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KNOWLEDGE BASED COST ANALYSIS

A KNOWLEDGE MANAGEMENT TOOL TO ARTICULATE THE ROLE OF KNOWLEDGE IN THE COST-BENEFIT ANALYSIS

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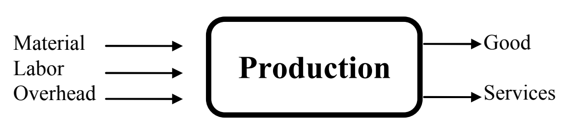
BACKGROUND

Evaluation of knowledge phenomena (intangible assets) and measurement of innovation activities (e.g. R&D) are tough challenges facing many managers. In recent years, numerous articles and reports on intellectual capital have been published, which provide a wide range of insights on how to deal with knowledge assets. Many of the existing documents discuss how to integrate knowledge variables in the 'generally accepted auditing standards' and annual reports, which constitute the backbone of businesses' external reports. This paper deals with the introduction of a new model to integrate the knowledge variables in the context of business internal reports, such as cost-benefit analysis.

The cost accounting plays a key role in the set of internal reports that managers use to make business decisions. From simple 'buy or make' decisions to the huge take-overs, managerial decisions are primarily based on the cost-benefit analysis. In conventional (standard) cost accounting, costs are classified into direct and indirect; then each group is further structured due to three main variables: **Material**, **Labor** and **Overhead**. According to this classification, overhead covers all costs other than costs of material and labor. In business, revenues are generated by sold goods and services. In this context, gross benefit is the difference between revenues and costs. This configuration, as depicted here, is the core of conventional cost accounting procedures. Evidently, this configuration does not incorporate an explicit role for knowledge and, in that context, intellectual capital and innovation. It seems certain that a variable which has not been introduced to a model cannot be traced in it.



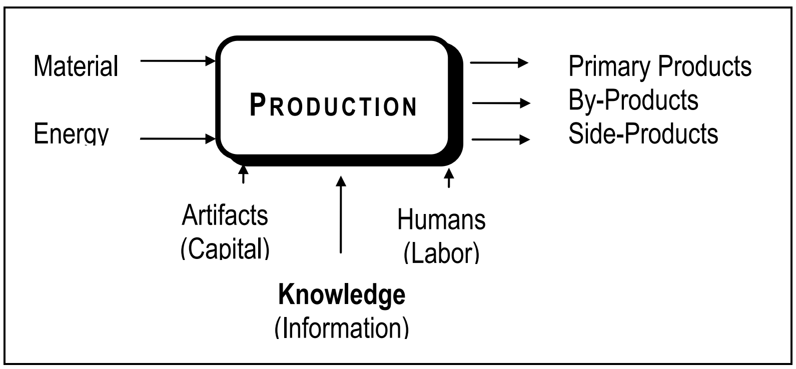
Gross Benefit =
Revenue from sold goods and services
minus the cost of material, labor and overhead

It has become increasingly evident that, in the success of a business, knowledge phenomena (intangible assets) play a more decisive role than the classical variables such as material or labor. In the above model, however, knowledge endeavors and innovation activities are usually buried under 'overhead', the burden that managers are supposed to get rid of.

Sundry papers and text books have studied the deficiencies of the conventional costing procedures. Mitchel[1] argues that the conventional (standard) costing systems emerged mainly during the first half of this century, when manufacturing facilities were designed to produce a smaller range of products which consumed similar amounts of support services and when non-volume related costs were relatively small. Consistent with the above point of view, Brimson[2] argues that the conventional cost accounting systems were designed for a prior era, when direct labor and materials were the predominant factors of production, technology was stable, overhead activities supported the production processes, and there was a limited range of products. In this environment, the valuation of inventory was the primary objective of cost accounting.

Interestingly enough, the above model for conventional cost accounting is also linked to the main model of macro-economics which classifies the factors of production into land, labor and capital, and the outputs of production into goods and services. An in-depth study of the interrelationships between the main models of accounting and macro-economics is, however, beyond the scope of the present paper.

DYNAMIC MODEL OF PRODUCTION



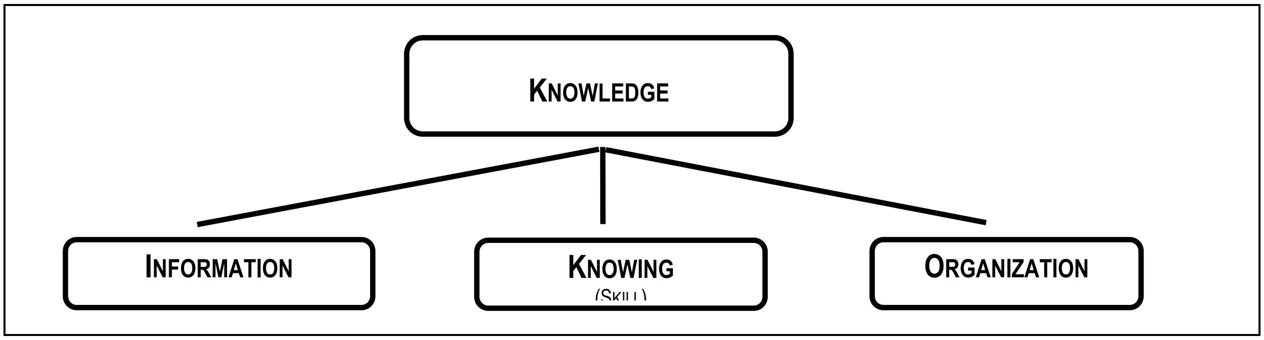
To compensate for the short-comings of the above model, a new formation entitled the **'Dynamic Model of Production'** has been introduced. The cornerstone of this model is the recognition of **knowledge** (information) as a distinct element of production. Natural resources have been classified into two main groups: material and energy. Nature, consisting of land, sea, air, and the sun, is the source of both material and energy. In this model artifacts (capital) is a generic term for all applications of working tools and equipment. Human resources embody all those people who work in a production system. This term includes labor in conventional accounting and economic studies.

The elements of production used in the Dynamic model, namely material, energy, artifacts, knowledge, and human resources, are being used inclusively. For example, knowledge includes information, ideas, data, software, experience, skill, management and organizational structure. Artifacts encompass capital, equipment and work instruments, from simple tools to complicated machinery, buildings and infrastructure.

In the Dynamic model, production outputs are referred to as products, further sub-divided into primary products, by-products, and side-products, such terms applying to both goods and services. By-products are the secondary products. Although they are not classified as main products, with effective marketing they can be sold. Side-products include secondary products for which there is no market; in addition, there are costs for their disposal. Effluent and waste materials are classified as side-products.

The Dynamic model, as above, encompasses also the management model - "5 Ms model" - which consists of five variables: Material, Machinery, Money, Management and Man. The most recent revision to the definition of industrial engineering is also consistent with the Dynamic model.

Knowledge, which forms the core of the Dynamic model, may be further classified under three main topics: information, knowing and organization.



Information, in the above context, includes codifiable and documentable knowledge. This information can have a wide range of carriers varying from clay to stone and from paper to electronic devices. Documented knowledge may be further codified into data, usually in a binary form. The information theory deals practically with data processing and transmission.

Knowing (skill), incorporates the mental and manual aspects of human capabilities. One must distinguish between the content of knowledge and the knowing capability. Skills, in contrast to information, change slowly and infrequently.

Organization covers all other aspects of knowledge that cannot be classified under information or knowing. Organization in this context may embrace structure, methodology, culture, attitude, values, even social myths. Organization is one of the greatest facts of contemporary life. It accounts for the most significant achievements of human life and goes far beyond both the physical and intellectual reach of the individual. It does this by combining diversely specialized intellectual qualifications for results superior to those otherwise available. And since many varied scientific, engineering and experiential qualifications bear upon each decision, the organization encompasses the crucial power of decision. The future theory of production, if it is to have relevance, will probably be a theory primarily of structure and organization[3].

The above variables are interrelated. For instance, humans play the key role in the generation, development and application of knowledge. Because human resources (capital) and knowledge (ideas) are so closely related, it is tempting to aggregate them into a single type of resource. It is important, nevertheless, to distinguish between knowledge and human resources because they have different fundamental attributes as resources, with different implications for cost-benefit analysis, as well economic studies. Human resources produce knowledge and knowledge is used to develop human resources, but they are nevertheless conceptually distinct resources. They have different implications for cost-benefit analysis.

APPLICATION OF THE DYNAMIC MODEL OF PRODUCTION IN KNOWLEDGE BASED COST ANALYSIS

A proper configuration for knowledge holds the key role in a knowledge based cost analysis. Consistent with the Dynamic model of production, in the knowledge based cost analysis, the input variables of a system of production are classified under four main groups:

1. **Knowledge and information:** which are **generated, developed and applied** in a process
2. **Human resources (labor):** which are **developed and applied** in a process
3. **Equipment and machinery:** which are **utilized** in a process
4. **Material, energy and services:** which are **consumed** in a process

In the knowledge based cost analysis, costs are classified into two groups: Substituting and Enabling. The substituting (consuming) costs are related to variables that should be substituted, should the process of production be repeated. In other words, for each new round of production, similar resources are required so the production can be re-performed. Material and energy are mainly related to the substituting costs, because material and energy are consumed in the process of production. If we plan to repeat the same process of production, the same or similar amounts of material and energy are required.

Not all production resources are substituting. As Paul Romer indicates, an idea (knowledge) can be used over and over again by everyone, provided it can be communicated[4]. He considers ideas as the instructions that let us combine limited physical resources in arrangements that are ever more valuable[5].

The enabling costs, which are attributed to developing, improving and enhancing the capabilities of a production system, are mostly related to knowledge endeavors. The cost of the enabling resources occurs only one time, and will not be repeated if the same process of production is performed. In the other word, knowledge is the only resource of production which is not subject to diminishing return. Engineering and design drawings are excellent examples of enabling costs. When the same product and process of production are used, the same drawing can be used over and over again.

The activities of the human resources of a firm may vary from operation to information generation. In addition, human resources endeavors are also related to improving one's own or one's colleagues' capabilities (skills), as well as improving the general organization of a business. Traditionally, the capabilities related to increasing skills are referred to as the 'learning curve' and improving the organization as 'corporate culture.'

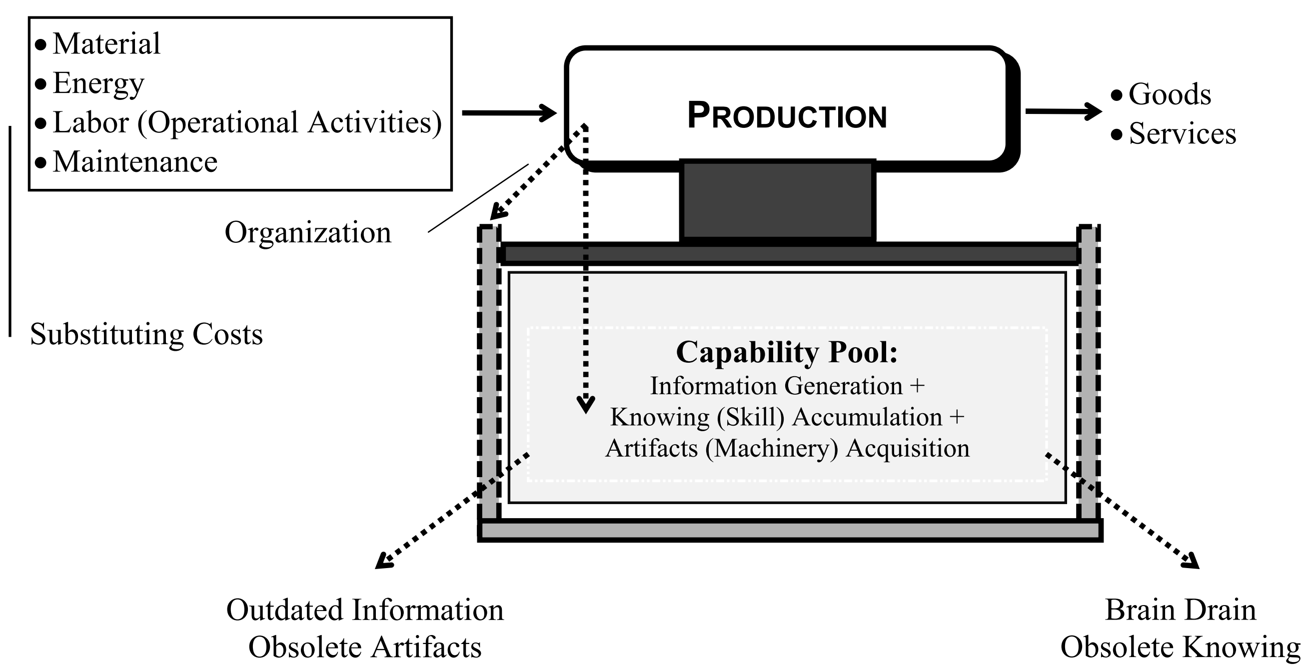
Consequently, the costs of human resources can be broken-down into operation, information generation and knowing (skills) and organization development. The charges related to operation can be organized as substituting costs, because similar operational costs are incurred when performing the same production. However, the costs of information generation and knowing and organization development, which relate to improving the capabilities of a system, are grouped under enabling. In the same way, maintenance of machinery is a substituting cost, while acquiring a machine is an enabling cost.

It should be noted that, the structure of conventional (standard) cost accounting has been reserved for the consumable aspects of production such as material, energy, operation, and maintenance. However, a new knowledge based dimension has been added to this system. In the conventional cost accounting procedures, all knowledge endeavors, as well as the cost of utilizing artifacts (depreciation, maintenance, insurance and related taxes) are usually buried under overhead.

The substituting and enabling costs are not linearly added or subtracted. They may be presented as the two dimensions of a vector or matrix. The horizontal dimension deals with the common impacts of production being analyzed in the conventional cost accounting, while the vertical dimension deals with the knowledge aspects of production, such as innovation, education, training, improvements, corporate culture, and so on. The relationships are depicted in the next diagram.

The diagram indicates that enabling resources (information, skill, and artifact) create a capability pool which allows the substituting resources to be transferred into goods and services. However, the capability pool, by itself, is exposed to continuous depletion due to brain drain, and the obsolescence of information, knowing and artifacts. Organizational capabilities play a key role in developing and updating the capability pool. Organization is the essence of any business. As Peter Drucker indicates the function of organization is to make knowledge productive[6].

The classifications of substituting and enabling are not absolute. They constitute a spectrum of behavior, where material and energy occupy one side and knowledge the other. Artifacts (equipment) and human resources are in the middle of this spectrum.



APPLICATIONS

Knowledge based cost analysis has a wide range of applications. This model may be used independently, or be combined with the standard or activity based costing (ABC), or in conjunction with the balanced scorecard. Following are a couple of examples which illustrate some applications of knowledge based cost analysis.

Suppose a company must decide whether to make or buy a machine, based on the following criteria:

To Buy

1. Price of the Machine = $100,000
2. Cost of purchasing = $10,000
   2.1 Cost of operation (for purchasing) = $5,000
   2.2 Cost of skills and organization development for purchasing = $5,000
3. Total Cost of Buying = $110,000

To Make

1. Cost of material, parts and utilities (energy) = $20,000
2. Cost of the personnel who directly deal with the production = $30,000
   2.1 Cost of operation (for making) = $20,000
   2.2 Cost of skills and organization development (for making) = $10,000
3 Cost of using the artifacts; covering leasing the machinery and facilities, including insurance and tax = $10,000
4. Cost of information generation (covering the cost of R&D and design) = $60,000
5. Total Cost of Making = $120,000

In this context, it appears that buying the machine ($110,000) is more feasible than making it ($120,000). However, we have to understand that when we buy the machine the total asset we will acquire include the machine $100,000, plus the quasi asset of skills development $5,000, for a total of $105.000. When we make the machine we acquire not only a machine with the asset value of $100,000, we also create the quasi asset of skills and organization development, valued $10,000, and the quasi asset of information valued at $60,000, totaling $170,000.

If we want to repeat the same procedure for a second machine of the same type, the knowledge based cost analysis is even more evident.

To Buy a Second Machine

1. Price of the second machine = $100,000
2. Cost of buying the second machine = $5,000
3. Total cost of buying the second machine = $105,000

To Make a Second Machine

1. Cost of material, parts and utilities (energy) for the second machine = $20,000
2. Cost of the operation (to make) = $20,000
3. Cost of using the artifacts; covering leasing the machinery and facilities, including insurance and tax = $10,000.
4. Total cost of making the second machine = $50,000

Due to the development of knowledge capabilities through the manufacture of the first machine, the cost of making the second machine will be no more than $50,000, which is much less than $105,000 to buy the second one. In addition to the above, we have to remind ourselves that making or buying require and support two different types of organization. A making procedure supports the organization for innovation (design and R&D) and manufacturing. A purchasing procedure requires and supports a buying organization.

The knowledge based cost-benefit analysis is easily applicable to software development. The cost of material (a set of diskettes or CDs and a package) and labor for packaging is just a fraction of the total price of the software. However, the cost of the first set of a software package (for instance an operating system or a word-processing program) can be a million times higher than the price of what is available in the market.

TECHNO-ECONOMIC ANALYSIS OF INDUSTRIAL PROJECTS

The financial (economic) cost-benefit analysis, as indicated before, is a well-known procedure for the study and evaluation of industrial projects. The consequences of industrial projects are, however, much broader than their direct economic gains. Industrial projects could also be reviewed to determine their impacts on the technological capabilities of a system. The method for studying the technological outcomes of industrial projects is referred to here as the techno-economic analysis of industrial projects.

The techno-economic analysis of industrial projects considers the economy and technology to be interrelated systems, where the existence of a technological base is essential for carrying out an economic activity. However, the technological base acquires increased capabilities and value through the execution of economic activities. This increased potential energizes both the economy and the technology to become elevated above their former level of capability. The new technology level will work as the technology base for the next generation of industrial projects.

The techno-economic analysis of industrial projects, consistent with the Dynamic model of production, covers five main inputs or variables: Material, energy, artifacts (equipment), knowledge (information) and human resources. This model regards technology as a system that provides both the artifacts (equipment) and knowledge needed for a given production.

As previously discussed, through executing an economic endeavor, a technology base can be upgraded from one stage to another. The development of a technology base can involve a wide range of activities, like developing and acquiring new know-how and knowledge, the development of new equipment and the upgrading personnel. Subsequent to the upgrading of the technology base, the production process will be performed according to the new technology base. The relationships between technology development and economic development may be depicted in a vector, with the economic development as its horizontal component and the technological development as the vertical component.

The current procedures for the economic (financial) analysis of industrial projects may be easily used for quantifying the economic component. A framework for quantifying the technology development should take into account the evolution and development of the technology base's variables; namely knowledge, and equipment. The new models should assist us to classify and quantify the technology development activities. Considering the point that appraisal of intellectual capital also seeks new methods for the integration of knowledge in the process of accounting and economic analysis, there will certainly be dynamic links between knowledge-based cost analysis and techno-economic analysis of industrial projects.

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