An Agility Performance Indicator System based on Business Process for Manufacturing Enterprise

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ABSTRACT: The objective of this paper is to introduce a methodology of agility performance indicators system (APIS) of computerized to set up for manufacturing enterprise. The methodology allows for the computer technology support to help the enterprise become more agility, with a specific objective of improving the manufacturing business process. To improve agility performance of manufacturing enterprises, such as time (T), quality (Q), cost (C), flexibility (F) and innovation (I) (TQCFI), is a key for the enterprises to win market and consumers. It is a great need that enterprise agility performance measure (APM). A building method of APIS is presented in this paper.

Key Words: Manufacturing enterprise, Agility performance measurement, Business process, Performance indicator

1 INTRODUCTION

The rapidly changing market and customization of production requires quick reaction of the enterprise. To address the challenges of a rapidly changing market, a new paradigm known as 'agility' is being promoted as the solution for maintaining competitive leadership in this new environment [1]. The agility manufacturing enterprise, characterized by its ability to respond to frequent and unpredictable change, is being promoted as the success future. By becoming agile, a manufacturing enterprise is positioning itself for profitability due to its innate ability to excel in a changing. The ability to respond rapidly to changing market opportunities by utilizing agile businesses is a key attribute of an agile manufacturing enterprise. In order to establish and maintain competitive advantage, manufacturing enterprises are presented with the task of creating agile business process. Agility performance of business process for manufacturing enterprise has been recognized as a crucial element to adapt rapidly changing environment. These enterprises require methods and tools to help improvement their agile business process [2, 3, 4]. It provides the necessary information for business process control, and makes it possible to establish challenging and feasible goals. It is also necessary to support the implementation of business strategies. Despite the fact that manager of the enterprise recognize the importance of APM, it has not been widely implemented in this industry. In some small to medium sized enterprise, most managers still make decisions mostly based on their intuition and common sense, and a few broad financial measures, which are no longer adequate in today's competitive environment. A number of studies have investigated the use of measures for evaluating the impact of improvement agility performance in manufacturing enterprises. However, few them are concerned with the problem of implementing APIS in organizations. Although choosing the right measures is important, it is also necessary to enable people to measures in their routine work, so it is necessary to have a suitable methodology and tools adapting rapidly change market.

This paper provides some agility characteristics on manufacturing enterprise. These agility characteristics are then used to structure an agility performance indicators model. An agility performance measurement model based on business process and method of APM are then presented. The methodology and models are applied to design an agility performance indicators system that is being faced by a small or medium manufacturing enterprise. Finally, simple concluding discussion is presented at the end of this paper.
2 AGILE MANUFACTURING AND AGILITY PERFORMANCE METRICES

What agile manufacturing (AM) is neither a detailed production process nor a detailed running mode. What it reflects is a philosophy, an object science which connects with other approaches. What is lays particular emphasis on is neither a detailed adjustment nor a reformation [5].

2.1 Agility theory and dimensions

In order to plan for agile business processes a thorough understanding of what can be termed ‘agility theory’ is necessary. Agility is a new paradigm in the manufacturing environment. ‘Agile-based competition is destined to displace mass-production based competition as the norm for global commerce’ [3]. The core of AM is that an enterprise should be set up on the basis of being of capable of operating profitably in the face of changing customer opportunities. What the AM enterprise is concerned about are agility performances of TQCFI. In particular, the AM enterprise will design and produce products rapidly according to the requests of customers [5]. In order to facilitate the understanding of the new paradigm of agility, the Agility Forum has introduced four dimensions of agility to convey the holistic approach involved. While these dimensions, and their relationships, are still evolving, their basic foundational elements remain relatively constant. The four basic elements include Cooperating to Enhance Competitiveness, Enriching the Customer, Mastering Change and Uncertainty, and Leveraging the Impact of People and Information [2].

2.2 Performance measures and agility metrics

From management and implementation perspective, agility metrics can serve as determinants of success (and agility) by an organization using them as performance measures. The performance measures that an organization must decide upon should be closely linked to the organizational and, in the case of the example provided here, the manufacturing strategy [4]. Change proficiency metrics (cost, time, robustness and scope) have been introduced by Dove to promote further understanding of agility and to assist in its management [6]. These indicators aid in monitoring the capability of a process to respond to unanticipated change. Cost and time are self-explanatory metrics that have had some history in measuring the performance of organizations. Robustness includes the characteristics of quality and flexibility as well as the ability to perform a task without constant monitoring. The agile determinant referred to as ‘scope’ addresses the ability to be able to change whenever, and to whatever. Scope has been defined as the magnitude of change which can be accommodated. For example, an agility and innovation technology such as computer-integrated manufacturing (CIM) is shifting the factory from an economy of scale to an economy of scope [4]. The agility measure of the enterprise mainly evaluates the agile performances of TQCFI of business process. The journey to agility is a never-ending quest to do better than the competition even as the competitive environment is constantly changing.

3 AN AGILE PERFORMANCE INDICATORS MODEL

The APIS is a guiding control system of enforcement of its agile manufacturing strategies. The aim of the system is to cooperating control comprehensive capacity of production and marking. This kind of comprehensive capacity shows not only results of production and marking but also tendencies and advantages of development and change of the enterprises. Established APIS must possess “resolving power” and “diaphaneity”. So called “resolving power” means that it can measure developing tendencies of production and marking and the degree of problem, and it can be point out improving direction. So-called “diaphaneity” is used to evaluate where there exists the problem and where make the cause, easy or difficult to solve it, and point out methods to improve it. APIS is an enterprise-wide framework, linking an enterprise’s strategy, resource, information, function, organization and business process. The managers and staff can use it to make their decisions and guide their activities. It can make all activities of enterprises advance to the strategy target and concrete business target. The functions of APIS are the following:

- It can guide the enterprise to fulfill operating and management target;
- To carry out change management;
- To support the enterprises in improving methods of management and business process reengineering;
- To make the enterprise operating and managing more agility and effect.

The use of performance indicators information to effect positive change in the enterprise systems and processes, by helping to set agreed upon performance goals, allocating and prioritizing resources, informing managers to either confirm or change current policy or program directions to meet those goals. A model of agile performance indicators is used as the main method and to realize agile performance improvement for the enterprise. It is used to realize performance modeling for the enterprise. Agile performance indicators model is integrated into performance improvement to carry on agile performance measurement, and diagnosis. A model
of agility performance indicator shows in Figure 1.

3.1 An agile performance measurement model based on business process

An agile performance of manufacturing enterprise is studied in terms of its abilities to performance major steps of production can be used as an indicator for the measure of its manufacturing capability. Therefore agile performance measures of manufacturing, business process, and performance measurement phases are three key elements in manufacturing indicators system in general. A performance measurement model based on business process for manufacturing enterprise shows in Figure 2.

The mode is conceptually represented by a cuboid whose three axes relate respectively to agile performance, performance measurement phases and agile performance size.

* The dimension of performance measurement phases It concerned with the performance measurement phases of the model from the requirement of definition, design to analysis and evaluation to measure.
* The dimension of agile performance It represents agile performance of business process for the enterprise, namely TQCFI.
* The dimension of agile performance size It concerned with business process of the enterprise. It represents the enterprise system, business process, and activities.

3.2 Method of APM

Agile performance of the enterprise is analyzed and evaluated in agile performance measurement model based on business process. That is to use the attribute concept of activities and the attribute concept of process. The parameter about agile performance of TQCFI is considered as the attribute that functions through the process of the activities, then on the base of the active attribute, one analyze and calculate the process attribute to obtain the activity and process attributes of the enterprise, at last analysis and evaluation with comprehension is utilized to analyze agile performance and gain complete agile performance of the enterprise [7]. Following are methods of agile performance measurement used mainly: Evaluation by Specialists, (e.g. scoring and arranging), Analysis in Economy (e.g. analysis of efficiency and cost, etc), Decision of Multi-target (e.g. planning for multi-targets, etc), Data Envelopment Analysis (DEA), Analysis Hierarchy Process (AHP), Fuzzy Mathematics, Mathematical Statistics (e.g. grouping analysis, factor analysis, et al), Activity Based Cost (ABC), and Activity Based Management (ABM), etc.

3.3 Benchmark of APM

If one wants to evaluate an agile performance of manufacturing enterprise accurately and objectively, it is important to setup benchmarking of measurement. The benchmarking of it consists of target, index, and benchmark.

Target: it is outcome or accomplished task that is expected to reach by the enterprise. The target of it includes enterprise target, business unit target (domain process target), process target and activity target. In the presentation of levels of the enterprise target, the target of high levels is the aim of the target of lower levels while the target of lower levels serves as the foundation of the target of high levels.

Index: it is a kind of measurement of objective and their characteristics. This measurement may be quantitative or qualitative. When quantitative and qualitative indexes are combined, the overall measurement of performance is obtained. The principle of selecting index is measurability, control ability, coherence and objectivity.

Benchmark: it is framework of reference, namely standard, used to evaluate performance of the enterprises. Generally speaking, the standard include standard of enterprise, standard of industry and time sequence, and standards of enterprise issued by the enterprise, standards of industry issued by industry and government, etc. Benchmark is that the advanced enterprise in the same industry is used as the standard. Time sequence is that the historical data of the enterprise itself are used as benchmark.

Figure 1. Agile performance indicators model

Figure 2. An agile performance measurement model based on businesses process
4 DESIGN OF AGILE PERFORMANCE INDICATORS SYSTEM

It possesses the system of applied integrated computer information in the environment of distributive computer network that is different in the structure. Hence its systematical architecture should have distributive heterogeneous computer technology, object-oriented technology, data warehouse technology, artificial intelligence technology, Web and agent technology.

4.1 A communication framework

CORBA (Common Object Request Broker Architecture) technology, which enables the enterprise to carry out management, is an absolutely necessary communication mechanism. It is the distributive object calculation standard that was worked out by OMG (Object Management Group). Its purpose is to share the information and the resource in heterogeneous distributed environment. There are three way in CORBA and WWW integrating, they are the CGI gateway to access the CORBA object, the interface of Jave ORB to access CORBA the object and Web server directly supports the CORBA/IIOP [8]. The APIS adopted CORBA/IIOP.

The APIS is characterized by all over information gathering, and it needs to support the applied system in the heterogeneous environment, the cooperative technology of the heterogeneous system. The communication framework in APIS for the enterprise is the structure of three-layer communication, which consists of the applied system layer, CORRA layer, Agent layer of performance data gathering, and the system layer of performance indicators. Figure 3 shows the communication framework based on Web - Agent for performance indicators of the manufacturing enterprise.

4.2 A function framework

The APIS is considered an organization to consist of four sub-systems: associated tools, data gathering, performance measure, knowledge database management, and performance measurement. As Figure 4 shows.

- The sub-system of associated tools
  It possesses assistant management APIS function, and include communication and user management.

- The sub-system of data gathering
  It gathers the performance measure data according to APM targets, and it forms the data snapshot database of the performance measure.

- The sub-system of knowledge database management
  Its function mainly is to carry out the management of knowledge database enterprises needed in the performance measure. It is divided from the view of knowledge database management, and the sub-system consists of three database management, they are the index calculation - method database of performance measure, including information such as its concept description and definition knowledge database of the performance evaluation, including the standard values, revised values of APM, the index weights measurement information, and the reasoning database of performance analysis, including produce rule, measure result and analysis characterization.

- The sub-system of agile performance measurement
  According to require of the different object (enterprise system, processes, activities) in the performance measure model, the main measurement procedure in the sub-system of performance measure is carried out. First, the measure object target is fixed, and then data gathering sub-system collect the data of performance measurement. After receiving the data, the performance measurement model, the index, the benchmark, and the method are selected. The agile performance measurement model is used to model of analyze and compare the deference between the practical data of the object that is to be evaluated and the index of APM that is previously fixed, at last the difference measurement is given, and the cause, responsibility, and influence of it are found out. The measurement report is worked out.

The integration of the performance measure target of every agile performance size (enterprise system, processes, and activities) is the strategy target and concrete target of the enterprise production and marketing. The measure target of every agile performance size object refers to key factors index system that has effect on the performance of analysis and evaluated object. It adopts the overall and partial and special performance measure index system.
The measurement report is the output of the subsystem of the performance measure, and also the conclusion report.

4.3 A database framework

The foundation of the database structure is a data mode [9]. According to design of database application system concept and methodology, design of database model of the APIS is based on performance measurement model of process. On this model base building an agile performance indicator data mode, and others information systems database models of the enterprise are considered to set up an agile performance indicator database model. Then, According to the agile performance indicator database model, performance indicator database are established. A snapshot database of agile performance indicators is built by collection requirement of performance measure for the APIS.

Design of database for the APIS have three parts, they are high layer design, middle layer design, low layer design. High layer design illuminate model for performance indicators system, it is an integration model that is integrated by agile performance measurement model. Middle layer design show how data of agile performance indicators store and data relation. It is briefness design of data of performance measure for performance indicators. Low layer illuminate how to design performance measure database and the measure snapshot database store, how transmit the data in the snapshot database to the agile performance measure warehouse. Design of database framework for the APIS is represented in Figure 5.

In the database design, it is use to base on the object of logic model, record of logic model and physics model. The logic model base on object make use of the high layer to describe the data, its characteristics to provide design of agility capability for data base, to admission the show type definition the data stipulation. Not only the logic model based on record make use of defining the database structure for overall but also describing the database structure for the middle layer. The physics model used to the low layer to handle data, it is a consistent model or a frame storage model.

5 CONCLUSIONS

Agility is a way by which the enterprise can continue to profit in the face of market competition. The concept of an agility enterprise addresses the question of how one should organize its structure. APM of manufacturing enterprise has been recognized as a crucial element to improve agility performance of business process. Utilizing modern information technology setting up APIS of manufacturing enterprise is an effective measure that can improve the core competition of the enterprise. The paper point out that setting up the APIS of the enterprise is an important target and content for manufacturing enterprise. A building computerized of APIS is a newmethod for sustained improvement agile performance of manufacturing enterprise. Therefore, there’s much to be done in the research of agile performance indicators system of the enterprise, for example, the technology of the workflow model, distributive data process, data warehouse, data mining in APIS of enterprise.
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REFERENCES


