

Complexity Level in Industrial Firms: Case Studies Implementation

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Abstract

Industrial firms require reduction in their complexity. Complexity in industrial firms represents a new challenge in the next decade. Estimation the level of complexity in industrial firms is difficult due to complicated analyses. This paper will put a framework to deeply analyze and estimate the expected complexity level in industrial firms. Also, a computer software package was created to manipulate a huge amount of collected data. Several case studies were conducted in industrial organizations to demonstrate the proposed methodology of analysis and estimation. The results show that the complexity of industrial organizations is unclear and need more attention from manufacturers and academicians.

Keywords

Complexity of manufacturing systems, performance measurements.

1. Introduction

The complexity in any organization has a direct impact on its performance. Reducing the complexity in industrial/service organizations reduces their costs and also increases their revenue and enhances their competence in local and international markets. Complexity has a direct relationship between inputs and outputs of the organization. As organizations grow bigger and expand to satisfy their demand, they tend to have more complex supply management and manufacturing operations than simple ones. Today, several definitions of complexity exist as immense international interest and knowledge for the scientific basis. There are two different forms of complexity: (1) static or structural complexity which is designed into the system architecture, (2) operational or dynamical complexity which also can change dramatically in short periods of time according to its environment.

2. Literature Review

A methodology based on a simulation model to analyze the manufacturing complexity in mixed-model assembly production systems was suggested [1]. A measurement framework to analyze the structural properties of the enterprise system as a complexity measure was presented [2]. A complexity measure for the business process level inside the organization on one product (e.g., the prepaid phone card) was developed [3]. They [3] defined the complexity measures as not only intrinsic to the system being studied but also depend on extrinsic properties of the observer. A new metrics for assessing the structural complexity of manufacturing system configurations was estimated by [4]. El Maraghy and Urbanic [5 and 6] introduced product, process, and operational complexity in modeling and assessment of manufacturing complexity. Different types of complexity to represent and model supply chain complexity were suggested [7]. Complexity levels in industrial firms were assigned four main issues: systems vision, structure of the system, system operation and evaluation [8].

3. Analysis of Industrial Complexity of Firms

Based on the different concepts of "*complexity*," this analysis suggests three frameworks to focus on complexity (organization management *ORM*, supply chain management *SCM*, and manufacturing operations *MO*). They are considered to be the pillars of complexity measure. The analysis could be performed in an interview survey by quantifying the importance from 1 to 10. This analysis is also proposed from an industrial system analyst's perspective, which means it has some delimitation by distributing a questionnaire among industry experts. These questions might not be enough but give an idea of how the company is struggling today and give an indication of influences in the future.

3.1. Analysis Form of Organization Management (ORM)

Organizations today operate in a world of constant change. Management is the process of deciding the best way to use an organization's resources to produce goods or provide services. An organization's resources include its employees, equipment, and money. Although the both definitions of organization and management is simple, the job of management is quite complex. The technology also plays a very important role in the promotion of an industrial organization management. Technology and society are changing more rapidly than ever before. Competition is fiercer than ever because organizations from all over the world now try to sell their products and services to the same customers. There are many fundamental reasons to adopt organization management issue to estimate the complexity of the firms: reduces the product development time to market, reduces the product delivery time to customer, enhances the flexibility of the production facilities, and improves understanding and control of the production processes.

The main issues in organization management concentrate on the following: planning, structure, communication, decision making, and monitoring. With the planning issue, recognition of opportunities, threats, weaknesses, and strengths with strategic and contingency plans are the most important issues. Number of geographic location plants; delegate the authority to lower level of employees, ratio of managers to total employees, outsourcing, relationship between departments, division of workplace and environment of workplace represent the major concepts or issues of structure. For communication, how many languages spoken in the firm and the way of communication (e-mail, phone,...etc) are the most important issues. Certain managerial decisions which were made in individual or in groups, who involved in the decisions, the time to make a decision, and enough information are represented for decision making issues. Regarding monitoring, number of rules, polices, work instructions and procedures, style of leadership will be the guide of monitoring.

3.2. Analysis Form of Supply Chain Management (SCM)

The term supply chain management (*SCM*) is relatively new. The *SCM* seems to have emerged and continues to gain interest at an increasing rate. Nearly all the concepts of forecasting, aggregating planning, and inventory control subject to known demand and uncertain demand involves *SCM*. The *SCM* deals with the management of materials, information and financial flows in a network consisting of suppliers, manufacturers, distributors, and customers. Traditionally, *SCM* called logistic.

As the *SCM* is the entire network related to the activities of an industrial firm that links suppliers, factories, warehouse, stores, and customers, this analysis will concentrated on these issues. Transportation problem, distribution resource planning, designing products for supply chain efficiency, the role of information in supply chain, multilevel distribution systems, and designing the supply chain in a global environment represent the most important issues in the *SCM* through suppliers, internal manufacturing process, and customers.

3.3. Analysis Form of Manufacturing Operations (MO)

The analysis form of manufacturing operations (*MO*) can be applied through some questions which help us to estimate the complexity of any firm. These questions include asking about how many products produced by the factory (firm) and how many parts per each product. Number of process (operations) in each part (component) which is assembled or processed and processing time per each operation are also included in the analysis. There are also some important questions needed to be asked such as: the ability of a firm to quickly increase or decrease its production rate, reduced product energy use, development of existing products, and use of new materials or components in manufacture.

Also, the assessment questions regarding the above three frameworks are not included due to page limitations but interested readers are welcome to contact the authors for copies (garbie@squ.edu.om).

3.4. Designing computer software package

The evaluation scores of the statements in each organization were analyzed via a specially designed program that uses a fuzzy logic approach.

The following steps show how the program was used to perform the analysis:

Step # 1: you need is to enter the organization's name.

Step # 2: After clicking Enter, another window will appear as shown in Figure 1 and what you need here is just to click on one of the bars (optimistic, most likely or pessimistic).

Step # 3: Again another small window will appear and now you need just to enter the score of each question (attribute) separately./

Step # 4. When you finish filling all the categories press *Calculate Complexity* bar and the results of complexity of each category and total complexity will appear

The screenshot shows a software window titled "WELCOME". At the top, there is a red label "Firm Name :". Below this, the interface is organized into three main sections, each with a colored header and three input buttons:

- Organization Management** (blue header): Three buttons labeled "Enter Optimistic Values (Crisp Data)", "Enter Most Likely Values (Crisp Data)", and "Enter pessimistic Values (Crisp Data)".
- Supply Chain Management** (pink header): Three buttons labeled "Enter Optimistic Values (Crisp Data)", "Enter Most Likely Values (Crisp Data)", and "Enter pessimistic Values (Crisp Data)".
- Manufacturing Operations** (green header): Three buttons labeled "Enter Optimistic Values (Crisp Data)", "Enter Most Likely Values (Crisp Data)", and "Enter pessimistic Values (Crisp Data)".

At the bottom of the window, there are two buttons: "Calculate Complexity" on the left and "Exit" on the right.

Figure 1: The main window of the program

4. Case Studies and Implementation

In order to test the analysis methodology presented in the previous section, several case studies were performed. The objective of these case studies was to analyze and measure complexity level in industrial organizations. In order to analyze the concept of "complexity," an interview survey was carried out in several Omani companies. These case studies were conducted exactly on seven organizations at Rusail Industrial Estate (Muscat). Each organization visited was evaluated according to the complexity level in the particular element of the subdivision organization. A score 1 represented a low complexity score and a 10 score represented a high complexity score. The name these of industrial organizations are as follows and the results from these studies will be presented in this section as follows: Hadid Majan, AL-naser Marble; and OMAN Marble.

An introduction of the organization is stated and its products at the beginning of each section. Then, the results of the evaluation of each section (organization management, supply chain management and manufacturing operations) are also not included due to page limitations but interested readers are welcome to contact the authors for copies (garbie@squ.edu.om).

4.1 Case Study # 1: Hadid Majan

Hadid Majan commenced commercial production in January 2003 and since then has been growing from strength to strength. A professionally managed company, with multinational work force, it is manned by the competent technical and management professionals. The company has an installed capacity of 100,000 metric tons per annum to produce high yield strength deformed steel bars. The company produces this product in diameter sizes of 8 mm to 25 mm conforming to following specifications. Steel billets of specified chemicals composition is heated in reheating furnace to 1050 degree and then rolled in a series of rolling stands to the required sizes. The hot finished bars are then subjected to an on-line heat treatment to get high yield strength bars with excellent elongation and

bend ability. These bars are then cut to 12 meter length, bundled and shipped to customers. At Hadid Majan quality control department ensures that the billets we receive are of prime quality. Samples of finished products are taken on-line at regular intervals and subjected to tensile tests on a fully computerized tensile testing machine and also provide Mill test certificates.

4.2 Case Study # 2: Al Nasr Group of Companies Marble

As everyone knows, there is no substitute for natural marble for its beauty and durability. Marble produced at Al Nasr's quarries are superior to imported products of the same range, and they are priced competitively. Further, our sophisticated, computerized and logic controlled plant gives you marble sections of any specified shape and size with a mirror finish. This is achieved by the unique diamond- edged 70/80 blades cutting machine with other computerized micro precision machines at our factory. To give you some ideas of the factors taken into account while embarking on this project of expansion, it should go back to early 1991.

4.3 Case Study # 3: Oman Marble

Oman marble company is one of the NASSAR STONE group companies which have other establishments in Palestine and Jordan. Oman marble company is using stones which are extracted from local quarries. Omani stones fierce beauty mirrors, its landscapes untamed wildness and timelessness; it's the skin of Oman's revered face .The various color shades fall like the shadows of Oman's rich civilizations. The manufacturing facility occupying a space of 90,000 m², equipped with the highest standard machinery & technology. The facility includes huge storages built to contain 30,000 m³ of raw blocks.

Results of all organizations (firms) regarding complexity are summarized and listed in Table 1.

Table 1: The expected level of complexity of all frameworks and the total complexity of each firm

Type of Complexity	Hadid Majan	AL-Naser	OMAN Marble
Organization Management	0.4865	0.5347	0.5659
Supply Chain Management	0.4263	0.4404	0.4923
Manufacturing Operations	0.4805	0.4945	0.5231
Total Complexity Level	0.8682	0.797	0.5421

The complexity level has a range from 0 to 1, with a value of 0 or close to 0 indicating the least possible industrial complexity and a value of 1 or close to 1 indicating the highest industrial complexity. It can be noticed from Table 1 that the level of complexity for organization management (*ORM*), e.g., Hadid Majan, is almost the same level of industrial complexity of manufacturing operations (*MO*). Their values were medium and need to be reduced. With respect to supply chain management (*SCM*), its value also was medium and it needs more reduction.

As the industrial complexity value of Hadid Majan equals 0.8682 and it is close to 1, the complexity level of this firm is high and needs to be reduced. As it is noticed from the table 1 that Hadid Majan scored the highest total complexity levels comparing to OMAN Marble which scored the lowest complexity level. Worth noting that scoring a high mark on total complexity doesn't necessary require that the subdivisions of the complexity score a high mark too? For example Hadid Majan scored a high mark of 0.8682 on total complexity but its subdivisions scored all in the range of 0.4 mean while OMAN Marble scored higher marks than Hadid Majan in the subdivisions but scored the lowest mark on total complexity.

Complexity is something that has several effects in different departments of the organization. Some of its effects appear clearly and everyone can see it like effects of layout and operations complexity. However, others are not feasible and only the analysts can observe them for example effects of complexity in management. As you know, visiting different organizations and trying to collect data about their services is one of the most difficult things and sometimes even impossible to collect the complete information or data. Because not all of them prefer to distribute their information which they think it is important and confidential, these data are essential for this research. The result helped us to compare the variation of the complexity of all infrastructures and also the total complexity among the three organizations.

5. Conclusions, Contribution, and Recommendations for Future Work

Estimation of the complexity level is very critical issue of industrial firms to survive. Analysis of industrial firms for complexity presented through the three main frameworks: organization management, supply chain management, and manufacturing operations was presented. Evaluating industrial organizations by three status (optimistic, most likely and pessimistic) will add credibility and objectivity to the evaluation. The results show acceptable variation in complexity compared to what seen in reality in the particular organization. Analyzing the huge amount of the collected data also is something very challenging and time consuming. Designing the computer software package which is based on fuzzy mathematical (logic) approaches program to analyze the collected data was created. It really was very helpful to get the results easily and accurately.

The main contribution of this research is to analyze and estimate the industrial firms considering complexity frameworks. For further work, authors are planning to conduct reconfigurations process to industrial organizations based on the amount of complexity levels in these organizations. . Also authors are intending to design or create a new computer software package to be more users friendly for reconfiguration process.

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