into SPSS software

Ranks

	Group	N	Mean rank	Sum of ranks
V01	1	17	18.47	314.00
	2	17	16.53	281.00
	Total	34		

Table IX. Test statistics provided by SPSS software

Test statistics[b]

	V01
Mann–Whitney U	128.000
Wilcoxon W	281.000
Z	−0.568
Asymp. sig. (two-tailed)	0.570
Exact sig. [2*(one-tailed sig.)]	0.586[a]

Notes: [a] Not corrected for ties; [b] Grouping variable: group

We considered the statistical hypothesis that the results provided by supervisors (recommended rankings) and the ones given by the proposed framework share the same mean value. We used Mann–Whitney U test, which is a non-parametric statistical hypothesis test, due to the nature of the data and size of each sample which was large enough. The null hypothesis (*H0*) is: both groups (results provided by supervisors and the ones given by the proposed framework) come from the same distribution.

We used SPSS software to perform the Mann–Whitney U test. The input information and test statistics are illustrated in Table VIII and Table IX, respectively.

Based on the obtained values, the p-value is 0.586, which is greater than $\alpha = 0.05$, thus the *H1* is rejected and, therefore, both groups come from the same distribution.

6. Conclusion

In this paper, we proposed a new framework for the assessment of KWrs. To design this framework, KWrs' value was defined as their contribution to organizational value-added. The importance of such a framework is twofold. First, this framework could remind mangers of the fact that in the knowledge-based economy, KWrs are not just cost-center employees; rather, they are the most invaluable capital and the most important source of value creation in organizations. Second, the results obtained from the implementation of the proposed framework could be used to manage KWrs effectively in terms of selection, planning, development, compensation, retention, promotion and financial reward.

Time needed for implementing the method depends on two factors. The first factor is the number of KWrs whom are assessed. The second one is quality of the job description and the process map. However, after first implementation of the method in an organization, it can be performed more quickly for next implementations. Because, elements of the method (e.g. learning time and knowledge domains) determined in the first implementation can be used for next implementations.

Future research trends fall into three groups:

(1) developing and implementing other practical models based on the index given by our proposed framework;

(2) using other models of knowledge evaluation to develop more advanced tools for KWrs' value assessment; and

(3) categorizing KWrs in a similar way that was introduced by Heidary *et al.* (2012) and analyzing the output of the proposed framework for each category.

References

Adelstein, J. (2007), "Disconnecting knowledge from the knower: the knowledge worker as Icarus", *Equal Opportunities International*, Vol. 26 No. 8, pp. 853-871.

Ahn, J.H. and Chang, S.G. (2004), "Assessing the contribution of knowledge to business performance: the KP3 methodology", *Decision Support Systems*, Vol. 36 No. 4, pp. 403-416.

Aldag, R. and Reschke, W. (1997), "Employee value added: measuring discretionary effort and its value to the organization", Center for Organization Effectiveness, 608/833-3332, pp. 1-8.

Baker, M. (1992), "Utilizing productivity indices to optimize the job-qualification match of knowledge workers", *Proceedings of the International Conference in Eatontown IEEE International Engineering Management Conference*, IEEE, NJ, pp. 59-62.

Blickenstaff, G. (2012), "How much are your employees worth?", available at: www.inc.com/glen-blickenstaff/how-much-are-your-employees-worth (accessed 1 May 2013).

Bogdanowicz, M.S. and Bailey, E.K. (2002), "The value of knowledge and the values of the new knowledge worker: generation X in the new economy", *Journal of European Industrial Training*, Vol. 26 Nos. 2/3/4, pp. 125-129.

Brelade, S. and Harman, C. (2007), "Understanding the modern knowledge worker", *Knowledge Management Review*, Vol. 10 No. 3, pp. 24-29.

Cascio, W.F. (1991), *Costing Human Resources: The Financial Impact of Behavior in Organizations*, 3rd ed, PWS-Kent Pub, Boston.

Cortada, J.W. (1998), *Rise of the Knowledge Worker*, Butterworth-Heinemann, Boston, MA.

Cripe, E.J. and Mansfield, R.S. (2002), *The Value-added Employee: 31 Skills to Make Yourself Irresistable to any Company*. 2nd ed, Butterworth–Heinemann, Woburn, MA.

Davenport, T.H., Thomas, R.J. and Cantrell, S. (2012), "The mysterious art and science of knowledge-worker performance", *MIT Sloan Management Review*, Vol. 44 No. 1, pp. 23-30.

Davis, G.B. and Naumann, J.D. (1997), *Personal Productivity with Information Technology*, Mcgraw-Hill, New York, NY.

Drucker, P.F. (1959), *The Landmark of Tomorrow*, Harper and Row, New York, NY.

Drucker, P.F. (1995), *Managing in a Time of Great Change*, Penguin Books, New York, NY.

Drucker, P.F. (1999), "Knowledge worker productivity: the biggest challenge", *California Management Review*, Vol. 41 No. 2, pp. 79-94.

Eppler, D.M.J., Seifried, P.M. and Ropnack, A. (1999), "Improving knowledge intensive processes through an enterprise knowledge medium", *SIGCPR'99 Proceedings of the International Conference in New Orleans, LA*, ACM, New York, NY pp. 222-230.

Eustace, C. (2003), "A new perspective on the knowledge value chain", *Journal of Intellectual Capital*, Vol. 4 No. 4, pp. 588-596.

Farrell, M. and LaMotta, L. (2008), "How much are key employees worth?", available at: www.forbes.com/2008/12/03/small-business-compensation-ent-hr-cx_mf_1203keyguyworth (accessed 5 May 2013).

Fitz-enz, J. (2009), *The ROI of Human Capital: Measuring the Economic Value of Employee Performance* 2nd ed, AMACOM, New York, NY.

Heidary, D.J., Afrazeh, A. and Hosseini, M.S.M. (2011), "An activity-based framework for quantification of knowledge work", *Journal of Knowledge Management*, Vol. 15 No. 3, pp. 422-444.

Heidary, D.J., Afrazeh, A., Hosseini, M.S.M. and GhezelArsalan, M.R. (2012), "Knowledge work difficulty factors: an emperical study based on different groups of knowledge workers", *SAJEMS*, Vol. 15 No. 1, pp. 1-15.

Heneman, R.L. and LeBlanc, P.V. (2002), "Developing a more relevant and competitive approach for valuing knowledge work." *Compensation & Benefits Review*, Vol. 34 No. 4, pp. 43-47.

Housel, T. and Bell, H.A. (2001), *Measuring and Managing Knowledge*, McGraw-Hill, New York, NY.

Housel, T. and Kanevsky, V. (1995), "Reengineering business processes: a complexity theory approach to value added", *INFOR*, Vol. 33 No. 4, pp. 248-262.

Housel, T. and Nelson, k. (2005), "Knowledge valuation analysis: applications for organizational intellectual capital", *Journal of Intellectual Capital*, Vol. 6 No. 4, pp. 544-557.

Kannan, G. and Akhilesh, K.B. (2002), "Human capital knowledge value added, a case study in infotech", *Journal of Intellectual Capital*, Vol. 2 No. 2, pp. 167-179.

Kreft, H.D. (2001), "Human potential: how knowledge can be measured", paper presented at KnowTech Conference, 1-3 November 2001, Dresden, Germany, available at http://www.humatics.de/uploads/mit_download/knwotech2001engl.pdf (accessed 3 May 2013).

Kreft, H.D. (2005), "Extension of the descriptive framework of economic theories by the introduction of knowledge functions", *Vision Patents AG Working Paper No. D5.05*, available at papers.ssrn.com/sol3/papers.cfm?abstract_id=756646 (accessed 3 May 2013).

Lavoie, M., Roy, R. and Therrien, P. (2002), "A growing trend toward knowledge work in Canada", *Research Policy*, Vol. 31 No. 8, pp. 1-18.

Lind, M. and Sulek, M. (2000), "A methodology for forecasting knowledge work projects", *Computers & Operations Research*, Vol. 27 Nos. 11/12, pp. 1153-1169.

López, M.P., Berends, H., Huysman, M. and Soekijad, M. (2013), "Knowledge evaluation in organizations: a systematic review", paper presented at the Organizational Learning, Knowledge and Capabilities Conference (OLKC) 25-27 April, Washington, DC, available at www.olkc2013.com/sites/ www.olkc2013.com/files/downloads/140.pdf (accessed 20 May 2013).

McFarlane, D.A. (2008), "Effectively managing the 21st century knowledge worker", *Journal of Knowledge Management Practice*, Vol. 9 No. 1, pp. 3-7.

MacLean, B. (2007), "Rewarding employee contributions, not job titles: a base pay strategy to retain peak performers", available at: www.shrm.org/hrdisciplines/compensation/Articles/Pages/CMS_020036 (accessed 3 May 2013).

Mulhern, F. (2007), "Employee lifetime value: measuring the long-term financial contribution of employees", Forum for People Performance Management and Measurement Performance Improvement Council.

Murray, A.J. and Greenes, K.A (2007), "From the knowledge worker to the knowledge economy", *The Journal of Information and Knowledge Management Systems*, Vol. 37 No. 1, pp. 7-13.

Nickols, F. (2000), "What is in the world of work and working: some implications of the shift to knowledge work", in Cortada, J.W. and Woods, J.A. (Eds), *The Knowledge Management Yearbook of 2000-2001*, Butterworth-Heinemann, Woburn, MA, pp. 2-11.

North, K. and Gueldenberg, S. (2011), *Effective Knowledge Work: Answers to the Management Challenges of the 21st*, Emerald Group Publishing Limited, Bingley.

Pan, W., Liu, J. and Hawryszkiewycz, I. (2008), "A method for describing knowledge work processes", *Workshop on Advanced Information Systems for Enterprises 2008 Proceedings of the International Conference in Constantine, Algeria*, IEEE, pp. 46-52.

Patalas-maliszewska, J. (2013), *Managing Knowledge Workers: Value Assessment, Methods, and Application Tools*, Springer, London.

Pyoria, P. (2005), "The concept of knowledge work revisited", *Journal of Knowledge Management*, Vol. 9 No. 3, pp. 116-127.

Ramírez, Y. and Nembhard, D. (2004), "Measuring knowledge worker productivity: a taxonomy" *Journal of Intellectual Capital*, Vol. 5 No. 4, pp. 602-628.

Schiuma, G., Carlucci, D. and Lerro, A. (2012), "Managing knowledge processes for value creation", *The Journal of Information and Knowledge Management Systems*, Vol. 42 No. 1, pp. 4-14.

Skyrme, D. (1998), *Measuring the Value of Knowledge: Metrics for the Knowledge-based Business*, Business Intelligence Limited, London.

Smith, A.D. and Rupp, W.T. (2004), "Knowledge workers' perceptions of performance ratings", *Journal of Workplace Learning*, Vol. 16 No. 3, pp. 146-166.

Strassmann, P.A. (1999a), "Calculating knowledge capital", *Knowledge Management Magazine*, October.

Strassmann, P.A. (1999b), "What's the worth of an employee?", available at: www.strassmann.com/pubs/km/1999-12 (accessed 3 May 2013).

Sveiby, K.E. and Simons, R. (2002), "Collaborative climate and effectiveness of knowledge work: an empirical study", *Journal of Knowledge Management*, Vol. 6 No. 5, pp. 420-433.

Wang, S. (2008), "Study on the evaluation of knowledge worker value based on rough set theory", *Proceedings of the International Conference in Dalian of Wireless Communications, Networking and Mobile Computing*, IEEE, *China*, pp. 1-4.

Further reading

Brown, J. (2002), "Training need assessment: a must for developing an effective training program", *Public Personnel Management*, Vol. 31 No. 4, pp. 569-580.

Cover, M.T. and Thomas, J.A. (1991), *Elements of Information Theory*, John Wiley & Sons, New York, NY.

Helton, R. (1988), "The 'best work' method of knowledge worker assessment", *Industrial Management*, Vol. 30 No. 5, pp. 19-22.

Marr, B., Schiuma, G. and Neely, A. (2004), "Intellectual capital: defining key performance indicators for organizational knowledge asset", *Business Process Management*, Vol. 10 No. 5, pp. 551-569.

Nonaka, I. (1994), "A dynamic theory of organizational knowledge creation", *Organization Science*, Vol. 5 No. 1, pp. 14-37.

Ramírez, Y. (2006), "Defining measures for the intensity of knowledge work in tasks and workers", Phd Thesis in Industrial Engineering, University of Wisconsin-Madison.

Appendix

KWrs' operational knowledge level in each knowledge domain related to the sub-processes:

Each of 17 KWrs (KWr1 – KWr17) was involved in several sub-processes. Each Table corresponds to a sub-process and shows the related knowledge domains along with KWrs' operational knowledge level in each of them.

Five knowledge workers were involved in the "Identifying the key consumer market" sub-process. Table AI shows their operational knowledge level in each of the related knowledge domains.

	KWr1	KWr4	KWr6	KWr10	KWr11
Strategic management	7	6	6	5	7
Marketing	7	4	6	6	6
Customer behavior	6	4	7	5	6
Procurement and distribution systems	5	5	5	5	7
Technical language	5	5	5	6	5
Statistics	6	6	4	6	5
Macro economy	6	6	4	6	7
Banking	6	5	5	7	7
Financial management	7	2	7	8	5

Table AI. KWrs' operational knowledge level in each of the related knowledge domains of "identifying the key consumer market"

Four knowledge workers were involved in the "creating the public identity" sub-process. Table AII depicts their operational knowledge level in each of the related knowledge domains.

Six knowledge workers were involved in the "monitoring current market trends" sub-process. Table AIII illustrates their operational knowledge level in each of the related knowledge domains.

Six knowledge workers were involved in the "building and maintaining customer relationship" sub-process. Table AIV shows their operational knowledge level in each of the related knowledge domains.

Table AII. KWrs' operational knowledge level in each of the related knowledge domains of "creating the public identity"

	KWr1	KWr2	KWr14	KWr17
Strategic management	7	6	5	7
Financial management	7	6	6	5
International marketing	7	7	6	4
Financial audit	7	5	4	4
Micro economy	6	5	5	7

Table AIII. KWrs' operational knowledge level in each of the related knowledge domains of "monitoring current market trends"

	KWr1	KWr3	KWr5	KWr8	KWr12	KWr15
Production management	7	6	5	2	5	6
International marketing	7	7	4	5	5	5
Customer behavior	6	5	5	4	4	5
Financial management	7	6	6	6	7	6
Statistics	6	5	4	6	4	5

Table AIV. KWrs' operational knowledge level in each of the related knowledge domains of "building and maintaining customer relationship"

	KWr1	KWr2	KWr7	KWr9	KWr13	KWr16
Customer behavior	6	4	5	3	4	6
Production management	7	5	6	5	5	6
Statistics	6	4	5	4	6	6
Procurement and distribution systems	5	6	4	4	7	7

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