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The Impact of Cloud Computing on Manufacturing Value Chain

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Abstract

Cloud computing enables collaborative innovation and service manufacturing possible which has brought new opportunities and challenges to the development of manufacturing enterprises. On the basis of the present situation of manufacturing value chain and characteristics of cloud computing, this paper tries to analyze the impact of cloud computing on the manufacturing value chain, in order to make a discussion on the application of cloud computing in manufacturing industry. The results show that on the one hand, cloud computing enables manufacturing value chain to implement the dynamic reconfiguration of low cost, high efficiency and excellent quality, on the other hand, to realize highly coordination among enterprises through the cloud platform, manufacturing value chain manifests stronger demand orientation, greater degree of network and flexibility, as well as highly dynamism and instability. In addition, cloud computing has changed the value-added links to a certain extent, thus deepening the degree of servicisation of manufacturing value chain.

Key words: Cloud computing; Collaborative manufacturing; Value chain; Collaborative innovation; Service-oriented manufacturing

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INTRODUCTION

Recently, China's economic environment has been greatly changed, China's manufacturing industry is undergoing the historical stage of strategic reform from "made in China" to "created in China". However, economic slowdown, rise of raw material price and labor cost, and increasingly sophisticated consumer groups have indicated that the demand for innovation and the trend of servicisation have become irreversible. The emergence of cloud computing is just to make the service-oriented and collaborative innovative manufacturing value chain possible, which has brought new opportunities and challenges to the development of the manufacturing industry. In this context, to analyze the impact of cloud computing on manufacturing value chain has some reference significance to promote the landing and popularization of cloud computing, as well as to assist in the follow-up study.

Since the concept of cloud computing is put forward, which is a new distributed computing model, it has rapidly triggered a global research and development boom. Mell and Grance (2011) concluded the definition of cloud computing as well as its essential characteristics, service models and deployment models. Feng, Zhang, Zhang, and Xu (2011) described the great requirements of cloud computing in security key technology, standard and regulation etc., and provided a cloud computing security framework. While a lot of research is currently taking place in the technology itself, there is an equally urgent need for understanding the business-related issues surrounding cloud computing (Marston, Li, Bandyopadhyay, Zhang & Ghalsasi, 2011). Motivated by the weakness in this area, Marston et al. (2011) identified the various issues that would affect the different stakeholders of cloud computing and also issued a set of recommendations for the practitioners who would provide

and manage this technology. With regard to the application of cloud computing in manufacturing sector, Li et al. (2010) put forward a new service-oriented networked manufacturing model called Cloud Manufacturing (CMfg) and then defined the concept of CMfg. On this basis, a cloud service resource sharing model for service-oriented manufacturing was proposed so that service-oriented manufacturing resource, service-oriented process and intelligent search could be realized (Guo, Yang, Zhang & Dong, 2012). In addition, Xu (2012) argued that cloud computing was emerging as one of the major enablers for the manufacturing industry: it could transform the traditional manufacturing business model, help it to align product innovation with business strategy, and create intelligent factory networks that encouraged effective collaboration. As can be seen, existing studies on the application of cloud computing in manufacturing are mostly focused on cloud manufacturing, as well as its concept, surroundings, architecture and critical technologies, while the impact of cloud computing on value chain is rarely discussed. Therefore, from the point of value chain, this paper makes an attempt to find the influence of cloud computing on manufacturing value chain.

1. PRESENT CONDITIONS OF MANUFACTURING VALUE CHAIN

For a long time, China's manufacturing industry has been at low-end of value chain with a high labor-intensive rate, low value-added products and a weak technological innovation capability. The core technology and key equipment of most industries are basically dependent on foreign companies and most of the products are still in imitation stage. The low synergic degree among manufacturing value chain enterprises leads to a poor efficiency. The response time is quite long so that it is often difficult to make timely treatments correspondingly in the event of order changes. Lack of effective unified supervision among enterprises makes it hard to guarantee the consistency of multi-agent decision. What's more, collaboration among most of the current manufacturers relies on the trust mechanism which is formed by long-term cooperation between core manufacturers and collaborative manufacturers, so although credit and stability of value chain can be ensured definitely, we can't find the optimal collaborative manufacturing services (Ma, 2012).

In addition, the reaction rate of value chain is difficult to adapt to the pace of change in consumer demand. In response to changes in demand, each node enterprise in value chain has to improve safety stock, resulting in high operational costs throughout the value chain and high business risks. From the dynamic process of value chain, the current manufacturing value chain requires a very high cost to build, run and reconstruct. Strategic value chain upgrading and transformation are always faced with many difficulties and a low success rate.

2. THE DEFINITION AND CHARACTERISTICS OF CLOUD COMPUTING

Cloud computing, adhering to the "on-demand" concept, is able to provide to users on-demand access to a shared pool of computing resources in a self-help, dynamic stretching, and measurable way, which has unparalleled advantages in cost, speed and efficiency. Currently, cloud computing has no uniform definition. According to NIST definition, Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell & Grance, 2011).

According to the above definition and related literature, we can sum up some characteristics of cloud computing. From the two dimensions of technology and service, we try to make a description of cloud computing features as a starting point for analyzing the impact of cloud computing on the manufacturing value chain based on its dynamic reconstruction process.

2.1 Technological Dimension of Cloud Computing

2.1.1 Resource Virtualization

Resource virtualization refers to the fact that cloud computing uses virtualization, Internet of Things and other technologies to bring computing and all kinds of physical resources access to the network, converging virtual resources (including hardware and software resources, knowledge resources and capacity resources, etc.), packaged as cloud services and published to cloud platform, to form a shared virtual resource pool.

2.1.2 Dynamic Configuration of Resources

Cloud computing is able to dynamically configure and release resources according to user demand. When user demand increases, cloud can be quickly acquired like water and electricity. When some computing resources are no longer needed, these resources can be rapidly released and users can pay according to the actual usage. This flexible scalability enables cloud service providers to configure computing capabilities according to user demand, and provide fast and easy access to on-demand computing power on the basis of pay-as-you-go.

2.1.3 Network Access Facilitation

With the Internet as the carrier, cloud computing provides on-demand and scalable service by distributing the computing across a large number of distributed computers, rather than a local computer or a remote server. Users can easily use a variety of terminal devices to access data and applications in the cloud. These devices

can be computers or mobile phones, and even electronic products such as televisions. So we can say access to the network is everywhere.

2.2 Service Dimensions of Cloud Computing

2.2.1 Resources and Capabilities as a Service

Through cloud computing, resources are encapsulated into services and connected to the cloud platform, so that the resources and capabilities become professional services. Users can simply hire a required resource or capability as a service through the Internet, including varieties of manufacturing resources and capabilities.

2.2.2 Business Collaboration

As an open service platform, cloud computing allows companies across the value chain operating on a unified platform to achieve a high degree of resource sharing and business collaboration (McAfee, 2011). The business collaboration is mainly reflected in information collaboration, knowledge collaboration, collaborative decision-making, business process collaboration (including design, manufacturing and management coordination), and collaborative order changes etc.

2.2.3 Standardized Services

In order to ensure quality of service and better serve the mass market, cloud computing services are provided in simpler and more standardized contractual arrangement (Venters & Whitley, 2012), allowing the use of simpler high-volume purchase channels such as credit cards (Tilson, Lyytinen & Sørensen, 2010) with little or no direct interaction between user and provider (Armbrust et al., 2010; Durkee, 2010), which also reflects a consumerization of IT services. In addition, cloud computing services are given clear formal explanation for their cost and performance through service level agreements (SLA), which is a promise for consumers to obtain high-quality cloud services (Yang, Luo & Ding, 2012).

3. DYNAMIC RECONFIGURATION PROCESS OF VALUE CHAIN IN A CLOUD ENVIRONMENT

Traditionally, R&D, manufacturing, sales and services are the basic value activities of manufacturing enterprises. These basic values and some ancillary activities (e.g., logistics, finance, IS management et al.) make up the internal value chain. Manufacturers, combined with the homogeneous enterprises in the form of market, production or technology correlation, form the lateral value chain. And when they are combined with upstream suppliers, downstream customers, as well as research institutes and other related businesses, they will constitute the vertical value chain.

However, manufacturing value chain in a cloud environment operates on a unified platform, which means a break of the traditional value chain. Thus, the dynamic reconfiguration of manufacturing value chain in a cloud environment presents such a process: Manufacturers choose optimum partners in the alternatives recommended by cloud platform, and rapidly construct a value chain. During the operation process, when encountered with changes of the external environment or their business strategies, such as market demand changes, disputes, technology update et al., which is common, a disconnect of the original value chain will probably take place. In this case, the enterprise can quickly and easily find new partners through the cloud platform, enabling dynamic reconfiguration of the value chain.

4. IMPACT OF CLOUD COMPUTING ON THE CONSTRUCTION AND RECONFIGURATION OF MANUFACTURING VALUE CHAIN

In the process of building the value chain, cloud computing can help provide alternatives of value chain node enterprises quickly and intelligently according to user demand and the information of resources and capabilities manufacturing service providers owned. Thus, through the cloud platform, users are able to make a two-way choice according to their actual situation and alternatives recommended by the platform in an open and fair environment and quickly set up the value chain. Owing to its great advantages in cost, speed and efficiency, cloud computing has significant effects on the construction and reconfiguration of manufacturing value chain. The main effects are listed as follows:

4.1 A Significant Cost Reduction

Cloud computing enables a significant cost reduction of the construction and reconfiguration of manufacturing value chain. The traditional costs of constructing manufacturing value chain typically include: search costs to find the right value chain, negotiation costs to add to the value chain, learning costs to coordinate the value chain relationship and the time and labor costs during the entire process (Hu, Wang & Hu, 2009). In a cloud environment, trading patterns among manufacturing enterprises have experienced a transition to a serviced mode, and value chain can be constructed directly on the cloud platform. Since cloud computing enables resource virtualization and dynamic reconfiguration, users only need to pay for the actual resource usage, rather than the enormous cost of computing resources configuration at once, which will lead to a great reduction of informatization cost for the node enterprises. What's more, users can quickly find and match the right partners through the cloud platform, as well as enjoy real-time information sharing, which will drastically reduce the search cost and coordination cost of setting up a value chain.

4.2 Efficiency and Agility

Cloud computing, which is based on network technology, provides a convenient and effective third party platform for the construction and reconfiguration of manufacturing value chain. On a cloud platform, node enterprises realize highly collaboration of the material flow, information flow and cash flow. Accordingly, they are able to know specific circumstances of the value-added links and cooperative manufacturers in real time, and respond quickly and agilely. When faced with complex market environment changes, manufacturers can rapidly get corresponding service candidates through the cloud platform and select the most appropriate partners, in order to reconfigure the value chain in a rapid, effective way and at a low cost.

4.3 High Quality and Intelligence

Cloud computing brings a standardized service environment and unified service level management, which promises a higher quality of service than before. In addition, the screening service for collaborative manufacturers provided by cloud platform allows manufacturing companies choosing the most appropriate partners and the best quality services, greatly enhancing the quality of the constructed value chain. In this way, resources on a manufacturing value chain are disposed more effectively. What's more, cloud platform converges a large number of enterprises to build huge interdisciplinary knowledge base and manufacturing service base, thus enabling intelligent collaborative value chain possible.

4.4 Highly Dynamism and Flexibility

Collaborative manufacturers screening services provide enterprises a new choice to find the optimal cooperative manufacturers in cloud, which has broken the original long-term, stable value chain, thus speeding up the reconfiguration process of value chain. In this sense, cloud computing brings constant reconfiguration of value chain, which means great dynamism, so as to realize the efficient allocation of social resources.

This highly dynamism in some cases also reflects the value chain flexibility. When market environment changes, or the enterprise business strategy changes, cloud computing allows the constructed value chain having certain adjustability itself. When a partner providing a scarce resource withdraws from the value chain for some reason, for example, the enterprise can still quickly find alternative manufacturers through the cloud platform, refraining from a meltdown in the value chain.

4.5 Strong Demand Orientation

Fundamentally, the competitive advantage of manufacturing value chain is the ability to create value for customers. In a cloud environment, the dynamic reconfiguration of the value chain is directed by market demand. On the one hand, the various manufacturers and designers on the value chain can directly face the customers, track customer requirements in real time and make timely response. On the other hand, when the partnership of the value chain is no longer suitable for the current market demand, manufacturers can quickly find the most appropriate alternatives through the cloud platform and reconfigure the value chain, in order to meet the personalized needs of products and services.

5. THE IMPACT OF CLOUD COMPUTING ON THE OPERATION OF MANUFACTURING VALUE CHAIN

In the operation process of value chain, manufacturers need integrate their optimal value activities, and fully communicate and coordinate with their suppliers, customers, as well as various research institutes, in order to maximize their competitive advantage. Owing to the characteristics of cloud computing, such as resources as a service and business collaboration, not only the value-added way of many links in the value activities is changed, the integration and optimization of the value chain logistics, information flow and cash flow is also achieved. Specifically speaking, the effects mainly manifests in the following aspects:

5.1 A Drastic Running Cost Decrease and Running Efficiency Increase

When used in manufacturing industry, cloud computing enables enterprises access to cloud platform to quickly implement optimization and integration of internal and external value chain. In this way, material flow, cash flow, information flow can realize highly collaboration. The material flow collaboration means enterprises only need to product and supply on demand, rather than ready for a large amount of safety stock, which can greatly reduce the running cost of value chain. The collaboration of cash flow speeds up the circulation of capital and the accounting treatment process, enabling the managers to obtain financial data in real time for analysis and decision making. Also, the information flow collaboration helps value chain enterprises get quick reaction capability to deal with all kinds of sudden business requests and changes in tasks. By the way, value chain enterprises can interact with each other in real time in a cloud environment, greatly improving the efficiency of business activities, as well as the value chain running efficiency.

5.2 Providing Support for the Collaborative Decision-making of Value Chain

On traditional value chains, it often occurs that node enterprises are disjointed and fragmented, and each enterprise makes decentralized decision based on their own mastery of information, leading to low efficiency and lags in response of value chain (Du, 2003). And the emergence of cloud computing effectively alleviate this

phenomenon. Cloud computing provides an effective third-party platform for the collaboration of value chain enterprises. The implementation of unified regulation help cross-sectoral and cross-enterprise cooperation. Related staff from different enterprises who have access are able to track and deal with the same business in real time, which ensures highly consistency and timeliness of the decision-making and behaviors among the node enterprises.

5.3 Increasing Instability of Value Chain

The stability of value chain must be ensured. Owing to the trust mechanism formed by long-term cooperation between core manufacturers and collaborative enterprises, the traditional value chain has some warranties in stability. However, the stability has been challenged by the introduction of cloud computing.

In a cloud environment, information is highly shared and value chain enterprises will be more transparent, and also more close to each other. But at the same time, the value chain will be more dynamic and more unstable. Cloud computing greatly reduces the transaction cost to join another value chain, so that the original stable cooperation relations might be broken. Enterprises may use cloud computing for the manufacturer's screening, and choose more high-quality services and new partners. In this case, how to maintain stable cooperative relations among enterprises, and how to develop the rules between the market and cloud platform enterprises have become urgent problems to be solved.

5.4 Collaborative Innovation and Service-manufacturing

As for the characteristics of business collaboration, cloud computing has realized effective convergence of innovation resources and elements and can break the barriers among innovators, which makes collaborative innovation possible. Collaborative innovation refers to the process that cooperative parties make full use of their advantages and collaborate with each other, thus improving the whole innovative ability and product development performance, reducing risk, as well as optimizing and integrating core competences. In a cloud environment, suppliers, customers, research institutes and manufacturers can be involved in the product development and design together, in order to design products that better meet the needs of customers with a shorter development cycle and at a lower cost.

In addition, as cloud computing regards all kinds of resources as professional services, the trades between manufacturers begin to be service-oriented. The relationship between value chain enterprises is no longer a simple buyer-seller relationship, but a relationship that providing and purchasing services through a cloud platform. Manufacturers sell not only commodities, but also commodity-service packs. From the perspective of society as a whole, the service-oriented characteristic of cloud computing greatly speeds up the process of servicisation in the manufacturing sector in China.

5.5 Customer-focused Network

Cloud computing makes manufacturing value chain enterprises more focused on their core competences, and other businesses can be dealt with through purchasing related manufacturing resources and services on the cloud platform. Thus the previous linear value chains gradually transformed into a customer-focused network structure which is shortened, virtualized and flat (Zhong, 2006). In addition, owing to its professional services and convenient network access, cloud platform will attract more and more manufacturers, making manufacturing value chain ecosystem more complete and complicated, as shown in Figure 1.

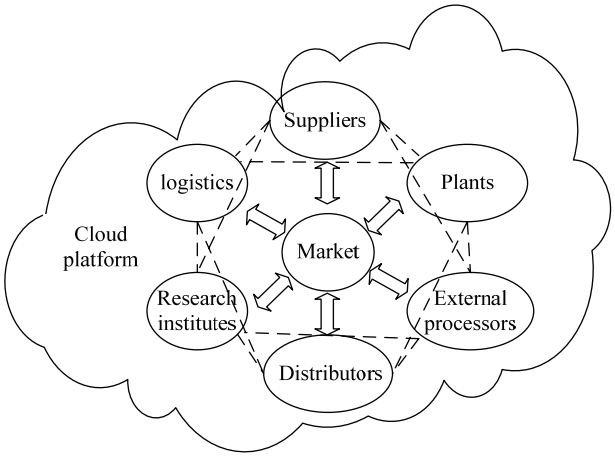

Figure 1
Value Chain in a Cloud Environment

Taken together, starting from its characteristics, we can get the influences of cloud computing on manufacturing value chain based on the dynamic reconfiguration process of value chain, as shown in Table 1.

Table 1
The Influences of Cloud Computing Characteristics on Manufacturing Value Chain

Characteristics Dynamic process reconfiguration process		Construction	Operation	Reconfiguration
Technological dimension	Resource virtualization	A low cost and high efficiency	A low running cost	Speed, high efficiency and a low cost
	Dynamic configuration of resources	Speed, agility and flexibility	Instability	High dynamics and flexibility
	Network access facilitation	Quality promotion and cooperation in more areas and at a higher level	Customer-focused network structure	To find the most appropriate partner on a broader scale and realize optimal reconfiguration of value chain
Service dimension	Resources and capabilities as a service	Improvements in resource utilization efficiency	Deepening the degree of service for manufacturing value chain	Changes in value-added process of value chain and trading manners of enterprises to some extent
	Business collaboration	Speed and agility; the whole process and all-round collaboration of value chain which brings synergistic effect	More efficiency and agility; providing support for the collaborative decision-making of value chain	Speed, efficiency and a low cost; more demand-oriented
	Standardized services	Promise for better QoS and value chain construction quality	Consumerization of IT services to better serve the mass market	Better value chain reconfiguration quality

CONCLUSION

Cloud computing has not only subtly transformed the way we live and work, but also carried huge implications for manufacturers. The widely adoption of cloud computing has changed the previous mode of manufacturing value chain operation. Thus, a highly informational and integrated value chain has formed among manufacturing enterprises. The cloud platform based on a united supervising third party has greatly reduced the building and running cost of manufacturing value chain. At the same time, cloud has made collaborative innovation and service manufacturing possible, which provides new opportunities for speeding up the process of service in manufacturing sector and achieving stable improvements of Chinese enterprises' creativity.

In a cloud environment, manufacturing value chain can realize highly resource sharing and business collaboration, and is more demand-oriented, networked and flexible, as well as a high degree of dynamics and instability, which means the value chain will probably confront continual and fast reconfiguration. This brings new problems for managers. How to deal with the dynamic reconfiguration and instability cloud computing brings about, and how to correctly understand and handle the relationship among manufacturing value chain enterprises in a cloud environment, have become a new direction of research.

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