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Graph analytics' centrality measurement in supply chain

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Abstract: This study examines the centrality measurement implications of graph analytics in the supply chain domain. To identify a graph's most important nodes, centrality measurement is essential in graph analytics. In a networked economy, centrality aids in pinpointing the crucial variables that affect suppliers' or businesses' management. Based on the three different supply chain models currently in use (Traditional Supply Chain, Modern Supply Chain, and e-Supply Chain), four major concerns that affect the supply chain were addressed. This publication included several references to centrality measurements, citing earlier research that had effectively applied supply chain models. The influence of centrality measurements significantly enhances supplier-customer relationships, cost effectiveness, risk management, and dynamic, quickly changing, time-varying market conditions.

Keywords: graph analytics; centrality measurement; supply chain models

1. Introduction

Graph is a representation of the relation between a set of objects. A graph consists of points denoted as vertices and lines connected among them, called edges. This type of representation shows the bonding strength or weighted edges between vertices. In a global system, the process of representing the whole system in terms of vertices and edges known as graph analytics, based on graph theory. The idea of graph theory was from its usage for urban planning in Konigsberg back in 1736, where a Mathematician named Euler, solving a problem of transferring from one city to another using all seven bridges there at once [1].

Since then, problems replicated into graph is vastly used to analyze inter-connecting data entries. Graph analytics can model data features and their relationships simultaneously for applications with complex, non-predictable data different from a conventional statistical

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method that assumes the data to be independently and identically distributed [2]. Graph analytics gained much attention nowadays due to its ability to model large and complex data problems and analyze big data problems such as large social network systems, knowledge discovery, cybersecurity, and others as a set of graphs [3]. It provides an efficient algorithmic solution for researchers to discover a meaningful pattern [4].

This paper investigates graph analytics implementations in supply chain management (SCM). We started by observing and comparing the differences between the three primary supply chain models, which are the traditional supply chain (TSC), modern supply chain (MSC), and e-supply chain (ESC). We would also address several SCM issues and the potential of centrality measurement within the graph analytics used to overcome the challenges.

2. Supply chain model

The supply chain explains a networking attachment between suppliers, manufacturing and fabricating, distribution of products, and facilities' logistics [5]. The action consisted of performing a function of obtaining raw materials, which these raw materials are transformed into desired products and continued by distributing products to customers. As a result, consumers are the final entity of the supply chain process, illustrated in Figure 1. During this process, the company should plan on how the product will reach customers. Hence, the transport and storage activities should be done earlier, including the geographical location to intend, integration activities, cost, and service levels.

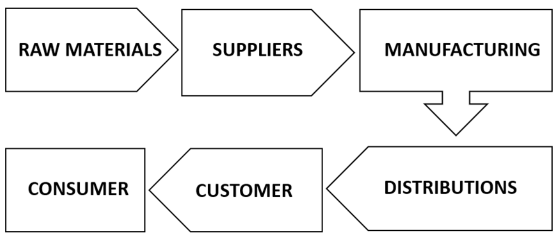

Figure 1. The basic concept of the SCM Model.

In the coming years, SCM must adapt to the increasing growth of technologies. The traditional supply chain (TSC) is becoming irrelevant in this era. The new modern supply chain (MSC) had been vastly developed before and continue to advance. The world had seen the introduction of information technology in the supply chain, namely the e-supply chain (ESC). ESC introduced recently and practices in the manufacturing sector. The main difference between MSC and ESC is the utilization of information technology (IT) to carry out value-added activities. The products produced by the manufacturer meet customers' demand and result in a good return on investment. As such, the company should increase its actions and adapt to changes in nowadays supply chain. The comparison between TSC, MSC, and ESC is analyzed in Table 1.

Table 1. Comparison between supply chain models.

Aspect	TSC	MSC	ESC
Management	As a cost center, focused on production and provision.	As strategic and competent, they are focused on the customer's needs.	As a coordinator for all processing activities originates at the customer level.
Suppliers	Limited selection	Competitive selection	Able to identify competitive advantages over suppliers.
Costing	Costly to set-up a project.	Cost savings sufficient: with strategic planning	Reduces management costs.
Process	Limited usage of technologies. Depend on human skills.	Involvement of high advances and integrated technology systems in process build-up. Reduce human workers. Reduce errors.	Reduce paperwork, administrative overheads, inventory build-up, and the number of hands that handle goods to customers.
Product Flow	Static linear process	Dynamic living ecosystem	Improved customer service reduces cycle time, increases revenue.
Information Flow	Time-consuming process. Require feedback from parties involves. Not able to monitor involved activities.	Technology transfer information sharing when reaching/ finishing up one process.	Involves real-time transmitting orders and updating the status of delivery
Financial flow	Involves on-site payment. Expose to the risk of monetary losses.	Credit terms, payment schedules, consignment, and title ownership arrangements.	Implementation payment throughout online systems.

3. Issues in supply chain management

This paper focuses on the four main issues that arise in SCM. Each case was the summarization of previous works done in the supply chain. An improvement regarding those issues has been determined. Firstly, the need to improve the quality of the relationship between customer and supplier. SCM focuses on the customer's needs, where it is about to give the desired quantity of product, with targeted quality and the right price. Interaction within customer-supplier relationships is the main point of innovation and improvement of production [6]. [7] agrees that maintaining a good relationship between supplier-buyer was the key to improve the interactions between both parties. Study shows that the customer preferred supplier status has a positive effect on the supplier contribution to the supplier firm innovations [8]. A further explanation for the strong connection between collaborative attitude and supplier contribution could address some suggestions. Developing bonding between supplier and customer would improve interaction performances.

Secondly, cost optimization provides an ideal costing in the supply chain that involves a balance of administration costs, inventory, and transportation costs [5]. The basis of charge in the supply chain regulates all the expenses in producing goods or services, including the machinery cost, tools, labor, raw material, and other equipment. As to increase the development of the operation, adjustment on setting parameters must be made to improve the operational costs. In the supply chain, the Floyd-Warshall algorithm (a multiple Dijkstra's algorithms) is used to find the shortest production path [9]. The method was improved later by looking into the betweenness centrality by reducing unweighted networks [6].

Thirdly, based on the changing of marketing strategy coming from various sources, such as customer demands, political agendas, and global sourcing, that the next challenging aspect in supply chain management is called as a risk management. [10] enlighten that there were at least six significant types of supply chain risks that occur regularly, namely supply risks, process risks, demand risks, intellectual property risks, behavioral risks, and political/social risks. For a time-varying chance in a time-varying supply chain system, the profit of inequity-averse retailers' gain may be lower [11].

Fourthly issue is the management of dynamic and fast-changing time-varying market conditions. With the advancement of technology every day, the company should stay on pace and adapt to technological advancements every day. Detecting any error that happened during the supply chain would decrease the losses in cost. [6] develop a model to evaluate the flexibility of the manufacturing supply chain. Mix Integer Linear Program gives benefit in dealing with a real problem in real-time. Optimizing the production-inventory in a multi-stage and time-varying supply chain demands a minimization of the production costs [7].

4. The application of centrality measure in supply chain

In the supply chain, the centrality of graph analytics had been used to enhance the supplier-customer relationship. For example, a supplier-customer network's centrality can be solved using the products' eigenvector [8]. It was proven that the central supplier portfolios tend to be more volatile than the central customer portfolio based on his study on supplier-customer network matrix from 2004 to 2014.

In other studies, on supplier centrality portfolios, the stock performance can predict the overall stock market's movements. Industries connected through customer and supplier by using networking shows the propagation of their connection [9]. With the implementation of centrality, it was revealed that the more centralized industries in a network, the higher stock return will be obtained compared to the industry that is less central [10].

Aspect from SCM's view was captured using some of the centrality measurements, as shown in Figure 2 [11]. Figure 2(a) is a graph example for Degree Centrality (DC). The idea of DC is to determine the number of links incident upon a node. It denotes the number of companies that the supplier serves. DC concept was extended to Eigenvector Centrality (EV) as illustrated in Figure 2(b). EV gives each supplier a score proportional to the sum scores of its customers [8]. In SCM, the company can identify essential customers of becoming suppliers themselves. Customers with the highest score summation in nodes can be a supplier to other companies [12].

Figure 2(c) is a variation of EV defined as PageRank (PR) centrality measurement. PR is used to identify a customer of many suppliers that contribute less to each of these suppliers [8].

Hence, the company can be discounting the importance of customers with many suppliers. Figure 2(d) illustrates the Betweenness Centrality (BC) in SCM. BC can improve supplier financial performance regarding the return of investment and sales growth rate [13]. The interpretation from BC measurement indicates the accessibility to the novel information, improves firm performance, controls opportunistic behaviors of supply partners, monitors the flow of information, and enhances performance [10].

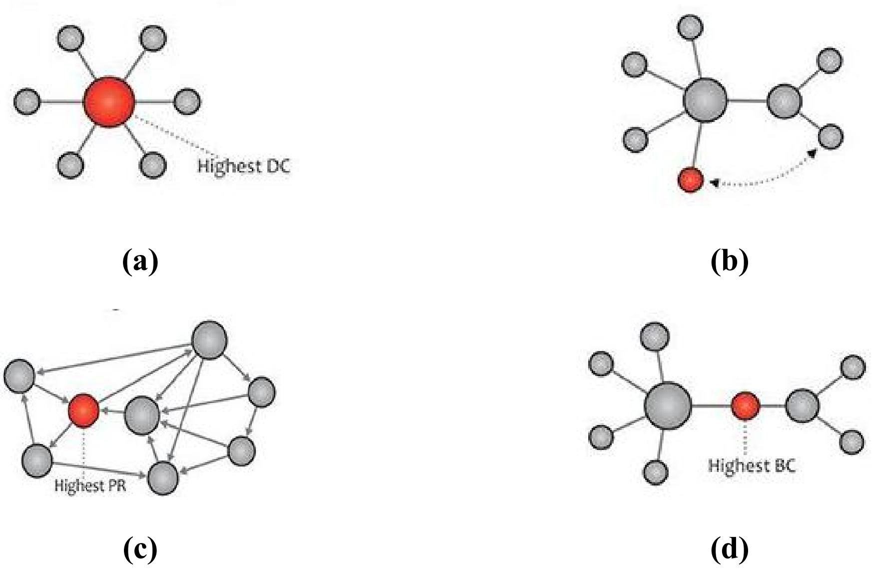

Figure 2. Centrality Measurement (a) degree Centrality (b) Eigenvector (c) PageRank (d) Betweenness Centrality.

It can be seen that all the previous studies utilize the centrality measurement independently. However, based on some analysis conducted, it is possible to combine certain centrality measurements into a single representation and evaluation of supplier-customer relationships in SCM. A more detailed framework is needed to deliver this concept, which can be seen as further research.

5. Conclusions

This paper briefly discussed the existing supply chain models, TSC, MSC, and ESC, and addressed the four issues arising in supply chain management. The four main issues were as listed: improving the relationship between suppliers-customers, costs optimization, risk management, and managing a dynamic supply chain. Previous studies have seen how it is possible to implement graph analytic centrality in SCM. This is done by representing the supply chain entities into a network graph. Several centrality measurements and their usage also been listed, such as finding the most connected nodes (DC) as the number of the company that supplier serves, identify particular nodes connected between separate parts of the network (BC), finding the nodes having the highest score as suppliers (EV) in SCM, and identifying nodes having many nodes, which may contribute less to the suppliers (PR). However, further, improvement is needed to have a more comprehensive representation and evaluation of the supplier-customer relationship in SCM by combining selected centrality measurements.

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