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Evaluating Business Productivity and Improving Through Expert Systems

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Abstract

For long-term survival of any business, it is essential to manage productivity. However, there are several obstacles due to lack of skills or time by the managers to analyze productivity to take necessary corrective actions in time. Such problems can be solved by the help of Expert Systems.

Business productivity mainly depends on the ability of the managers to take fast and correct decisions in uncertain conditions that requires expert systems. Among the highly complex interacting systems of the world, human being is a special but sophisticated central system, which acquires knowledge and skill in a particular domain to become expert in that area/field over a large period of time.

However, in the age of science and information technology, to gain competitive edge and to avoid competitive disadvantage, the businesses must make use of expert systems for strategic functioning. The main idea is based on the principle or belief that human experts do possess different knowledge but they don't process their knowledge differently.

Keywords: Productivity, Artificial Intelligence, Expert Systems, Evaluation, Measurement

Introduction

According to *Industry Week's* 27th annual survey of CEO's in 1998, productivity is the most important performance indicators for CEO's in their strategic decision-making. Productivity is the quantity of output produced by a system over a period of time to the quantity of resources consumed to produce that output over the same period of time.

A survey by the Institute of Industrial Engineers asked practicing industrial engineers, who play a pivotal role in increasing productivity within their firms to cite the major obstacles to productivity. The top three responses were:

1. Failure of management to apply proper measurement programs to evaluate productivity improvement.
2. Failure of management to understand how productivity can be improved.
3. Failure of management to authorize sufficient manpower to direct productivity improvements.

The first obstacle is crucial and leads to the second and third. Without measurement, there can be no evaluation or productivity analysis. The outcome of productivity analysis is the diagnosis of productivity problems and the creation of corresponding solutions. Without productivity analysis, obviously, there can be no understanding of the problems and thus little understanding of how to improve productivity (obstacle #2). This leads to the third obstacle, inadequate support given to productivity improvement and hence, the lost opportunity for productivity improvement. But technologies such as expert systems can help analyze and diagnose the problems as well as recommend solutions. This paper describes how the expert systems can be successfully used by managers in nearly all phases of the productivity management process.

Research Design

To improve the productivity of a business organization by developing and employing expert systems.

Expert Systems an Overview

An Expert System is an application of Artificial Intelligence that can use a knowledge base of human expertise to offer an intelligent advice or to take an intelligent decision to assist in solving a problem. It is a system that employs human knowledge captured in a computer to solve problems that ordinarily requires human expertise. So, it simulates the judgement and behaviour of a human or an organisation that has an expert

knowledge and experience in a particular field. Such a system possesses a knowledge base accumulated through experience and extensive learning and a set of rules for applying the knowledge base to each particular situation. While some expert systems are designed to act or perform like human experts, the others are designed to assist human experts.

The primary goal of expert systems research is to make solutions available to decision makers and technicians involved in expert system.

The general architecture of an expert system consists of two main components

1. A problem dependent set of data called knowledge base or rule base
2. A problem independent program called inference engine.

Three individuals are involved in expert systems which are

End User

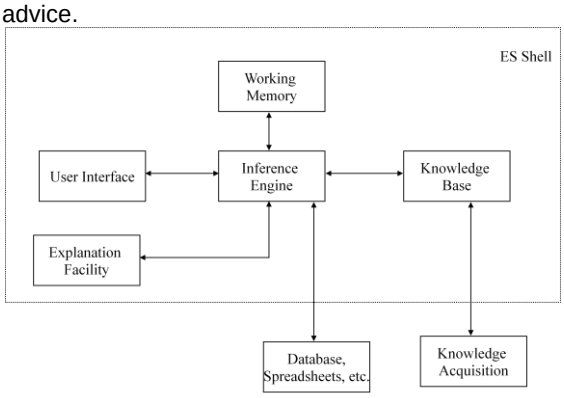
Who uses the system for its problem solving assistance?

Problem Solving Expert

Who builds the knowledge base for a system about the specific domain?

Knowledge Engineer

Who defines the inference engine used to process knowledge, required to obtain assistance/ advice.



Basic ES Structure

Characteristics of Expert Systems

An Expert system has the following characteristics

1. It possesses vast domain specific knowledge to the minute details.
2. It solves difficult programs in a field, as good as if not better than the human experts.
3. It permits the heuristics search process.
4. It can accept advice, modify, update and expand.
5. It can deal with uncertain and irrelevant data.
6. Itcan communicate in natural languages.

Benefits of Expert Systems

Expert systems are beneficial for certain applications and not appropriate for others.

The benifits of the expert systems are as follows

1. Expert systems work faster than humans, which means less number of workers are needed. This reduces the cost of the product and increases the output and the productivity.
2. Expert systems provide consistent advice to reduce the error rate.
3. Expert systems make knowledge available to the people easily, who query the system for some specific advice.
4. Expert systems provide a great amount of flexibility.
5. Expert systems are also useful in interdisciplinary domains where multiple experts are required.

Limitations of Expert Systems

The limitations of the Expert systems are as follows:

1. It is very specific in nature. The major problem lies in knowledge building, and maintenance of large databases in addition to the extraction of the knowledge.
2. Lack of proper knowledge representation hampers the progress in development of expert systems.
3. Program description is language dependent.
4. Development of Expert systems is expensive and time consuming.

Generic Applications Areas of Expert Systems

Expert systems can be used in a wide variety of areas with initial vast applications mainly in medicine and engineering. However, business applications are also becoming popular and very successful to facilitate the decision-making process in a wide variety of applications. Following this trend in medicine and engineering, expert systems have also been applied to business decision-making.

Wong and Monaco have identified 214 articles that report expert system application research in business. The expert systems are being used for a diverse range of functional activities, including production/ operations, finance, and information systems. Wong and Monaco classify the literature on expert system applications in business by application area, generic problem area addressed, problem domain, level of management, level of task interdependence among other characteristics.

In another study, Eom has presented that expert systems in business are most widely used in production/ operations and scarcely in human resources. Some operations management application examples include scheduling factory orders, inventory and equipment tracking, shipping route optimization, material purchasing, and repair problem diagnosis. The understanding of knowledge and its role are critical for an organization's success. Evolution of web-based expert systems is an important trend that will change the nature of business as well. Widespread Internet access, availability of internet-compatible tools for expert system development, and portability of internet-based applications make them more powerful over their alternatives. They are already being employed in applications, such as online advice, expert advice and problem-solving knowledge, and data management.

Web-based expert systems bring flexible data manipulation capabilities, intelligent fault diagnosis systems, highly efficient distribution schedules, and intelligent planning tools to assist

communication and control tasks. Similarly, in today's business, spreadsheets have become a fundamental tool. Numerous Fortune 1000 companies have made use of knowledge-based systems to solve business problems,ranging from scheduling their manufacturing operations to managing their investment portfolios.

Most existing expert systems can be grouped into the categories of interpretation, diagnosis, prediction, design, planning, monitoring, Debugging, repair, instruction, and control.

Interpretation infers descriptions from observable data. DENDRAL is such an expert system. It infers a compound's molecular structure from mass spectral and nuclear response data. CSR ADVISOR is an application in the marketing area and is used to tailor the knowledge about products and services to the needs of each client and then make it available to the customer service representatives. COMVOB is a knowledge-based system developed to determine the marginal value of building projects.

Diagnosis infers system malfunctions from observable data. Diagnostic expert systems relate these inferences to underlying causes. DELTA, for instance, helps identify and correct malfunctions in locomotives, whereas MYCIN helps diagnose and treat bacterial infections. Expert systems are used in diagnosis in production processes such as automobile assembly or textile manufacturing.

More and more of these decision support systems are used in customer relationship management, interactive marketing, and e-commerce. Chiu explains the use of a case-based reasoning system to predict customer-purchasing behavior. In a similar study, Song et al. develop a methodology to detect, understand and adapt to changes of customer behavior in Internet shopping mall.

Design involves configuring objects under constraints. XCON [30], for instance, configures VAX computer systems. Expert systems also assist in the design of flexible manufacturing systems.

Planning involves designing actions. FADES, for instance, is a facilities layout planning system.

Expert systems have been used in production/ 9\\\\\\\operations in matching guests' room needs with the available rooms and in capacity and layout planning. Productivity adjusted construction schedule is another area of application. In the production/ operations field, more advanced intelligent systems are used for efficient enterprise resource planning (ERP) maintenance.

Monitoring involves comparing current observations to expected outcomes. ALEES is an expert system developed to be used by loan officers in evaluating agricultural loans.

Debugging evaluates source code to identify syntax errors, prescribe corrections, and make corrections.

Repair is similar to debugging but its use is not limited to programming. TQMSTUNE fine-tunes a triple quadruple mass spectrometer from mass spectral and nuclear response data. Repair and debugging of digital electric circuit cells is another application area. CAST is a rule-based expert system developed by Hewlett Packard to aid in configuring SAP implementations.

Instruction involves diagnosing learner weaknesses and prescribing remedial lessons. STEAMER teaches the operation of a steam propulsion plant.

Finally, control involves maintaining a system in a predetermined state. It involves the interpretation, prediction, repair, and monitoring of system behavior. YES / MVS helps computer operators monitor and control the MVS operating system. Control of manufacturing cells via expert systems is also mentioned.

IVAN, a case-based knowledge system, is used for pain control and symptom relief in advanced cancer.

One concern of extreme importance to the operations management function and to the company overall is measuring the productivity. Expert systems have been suggested as a potential tool to increase productivity in automating many production functions, such as process planning, capacity planning, facility layout planning, design, diagnosis and trouble shooting, monitoring, and controlling production and operations management systems. Expert systems mimic the heuristic methods that humans employ for production planning and control. The decisions of what level to make a given resource available and when to commit a given resource to a given unit of product can be assisted by expert systems to increase productivity. An expert system that can measure the productivity of a company and interpret the results is essential and valuable to increase the productivity. Sumanth and Dedeoglu have developed an expert system using the total productivity model.

From the literature review, production/ operations has emerged as the business function where expert systems have been developed most widely. Total productivity measurement and control is one application area in operations management.

Expert Systems in Productivity Management

The productivity management process consists of measurement, interpretation, evaluation, choice of corrective or improvement solutions, and implementation of chosen solutions.

1.	Select appropriate measurement model
2.	Set upmeasurement System
3.	Gather Relevant Data
4.	Generate Performance Results
5.	Identify Performance Results
6.	Assess Performance Significance
7.	Interpretation of Numerical Results into a Performance Story
8.	Evaluation: Association of Causes with Effects
9.	Evaluation: Causes of Resource Inefficiencies
10.	Selection of Improvement Solutions
11.	Implementing Improvement Solutions

Measurement

Selection of Appropriate Measurement Model or Models

The first step is to select an appropriate measurement model. Productivity measurement models have been classified in differently. The model selected mainly depends upon the taxonomy or criteria used for classification of the measurement

models. A comprehensive taxonomy for the classification was developed by Sink et al, which uses two criteria to categorize models, unit of analysis (from individual to national level) and scope of measurement or time frame (from minutes to years). An appropriate expert systems approach to select the model was given by Riel and Shin. In general, the most appropriate model for measuring the overall productivity at the firm level is the total factor model, e.g. Total Productivity Model (TPM) by Sumanth. The more recent approaches e.g. MFPMM links productivity performance directly to the bottom line of the firm. It is a variant of the American Productivity Center (APC) model. "Profitability = Productivity + Price Recovery" (PPP) procedure, introduced by Miller, is another such model.

Setting up the Measurement System

Once an appropriate model is selected, it should be implemented. Some models are easy to set up while as others require a huge amount of time and skill. An expert system application can assist to generate a measurement system since organisations lack experts.

Gathering of Relevant Data

To implement a measurement model, it is necessary to gather any two of quantity, price, or value of each input and output. Inputs are classified as material, labor, energy, capital, and miscellaneous resources. Outputs are grouped into product lines.

A "typical" period or optimal data is chosen for the base period. To measure the productivity performance of a particular period, the same type of data is gathered for that period, which is then used in the model to obtain the productivity, profitability, and price recovery contributions of each element and category in dollar terms. The model can also generate measures such as deflated gross profit and deflated net sales, which are also useful in the productivity analysis.

The data depends on the model selected. The frequency of data collections is also dependent on the situation. Performance may be monitored monthly, quarterly, or yearly and the data may have to be collected manually or it may be available on a computer in a proper format for the use of measurement system.

Generation of Performance Results

The results should be computed by the system, once the data is fed into the measurement system.

Interpretation

Interpretation is the phase between measurement and evaluation which involves making tentative assessments based upon the numbers generated by the measurement model.

An expert systems application for interpretation is suitable. There are three steps in the interpretation of measurement results:

1. Identification of performance results
2. Assessment of performance significance
3. Interpretation of numerical results into a performance story.

These steps are discussed next with examples from an expert system prototype called' PET (Productivity Evaluation Technology).

Identification of Performance Results

The expert system identifies changes in performance results whose primary source is the measurement system which may be based on any model such as PPP, APC, MFPMM, TPM, or the Objectives Matrix. The expert system executes this measurement system and collects the relevant results and data from it. The performance changes vary from point-to-point or other data patterns such as trends. This identification takes place at various levels such as the macro-level, category-level, and element-level performance. Moreover, it is not limited to the results of a measurement system such as productivity, price recovery, or profitability contributions alone. It should be able to use indexes, reported and deflated sales and profit margins, results from other models. r.

The greater the ability to access and use data from various sources, the better the precise identification of problems.

Assessment of Performance Significance

Once the performance results are identified, a generic system should be able to assess the significance of the performance changes which allows ranking of problems as per their severity otherwise minor problems and serious problems would receive the same attention. Hence, an expert system for productivity analysis should be able to identify non-random variations and make a value judgment about the significance of the problem such as very serious, serious, significant, moderate, minor, insignificant or no problem. Converting numerical values into such descriptive terms makes them more meaningful to a manger. Since knowledge-based technology is efficient for symbolic processing, hence, such value-judgment features can be easily handled with knowledge-based technology.

IInterpretation of Numerical Results into a Performance Story

The value judgments useful in analyzing productivity performance would be even more useful if the results were presented to the user as a complete performance "story" rather than just a number or a single word, such as SERIOUS. A valuable system would display at least a one-sentence statement such as; "There is a SERIOUS PROFITABILITY-PROBLEM with WOOD-WORKERS with a 0.7 certainty." However, a performance story needs to be much more than one sentence. A comprehensive narrative portrayal is vital if an expert system is to provide quick, accurate and understand able productivity analysis to a manager.

Evaluation

Interpretation is just one useful step in the analysis. The numbers and ratios resulting from a model yield nothing more than a set of symptoms. Evaluation leads to identifying the real causes of poor productivity, price recovery, and profitability. To find the causes of symptoms, evaluation requires interaction between the productivity analyst and the manager of the profit center. The answers are not obvious because they depend upon many variables

such as product-mix, volume, and resource-mix, any of which might have changed because of a number of factors such as market conditions, employee morale, union problems, safety, overtime, scheduling problems, and inventory problems.

Association of Causes with Effects

A generic system for productivity analysis should be able to determine the causes of identified problems. For example, if labor productivity has been identified as a problem, then the system should be able to determine that the problem is motivation, training or whatever the case is. An expert system can determine such a cause by gathering information electronically from company databases or manually from the user. For example, if absenteeism and tardiness point to motivation as the cause, actual absenteeism and tardiness data for recent periods can be obtained from company databases. If the relevant data is not in the company databases, the user must provide it.

Causes of Resource Inefficiencies

Evaluation involves diagnosing from among a list of problems identified in each of the resource categories such as labor, capital, material, energy.

Selection of Improvement Solutions

Based on the causes identified, a generic system for productivity analysis should be able to recommend corrective actions. For example, if there is a simple cause that lack of training is lowering labor productivity, then training is the appropriate corrective action. However, there may be several causes which requires a comprehensive treatment or there may be one cause requiring several types of treatment. So, an expert systems application for selecting the right solutions to correct the identified problems seems ideal.

Implementing Improvement Solutions

Involves management action. Some of the improvement solutions may include expert systems applications, of which there are virtually an unlimited number of applications. For instance, if the problem is with layout, one could use an expert system such as *FADES*.There is several expert systems applications for improving scheduling, maintenance, forecasting, etc.

Conclusion

With IT infrastructure already in place, a huge amount of data is generated and processed by the managers at an ultra high speed. If this big data of a business organization is well organized as and when it is used to form a knowledge base, a system may be developed which can be constantly refined and reformed using rules to form an expert system for that organization that may in turn be used by the top level managers of the organization for improving their decision making process about their core activities and hence lead to the overall development in productivity of the organization, by enhancing the performance and quality of that system.

This paper is an endeavor to simplify and describe each stage of business productivity management process and discuss how expert systems applications can help. Examples of existing prototypes illustrate the possibilities and the strengths of the expert systems to improve productivity in the business world.

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