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Cloud Computing: The Key To Better Supply Chain Management – A Brief Review

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***Abstract*— It is wide known that rapid development in information technology has made an impact on the manufacturing industry. Cloud computing (CC) is one of the important names in the field of information technology (IT). In recent years, CC has gained influence in supply chain management (SCM). Nowadays, the use of CC in SCM offers advantages, from cost efficiency, simplicity, flexibility and scalability of the system, to real-time visibility of flows/ operations. On the other hand, the use of CC in SCM results in benefits such as integration of processes, activities, systems information, and business partners. The main goal of this research work is to review and highlight the importance of using CC in SCM.**

***Keywords*— Cloud Computing; Industry 4.0; Information Technology; Internet of Things; Supply Chain Management**

I. INTRODUCTION

The developing world's CC sector has received considerable attention from global and local IT players, national governments, and international agencies. For example, IBM has established CC centers in China, India, Vietnam, Brazil, and South Korea. Other global cloud players such as Microsoft, VMware, Salesforce, Dell, and Parallels are actively searching for opportunities in the developing world. Perhaps even more impressive is that developing-world based firms have jumped on the cloud bandwagon. Cloud-related venture capital and other investments are also flowing into developing economies. It is probably fair to say that in no other major technological innovations has the developing world received this level of attention [1].

It is important that the use of CC in SCM also considers the economic, environmental and social impact for many organizations, the management of these factors being a key challenge. As globalization expands, it is becoming more difficult for organizations to maintain adequate relationships with suppliers to balance economic, environmental and social performance initiatives [2].

According to [3], CC is a technology with the potential to generate substantial productivity by changing the cost structure of companies, simplifying the creation of new businesses, reducing working hours and encouraging the creation of new working methods. CC allows users to access on-demand shared configurable computing resources hosted by third parties on the Internet, instead of building their own IT infrastructure. An enterprise that migrates its IT system and data to cloud computing can store the necessary resources as needed, instead of using its own infrastructure, can reduce server and storage costs, software maintenance costs, network and energy costs. and the costs associated with disaster recovery.

According to Elena [3], Cloud technology has been growing rapidly in the last four years in terms of its use in supply chain management. Overall, comparing the four years 2016 and 2020, the utilization rate of Cloud technology is increasing, with a percentage of 31.11% (see Figure 1).

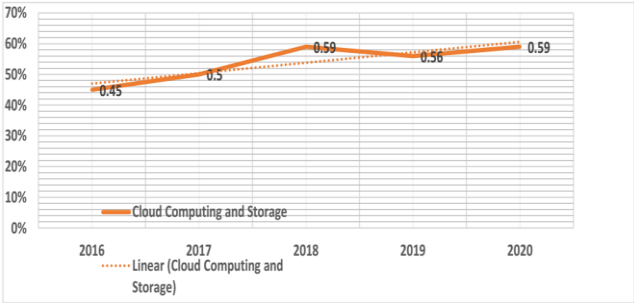

Fig. 1. The level of use of Cloud technology in the last four years in Supply Chain Management (2016 - 2020).

II. BACKGROUND

A. *An Overview of Supply Chain Management*

Successful firms have made a focused and clear idea of value creation, no matter if it is related from high-end products to custom-tailored services or generic and cheap commodities. However, how good your marketing is, no one may buy it if the product or service cannot be delivered to the consumer at an acceptable cost. Many companies should improve their SCM because their products spend time in inventories at least six months to a year or more. Since the products spend a lot of time in inventory, there is a huge opportunity to increase flexibility, reduce costs, make better deliveries, reduce cycle time, and lead to a more corresponding reduction in inventory. Several companies have improved their supply chain with

internal operations. They have recognized that it has a relation to external customers and suppliers and with it they can gain further improvements in operations. Krichen & Ben [4] described SCM to the decision-making process which manages different activities that create beneficial profits to suppliers, retailers, and customers. The efficient planning of activities can be cost-effective for production, sourcing, product development, logistical solution and for all flows that is linked between these activities. It can also be a process which optimizes a set of decisions. The process generates profitable solutions to provide efficient plans for acting on numerous levels while considering all decision-making standpoints. Krichen & Ben [4], Jacobs & Chase [5] advise that operations and SCM is critical for everyone to learn, no matter what your major is. They stated that even if your interest is in financial field, convert all values to the currency of your choice and after that, you will understand that it is about currency moving, storing, and exchanging the value. SCM is a vital aspect of making business today. For reader to understand what supply chain is, the research provides a formal definition of supply chain. There is a set of entities and relationships which are called supply network. In this supply network information and material flows are called downstream and upstream. Downstream goes towards the customer and upstream towards to the first supplier [6].

According to Figure 2, SCM is a vital aspect of making-business today. For reader to understand what supply chain is, the research provides a formal definition of supply chain. There is a set of entities and relationships which are called supply network. In this supply network information and material flows are called downstream and upstream. Downstream goes towards the customer and upstream towards to the first supplier. Downstream from the supplier to the customer consists of materials and requisite information, for example, usage instructions, invoices, inventory levels etc. and it flows until materials are transformed to the final product and sold to the end-customer. Upstream from the customer to the first supplier consists returned materials like defective units, customer returns, recyclables etc. and requisite information like forecasts and demands. With information of forecasts and demands, it is easier for suppliers to plan capacity and inventory level [6].

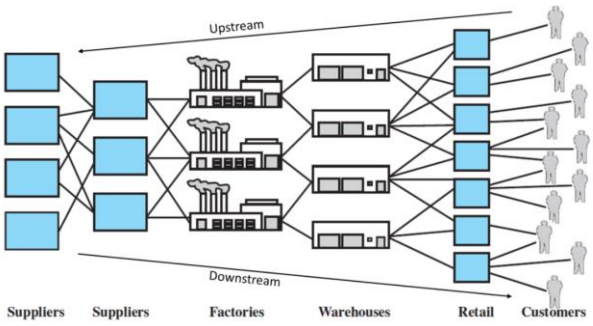

Fig. 2. Supply Chain Overview.

B. An Overview of Cloud Computing

According to [7], a Cloud is defined as a space over network infrastructure where computing resources such as computer hardware, storage, databases, networks, operating systems, and even entire software applications are available instantly, on-demand. It is true that Cloud computing may not involve a whole lot of new technologies, but the fact that it surely represents a new way of managing IT cannot be denied. For example, scalability and cost savings can be achieved to the largest extent from Cloud Computing.

CC is bound to be compared with service oriented architectures (SOA), Grid computing, Utility computing and Cluster computing. CC and SOA are persuaded independently. Platform and storage services of Cloud computing offers value addition to SOA's efforts. With technologies like Grid computing, computing resources can be provisioned demand resource provisioning. It also removes the necessity of over-provisioning to accommodate the demands of several customers. Utility computing is paying for resource usage, similar to the way we pay for a public utility (such as electricity, gas, and so on).

Figure 3 depicts the construction and deployment for Cloud service delivery model. End-users access Cloud services such as computing and datacenter resources via the Internet. The user needs to have an account with the Cloud service provider (CSP) for security and billing schemes. The required resources are specified by the users. The CSP provisions resources in the form of virtual machines directly to user accounts. This offering facilitates users more flexibility in building their own applications on top of remotely hosted resources. Users essentially rent operating systems, CPU, memory, storage and network resources from the CSP to improve elasticity and scalability of workloads.

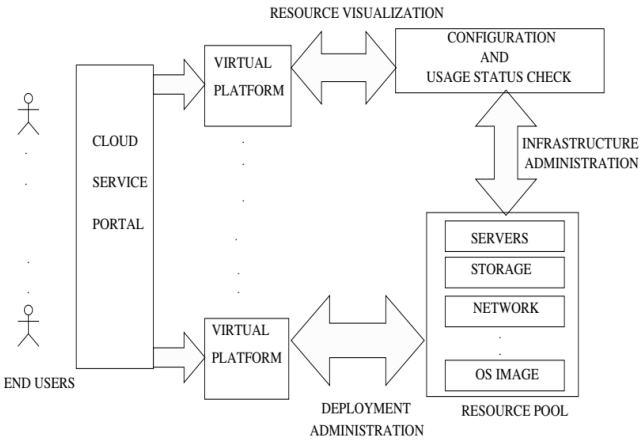

Fig. 3. Cloud scenario.

According to [8], CC is a computing paradigm in which tasks are assigned to a combination of connections, software and services accessed over a network. This network of servers and connections is collectively known as "the cloud". Computing at the scale of the cloud allows users to access supercomputer-level power. Cloud architectures also

include provisions to best guarantee service delivery for clients and at the same time optimize the efficiency of resources for providers. “Cloud” is a virtualized pool of computing resources. It can: Manage a variety of different workloads, including the batch of back-end operations and user oriented interactive applications.

Rapidly deploy and increase workload by speedy providing physical machines or virtual machines. Support for redundancy, self-healing and highly scalable programming model, so that workload can be recover from a variety of inevitable hardware/software failure Real-time monitor resources usage, rebalance the allocation of resources when needed. The core concept of cloud computing is reducing the processing burden on the users’ terminal by constantly improving the handling ability of the “cloud”, eventually simplify the users’ terminal to a simple input and output devices, and providing the powerful computing capacity of the cloud on demand. All of this is available through a simple Internet connection using a standard browser or other connection.

C. Cloud Computing for Supply Chain Management

SCM Cloud offers - “a set of services that provide SCM functions to any cloud user in an efficient, scalable, reliable and secure way”. That is, Cloud masks all the heterogeneities involved in implementing various SCM functions and the tiers within each function and provides a purely functional view rather than having to deal with the inherent technologies. The view of the cloud makes us, the service providers the best ones to take the cudgel to implement the CLOUD. We must therefore prepare a pool of requirements and a pool of plausible technologies and create a layer of abstraction to free the user from choosing packages, best-of breed solutions, databases, integration middleware, and infrastructure and think only about the required functionality and how much he can/should pay for it. Here is a simplified tiered-illustration of SCM cloud components (see Figure 4).

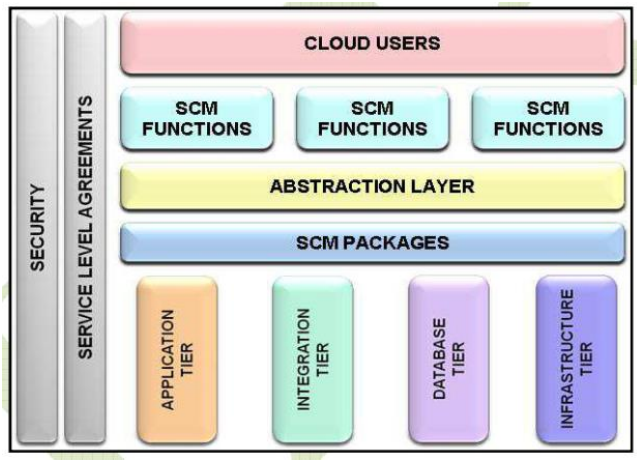

Fig. 4. SCM cloud components.

Most enterprise applications today use third party cloud services to implement a significant part of their functionality. This results in hybrid environments that require the integration of on-premises services with public cloud services made available on a pay-per-use basis by external cloud providers. The use of third party cloud services (e.g. payment services, storage services, etc.) in enterprise applications has many benefits, but at the same time presents challenges as both the functional and non-functional characteristics of cloud services are controlled by autonomous cloud service providers. Service consumers are primarily responsible for the selection of services, integration of cloud services into on-premises enterprise applications and managing continuity of operation during runtime. With the increasing use of cloud services, it is important that cloud service consumers use suitable methods and tools to manage the entire lifecycle of enterprise applications [9].

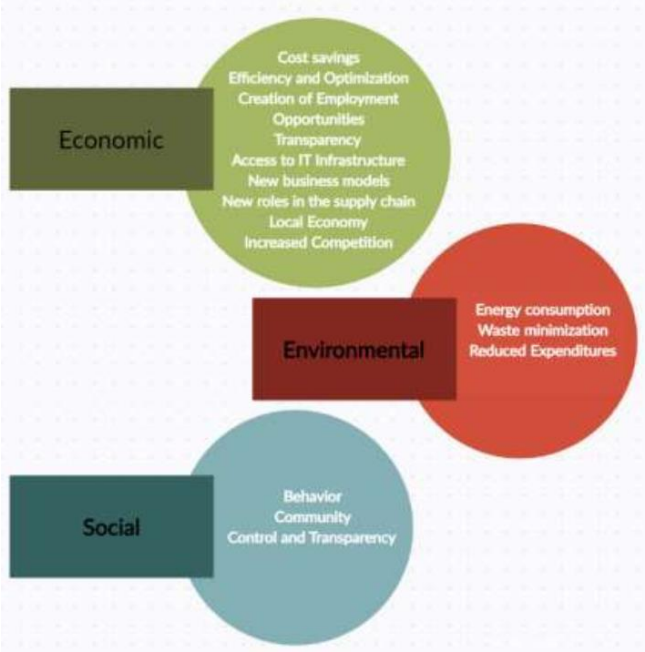

Fig. 5. The Economic, Environmental and Social Impact of using Cloud Technology.

According to Elena [3], above is the economic, environmental and social impact of using CC in SCM. According to Figure 5. SCM is influenced by a multitude of elements, which lead to the transformation of classical processes with modern ones. The CC in SCM from a social perspective has an impact on the communication between the process actors, making it more efficient (suppliers, customers, companies), but also on the way they collaborate to fulfill their work tasks. If in the traditional SCM there is no transparency and visibility on the activities/processes, through the CC, the processes can be controlled easily and quickly.

Cloud computing provides for flexibly outsourcing software for supply chain collaboration. Supply chain management acts on operational processes, different and consolidated information flows, and interaction processes with a variety of involved parties. Taking into account all the well-known problems of these central information systems, the question arises whether cloud-based information systems represent a better alternative to the establishment of an IT support

for supply chain management. The cloud supply chain represents a network of interconnected organizations in the cloud computing area involved in the provision of products and services required by customers. The developments of cloud computing influence the organizations and their supply chain activities in several crucial ways. It enables start-up companies to establish in the market with low up-front cost, by making services more valuable, accessible, and affordable [10].

More flexible and adaptive to prevailing situations of the market. The addition of CC can be the right technology in supporting the changing business norms and help the businesses cope up with the today's increasing and demanding needs. Efforts have been made to make centralized data management systems for better management and strategy formulation. SCM is in itself a very complex system involving infrastructure, processes, customer, products, and delivery. CC can help in simplifying this complex system and bring more clarity in operating the businesses. In recent times the organizations are seeing drastic changes from silos based structure to process based structure. This has integrated and streamlined the processes in the way they are to be used. This change has changed the internal structure and the way traditional SCM was managed. Now, in order to adapt with the changing structural issues, there is a need to integrate IT to make the systems more adaptable and gile [11].

III. DISCUSSION

CC is already making a significant impact on the supply chain management application market, and adoption is expected to continue to grow. Companies that provide SCM software applications – including e procurement, warehouse management systems, transportation management systems, supply chain planning, and business intelligence & analytics – are either already offering 'software as a service' (cloud based) solutions or are articulating a clear strategy to move to such solutions as more customers' demand it. CC is a computing paradigm in which tasks are assigned to a combination of connections, software and services accessed over a network. This network of servers and connections is collectively known as the cloud. The demand for CC services has grown tremendously over the past 2 year. SCM Cloud offers a set of services that provide SCM functions to any cloud user in an efficient, scalable, reliable and secure way [8].

According to [1], In China, IBM's pilot project Yun (Chinese for "cloud") lets businesses select and implement cloud services. The platform dynamically allocates storage, server, and network resources without human input. The Wang Fu Jing department store, one of China's largest retailers with more than 10 million customers, has deployed cloud computing in supply-chain management, which it uses to share information with its network of retail stores and implement business-to-business e-commerce. In Korea, banking, telecommunications, and IT hosting services use the cloud; while in South Africa, Nedbank is automating its business processes through the cloud.

Cloud-based information systems are a better alternative to establish IT support for supply chain management and the resulting economic, social and environmental effects have advantages [3]. Increasing stakeholder and environmental pressures are key challenges for supply chain professionals in finding tools that can enhance both economic and environmental performance. Moreover, growing complexity in supply chain networks makes leveraging different strategic priorities with other supply chain partners quite difficult [12].

In the recent times, more and more companies in the developed nations are migrating towards CC, which implies the transformation of their existing services through emerging virtual CC services. The adoption of CC entails that certain tasks are assigned virtually to the applications and networking services to ensure efficiency and cost-effectiveness [13].

Cloud service integration is not without difficulties, so a clearly structured approach for successful implementation with minimal risks to organizations is required. Enterprises may be keen on cloud-based supply chain solutions because of their potential advantages, yet may not be fully aware of potential problems. All organizations in a supply chain network are connected to the same cloud environment, so breakdowns or bad performance due to technical difficulties or some other reasons will have negative impact on the performance and productivity of the whole supply chain. Since all organizations in a supply chain network share all the sensitive information via the cloud, they should be ensured that there are no information spillage or any potential security lawful issues. The cloud service outage situation will have extremely negative effects on the efficiency of the supply chain. So it is essential for supply chain executives to evaluate and control risks related to using cloud based supply chain solutions. For this it is required to provide some practical guidelines from the decision science perspective to the executives to examine the behavior of the supply chain after adoption. Decision makers need to assess and control associated risks, this will help enterprises to ensure the success of adoption of cloud supply chain solutions [10].

According to [14], CC system uses lot of technology like standardization technology, virtualization technology, data management technology and platform management technology in supply chain information collaboration. Flexibility is great power of CC system. It has the ability to increase or decrease computing power as required by users. This term is referred as scalability. Scalability ensures that computing services available to the users at any point in time. Scalability is highly concern issue in supply chain management system. Because supply chain is

distributed in nature and each firm wants to grow its supply and distribution, there should be need to scale IT services of supply chain at big level. Distributed datacenter provide better bandwidth and traffic for supply chain users in cloud.

CC has been considered as an opportunity for small organizations to share the same services as larger firms, as well as share in the benefits garnered from their ability to openly interact and manage processes outside the organization. At the same time, this also allows organizations to reduce the cost of ownership of supply chain collaboration [15].

IV. CONCLUSION AND FUTURE DIRECTIONS

The results of Elena's [3] research indicate that information and communication technology with a focus on CC has a positive impact on SCM, gradually maximizing economic profitability, minimizing environmental impact and maximizing social welfare. At the same time, this technology has disadvantages that should be taken into account when implementing these services. Taking into account all that has been discussed, cloud-based information systems are a better alternative to establish IT support for SCM and the resulting economic, social and environmental effects have advantages. According to [10], Cloud-based solutions are not without risks, since services are provided by risks have been identified for enterprises adopting cloud based solutions. The European Network and Information Security Agency [ENISA] [16] has listed risks into different categories: 1) Policy and Organizational Risks: Lock-in, loss of governance, supply chain failure, conflicts between customer hardening procedures and cloud environment, and social engineering attacks; 2) Technical Risks: Resource exhaustion (under- or overprovisioning), isolation failure, cloud provider malicious insider, management interface compromise, intercepting data in transit, insecure or ineffective deletion of data, Distributed Denial of Service (DDoS), Economic Denial of Service (EDoS), Compromise of Service engine, loss of cryptographic keys, non-cloud specific network related technical failures or attacks, loss of backups, and natural disasters and 3) Legal Risks: Subpoena and e discovery, risk from change of jurisdiction, data protection risks, licensing, and intellectual property issues.

It is necessary to identify and assess the risks by implementing probabilistic risk analysis methods, such as Fault Tree Analysis, Event Tree Analysis, Monte Carlo Analysis, Scenario Planning, Sensitivity Analysis, or Failure Mode and Effects Analysis. These approaches are applicable only when enough required data is available. If not enough reliable and correct information is available to assess the risk, then Fuzzy techniques can be useful to do a risk analysis. The implementation of the risk optimization approach is required to control the risks occurrences which can control the impact of risks. The identified risk factors, likelihood and severity of risks information, and the establishment of contingency plans are required in the development of a risk optimization model.

Observing the benefits of cloud supply chain solutions, it can be concluded that the adoption of cloud computing is recommended to the organizations which are willing to improve their supply chain performance. Along with cloud based supply chain systems, the enterprises have to use efficient decision models to identify inefficient parties in the entire supply network and take good decisions on strategies to achieve more efficiency. Moreover, supply chain decision makers can use risk assessment models to identify risks and their attributes, and finally enterprises have to use risk optimization models to determine the optimal investments and minimize the cost of failures.

According to [1], Future research might also examine how political, ethical, social, and cultural factors are associated with security issues in CC. For instance, privacy and security issues of data stored on the cloud currently fall into a legally gray area. It is, however, reasonable to expect a gradual evolution of legal institutions as well as ethical and professional standards related to data stored on the cloud. Countries could avoid some barriers to realizing the cloud's full potential through better planning and efforts to address human resources. Workers' existing skills might be insufficient for developing the cloud industry. Governments must take measures to develop cloud-related skills, and universities must provide hands-on experience. The development of industries necessary for backward and forward linkages is equally important. The evolution of the CC led telecommuting in South Africa, for instance, can be attributed to the country's high-speed, low-cost bandwidth.

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