International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 9 Issue 2, Mar-Apr 2025 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Cloud Computing in Supply Chain

Matthew N. O. Sadiku[1], Paul A. Adekunte[2], Janet O. Sadiku[3]

[1]Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX, USA
[2]International Institute of Professional Security, Lagos, Nigeria
[3]Juliana King University, Houston, TX, USA

ABSTRACT

Cloud computing refers to the access and use of remote servers as opposed to in-house servers to handle data. It has emerged as a powerful tool in revolutionizing supply chain management processes. The migration of supply chain processes to cloud computing is a strategy adopted by more and more businesses. By leveraging the cloud, companies can efficiently streamline their operations, enhance collaboration, and improve overall efficiency. With a cloud solution, buyers have access to information from different places and devices. Cloud computing provides a reliable and scalable infrastructure to store and process the vast amounts of data generated in the supply chain. The competitive advantages of the supply chain cloud for your supply chain are too significant to ignore. The main purpose of this paper is to explore various uses of cloud computing in the supply chain industry.

KEYWORDS: *technology, cloud computing, supply chain, supply chain management, SCM, supply chain industry*

How to cite this paper: Matthew N. O. Sadiku | Paul A. Adekunte | Janet O. Sadiku "Cloud Computing in Supply Chain" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-9 | Issue-2, April 2025, pp.159-168, URL: www.ijtsrd.com/papers/ijtsrd76270.pdf

IJTSRD76270

INTRODUCTION

The digital revolution has ushered in transformative technologies that have disrupted various industries, including supply chain management. Technology is tremendous in reshaping the supply chain strategies in the business world by enhancing efficiency, streamlining operations, predictive analysis, and sharing real-time data. Technology in supply chain boosts digital infrastructure that permits companies to become accustomed to fast changes in market situations and continuously drive enhancement through their supply chain management. The main purpose of cloud computing is that the public can use computing power just like the way they use water, electricity, gas and telephone. Cloud will be available in a pay-as-you-go model that users can pay for only what they use. Figure 1 shows the symbol for the cloud computing [1].

The demands on modern supply chains have never been higher. When we talk about cloud supply chain we mean ensuring a collaborative development on the Internet from the start of the chain until the product reaches the consumer's hands. Cloud computing is the most efficient way to manage a global business with many participants as agents like the supply chain [2]. It is the backbone of any industrial digital transformation. Consumer behavior changes swiftly, e-commerce continues to disrupt traditional models, and global markets present constant unpredictability. Cloud-based solutions are changing the way supply chains operate, making processes like forecasting, downtime reduction, and collaboration much smoother. By utilizing cloud supply chain management (SCM), companies gain operational efficiency, automate mundane operations, save costs, and improve visibility.

CLOUD COMPUTING BASICS

Cloud computing represents a newly emerging service-oriented computing technology. It is the provision of scalable computing resources as a service over the Internet. It allows manufacturers to use many forms of new p systems such as 3D printing, high performance computing (HPC), industrial Internet of things (110T), and industrial robots. It is transforming virtually every facet of modern manufacturing. It is innovating, reducing

cost, and bolstering the competitiveness of American manufacturing [3].

The key characteristic of cloud computing is the virtualization of computing resources and services. Cloud computing is implemented in one of three major formats: software as a service (SAAS), platform as a service (PAAS), or infrastructure as a service (IAAS). These services are illustrated in Figure 2 [4] and explained as follows:

SaaS: This is a software delivery model in which software and associated data are hosted on the cloud. In this model, cloud service providers offer on-demand access to computing resources such as virtual machines and cloud storage. Nowadays oil & gas companies transition to cloud computing and implement SaaS solutions for operations.

PaaS allows the end-user to create a software solution using tools or libraries from the platform service provider. In this model, cloud service providers deliver computing platforms such as programming and execution.

In the laaS model, cloud service providers can rent manufacturing equipment such as 3D printers.

Just like cloud computing, CM services can be categorized into three major deployment models (public, private, and hybrid clouds) [5]:

- Private cloud refers to a centralized management effort in which manufacturing services are shared within one company' or its subsidiaries. A private cloud is often used exclusively by one organization, possibly with multiple business units.
- Public cloud realizes the key concept of sharing services with the general public. Public clouds are commonly implemented through data centers operated by providers such as Amazon, Google, IBM, and Microsoft.
- Hybrid cloud that spans multiple configurations. and is a composed of two or more clouds (private, community or public), offering the benefits of multiple deployment modes.

These models are shown in Figure 3 [6]. Cloud computing finds application in almost every field.

CLOUD COMPUTING IN SUPPLY CHAIN

The aim of every business is to get their products or services to target customers. This is where supply chain comes in. The supply chain refers to the system, collection and connection of resources, both human, material, financial, information, that are used in a product or service to customers from the producer. Given the importance of the supply chain to businesses, there have been several attempts to improve the efficiency of supply chains. Several new technologies, including cloud computing, have been utilized to increase the effectiveness, reach, and performance of supply chains. Technology is not considered a dispensable luxury these days but an indispensable necessity for businesses and industries to be a part of this competitive world. Supply chain technology is now an essential means of coordinating logistics, inventory management, suppliers, and demand forecasting. For example, by implementing supply chain technology, companies can accomplish exceptional proficiency and flexibility levels and reduce fraud. Supply chain technology trends offer suitable and consistent operation handling and transparency while delivering products according to the company's needs. As the future of manufacturing is emerging gradually, supply chain technology is being directed to adopt better approaches to stay ahead in the dynamic market [7]. Figure 4 shows a symbol for supply chain [8].

Supply chain management is a complex and critical component for any business operating in today's globalized marketplace. Traditional supply chain management often faces key challenges, including limited inventory visibility, fragmented operations, slow decision-making, and escalating costs. These issues can hinder efficiency and responsiveness, making it harder to stay competitive. Cloud computing in supply chain management is a technology that allows you to store data on a centralized platform with access via the Internet. Cloud technology for supply chain management offers computing services for large data processing and accessibility in organizations. It includes tools, processes, and infrastructure that provide people with an overview of the transportation of goods from anywhere. With cloud computing in supply chain management, you are leading the way and everything is streamlined and accessible in real-time. No more headaches from siloed operations or data delays. Cloud solutions help you stay agile, save money, and make better decisions on the fly. Cloud-powered supply chains are faster, smarter, and more efficient, ensuring you stay agile, cut costs, and fulfil your promises, even in unpredictable markets.

COMPANIES THRIVING WITH CLOUD-DRIVEN SCM

Cloud computing in supply chain management is a technology that allows you to store data on a centralized platform with access via the Internet. Here are real-life examples that demonstrate the transformative power of cloud-based SCM supply in the manufacturing industry. These companies have

harnessed the potential of data analytics, real-time monitoring, and cloud-based solutions to drive efficiency, reduce costs, enhance customer satisfaction, and maintain a competitive edge in their respective markets. Typical examples include the following [9,10]:

- *General Electric* (GE): GE, a global conglomerate, leveraged cloud-based supply chain management to enhance visibility and collaboration across its extensive network of suppliers and manufacturing facilities.
- *Flex Ltd (formerly Flextronics):* Flex, a multinational electronics manufacturing services company, embraced cloud-based supply chain solutions to optimize its global supply chain. The company leveraged cloud platforms to gain real-time insights into its supply chain operations, enabling better demand forecasting, inventory management, and order fulfillment.
- *Jabil Inc.:* Jabil, a leading contract manufacturer, integrated cloud-based supply chain management to orchestrate its global manufacturing operations. Cloud technology enabled Jabil to optimize production schedules, monitor equipment performance remotely, and collaborate seamlessly with suppliers.
- *Lockheed Martin:* Lockheed Martin, a global aerospace and defense company, adopted cloud-based supply chain solutions to ensure agility and resilience in its complex supply chain. By centralizing data in the cloud, Lockheed Martin gained real-time visibility into its supply chain, allowing the company to respond swiftly to changes in demand and disruptions in the aerospace industry.
- *Caterpillar Inc.:* Caterpillar, a renowned manufacturer of construction and mining equipment, implemented cloud-based supply chain management to enhance its global supply chain processes. The company integrated cloud technology to monitor the condition and performance of its heavy machinery worldwide.
- *Walmart:* This company uses cloud-based platforms and AI to manage its supply chain. Walmart's use of cloud-based technology helps the company analyze data, optimize supply chain operations, and improve customer experience. Leading up to 2023, the Walmart supply chain has seen huge overhauls, but it still remains one of the most efficient in the world. Figure 5 shows a Walmart store [8].

APPLICATIONS OF CLOUD COMPTING IN SUPPLY CHAIN

Cloud computing in supply chain refers to the use of cloud-based technology to manage and optimize various aspects of a supply chain, streamlined processes across the entire supply chain network, all through centralized data storage and access via the Internet from any device. A cloud-integrated supply chain leverages cloud computing technology to connect and manage all aspects of a supply chain, allowing for real-time data access, improved collaboration between stakeholders, enhanced visibility into inventory and shipments, and ultimately leading to greater efficiency, cost savings, and faster decision-making across the entire supply chain network. Common areas of applications of cloud computing supply chain include the following [11]:

- *Predictive Analytics:* Ever found yourself overstocked with items that did not sell or out of stock on bestsellers? Traditional forecasting methods often miss the mark. That is why businesses are turning to supply chain cloud computing for AI-driven predictions. Cloud solutions use predictive analytics to study sales trends, seasonality, and customer behavior. They help organizations plan smarter, avoid waste, and keep customers happy.
- *Forecasting:* This is one of the most integral parts of supply chain. Forecasting and making predictions for what the future may hold is one of the most important functions within supply-chain management. Every company wants to be able to forecast demand and supply, so as to plan for production and supply. Cloud computing is essential for effective enterprise planning and logistical forecasting. It can be of help by collecting and unifying data from customers, retailers, wholesalers, and even the producers themselves.
- *Logistics:* One of the things that plagues supply chain managers is logistics. From inventory to transport management, poor logistics can be the downfall of even the best supply chain. Maintaining a responsive and effective supply chain requires a strong grasp of logistical efficiency. Cloud computing can help with logistics by providing tracking operations, automatic inventory management and transport route optimization. The sharing and unification of data on the cloud can also help the various entities involved in logistics plan effectively. Figure 6 shows different components of logistics [8].

- *Communication:* Effective communication between partners is critical for optimizing the supply chain. When trading partners have effective communication methods in place, they can achieve mutual goals, deliver orders reliably and quickly, and drive efficiency across the supply chain. Cloud computing in the supply chain takes communication to another level. Cloud-based platforms can collect a plethora of data on sales, product movement, replenishment frequencies, and more.
- *Beef Supply Chain:* Beef is a vital source of protein and is widely consumed across the globe. It accounts for almost 24% of global meat production. Beef supply chain is one of the segments of food industry having considerable carbon footprint throughout its supply chain. The major emissions are occurring at beef farms in the form of methane and nitrous oxide gases. The main reason behind it is the emission of methane from the cattle because of the process called enteric fermentation. Carbon emission is occurring at different stages in the beef supply chain. Stakeholders are concerned about the carbon footprint generated from their operations as well because of the pressure from government authorities. Cloud computing technology is deployed to minimize the carbon footprint of the entire beef supply chain.

BENEFITS

The benefits of the cloud for supply chain are almost countless, including easy access to information, scalability and reliability, reconfigurability, and high performance, all without complex infrastructure management. Cloud computing significantly benefits a supply chain by enabling increased collaboration, better visibility into inventory and operations, improved scalability, cost efficiency, real-time tracking, data analytics, and enhanced agility. The intelligence and automation provided by cloud computing is perhaps the most important benefit. Increasing competitiveness and productivity is the key reason businesses are moving their procurement operations to the cloud. The use of cloud computing for supply chain helps to curb global warming. Other benefits of cloud computing in supply chain include the following [12,13]:

- *Automation:* Automation is one of the most significant benefits of a cloud supply chain. Automating time-consuming inventory tasks with the cloud significantly simplifies overall management. The automation of the procurement cycle frees teams to work in a smart way, with short- and long-term strategies, which increases the competitive strength of businesses. Managing things like inventory tracking, order processing, and handling paperwork can be a hassle and is often full of human errors when done manually. Cloud-based supply chain planning simplifies automation by handling tasks like inventory updates and reordering automatically. There is no need to manually track stock or stress about inventory levels—everything gets updated in real time. This makes operations run more smoothly and efficiently, reducing errors, and allowing businesses to grow quickly without getting bogged down in day-to-day tasks.
- *Accessibility:* There is accessibility, via the cloud, of all the documentation and ongoing data-gathering that makes for a harmonious supply chain ecosystem. Supply chain coordination and financing can be complex beasts — and some companies might need the speed, efficiency, and organization the cloud provides to enable reverse factoring and other types of cash-flow-boosting financing options.
- *Scalability:* Scalability is a major advantage of operating a supply chain in the cloud. The term "scalability" is related to a company's ability to meet increasing demands, but without losing quality. Cloud computing offers scalability and flexibility, which are crucial for supply chains dealing with fluctuations in demand and rapidly changing market conditions. Cloud computing, with its immense computing power and flexible infrastructure, provides a scalable platform for supply chain operations. The use of the cloud in B2B procurement management assures higher scalability, because resources can be easily adapted to different scenarios. A scalable supply chain integrates people, processes and technology, which is crucial to gain agility and competitiveness in an increasingly dynamic market.
- *Sustainability:* Using the cloud to run a supply chain can also support sustainability goals. By using cloud solutions, you can increase resource savings. For example, printing and paper become very rare. These actions contribute to decrease greenhouse gas levels and their negative impacts on climate and the environment.
- *Cost Efficiency:* The increased efficiency provided by cloud computing means that companies can save costs previously resulting from bottlenecks, logistics issues, and other mishaps. The best part is that cloud computing does not require investments on in-house servers or software. Cloud supply chain management

reduces the need for hardware or significant upfront costs, enabling companies to avoid large capital investments. Moving to cloud-native services helps reduce operating expenses and allows for cost savings.

- *Cost Optimization:* The ongoing expenses of maintaining traditional supply chain systems—such as hardware, software, and IT services—pose a significant challenge for many small and medium-sized businesses. Cloud-based supply chain management software offers a much more affordable and flexible option. With no need for physical infrastructure, businesses can save money on hardware and IT support.
- *Speed:* The speed with which companies can now perform supply chain operations and activities because of the efficiency provided by cloud computing is another benefit. The proactive identification and prediction of opportunities and risks will ensure that companies swiftly swing to action. Also, there is an enhanced responsiveness to increase in demand or other things. A competitive company must be agile. Having a cloud solution for corporate procurement processes will allow making important decisions, based on information and analytics and, consequently, in a more agile way.
- *Real-Time Visibility*: One of the key advantages of cloud computing in supply chain management is the ability to achieve real-time visibility and transparency. Increased visibility is significant when opting for a cloud computing solution, as data is updated in real time. Real-time visibility helps you avoid costly disruptions. Without real-time access to data, managing your supply chain becomes quite difficult. Cloud-based platforms provide real-time visibility, enabling businesses to track and monitor inventory levels, shipments, and supplier performance. Cloud-based supply chain software gives you immediate access to live data—inventory levels, shipments, and supplier performance—across your entire network. With all this information in one place, you can make quick, better decisions to keep your operations run smoothly.
- *Collaboration:* One of the reasons cloud computing initially gained popularity is that it allows people to work together and get things done more efficiently despite geographical boundaries. As illustrated in Figure 7, Cloud computing enables seamless collaboration among partners and stakeholders [8]. It allows real-time collaborative planning, forecasting, and inventory management across the entire supply chain network. Shared and collaborative work is vital to make the procurement area more productive and strategic. Traditional supply chains often face the challenge of not sharing data across different partners or teams. Supply chain cloud solutions bring everything together in one spot. With cloud tech, suppliers, manufacturers, and retailers all have access to the same up-to-date information. This keeps inventory, orders, and forecasts on point, helping teams solve problems faster and keep things running smoothly.
- *Reduced Cybersecurity*: Reduced cybersecurity is another possibility associated with cloud tools. Cloud providers invest significantly in advanced architecture and cybersecurity. Cybercriminals often strategically plan attacks to cause the most disruption. Company IT teams should follow cybersecurity frameworks that help them create best practices. A well-managed cloud platform is ultimately more secure than a traditional database. With a cloud supply chain, your data is protected with the latest advancements.

Some of these benefits are displayed in Figure 8 [14].

CHALLENGES

Cloud-based supply chain tools have some potential downsides. When implementing cloud computing in a supply chain, major challenges include data security and privacy concerns, integration difficulties with existing systems, potential service disruptions, managing complex data sharing across multiple parties, and adapting to changing consumer behaviors. Adapting to rapidly changing customer demands and expectations, such as faster delivery times, can be difficult with a cloud-based system. Other challenges include [10]:

- *Data Security and Privacy:* Protecting sensitive supply chain data stored in the cloud, especially when shared across multiple partners, is a significant concern. Data protection and privacy are key considerations and securing the cloud-based infrastructure is crucial.
- *Integration:* Integrating cloud-based systems with existing legacy systems within the supply chain can be complex and time-consuming. If your supply chain runs on legacy systems, you need to develop an implementation approach that will transfer all your data and dealings without any hitch.
- *Change Management:* Implementing cloud-based systems often requires significant organizational changes and employee training, which can be challenging.

- *Lack of Expertise*: The logistics and supply chain industry suffers from labor shortages, equipment availability, persistent unpredictability, and the ripple effect of global bottlenecks. Implementing and managing cloud-based systems may require specialized skills that might not be readily available within an organization.
- *Compliance:* In today's digital supply chains, businesses face a growing number of security risks, including data breaches and the challenge of staying compliant with strict regulations. Protecting sensitive customer and financial data across a wide network of suppliers and partners has never been more critical to a company's success. Cloud supply chain management software is a powerful tool for strengthening data security. By automating compliance, businesses do not have to worry about falling behind on regulations or getting hit with fines. It also helps prevent security risks and keeps everything running smoothly.
- *Risks:* It is important to note that introducing cloud computing in supply chain and logistics creates risks that, in turn, must be managed. 88% of cloud breaches are the result of human error. This highlights the importance of airtight governance and regular training for cloud users. In today's hyper-competitive business environment, the stakes in supply chain management have never been higher. Cloud solutions help to avoid financial losses in B2B procurement processes.
- *Global Warming:* This is an alarming issue for the whole humanity. Carbon emission in the environment is becoming a crucial issue and has a wide range of consequences for both society and climate. Climate change and global warming are drawing the attention of all stakeholders of supply chains from various industries. There is a huge amount of pressure from government authorities to all the business firms to cut down carbon emissions. All major industries and organizations are looking for ways to cut down carbon emissions in their supply chain and have fewer burdens on the environment. The manufacturing and food supply chains are contributing significantly to the large-scale carbon emissions.

CONCLUSION

The cloud has been gaining popularity throughout every industry for the last several years. Companies have been using cloud computing to bring innovation to the management of their supply chain. As industries continue their digital transformation, the cloud will continue to drive the success of modern supply chains. It is no longer enough to rely solely on experience and intuition; success now hinges on the ability to harness the power of cloud technology to drive efficiency, precision, and competitiveness. This transformation is a fundamental shift in how we approach supply chain management in the modern world. More information about cloud computing in supply chain can be found in the books in [15-20] and the following related journal: *Journal of Cloud Computing*.

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Figure 1 The symbol for the cloud computing [1].

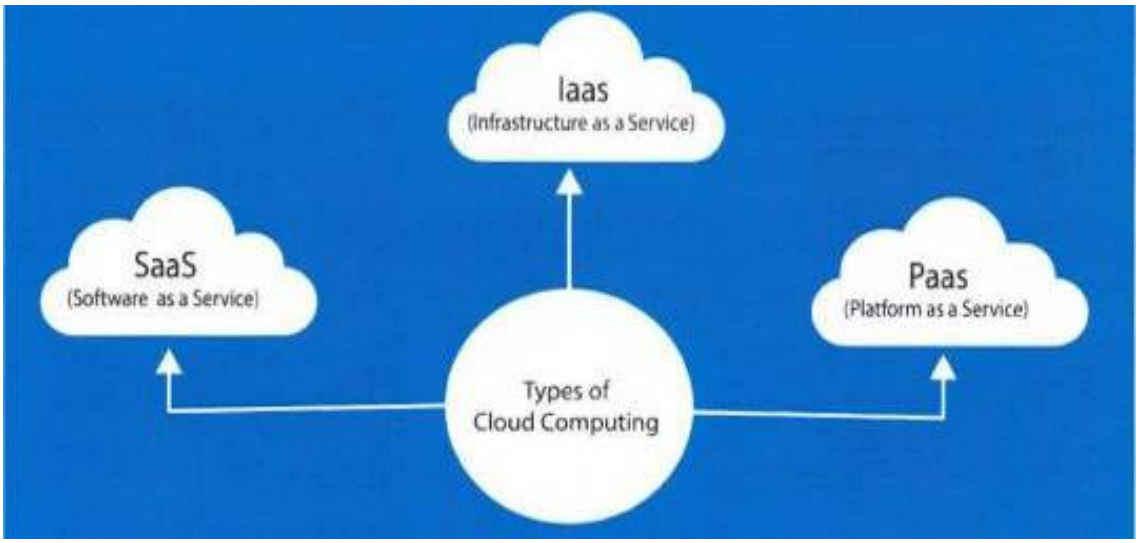

Figure 2 Three types of cloud computing services [4].

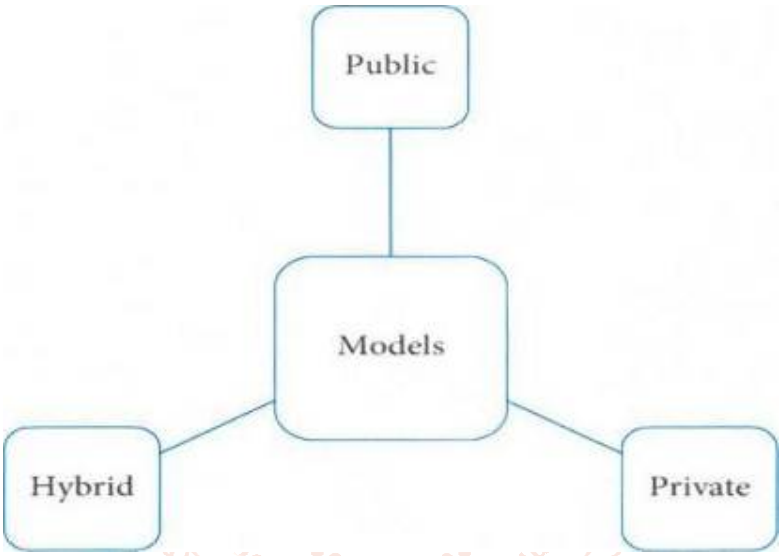

Figure 3 Cloud computing models [6].

Figure 4 A symbol for supply chain [8].

Figure 5 A Walmart store [8].

Figure 6 Different components of logistics [8].

Figure 7 Cloud computing enables seamless collaboration [8].

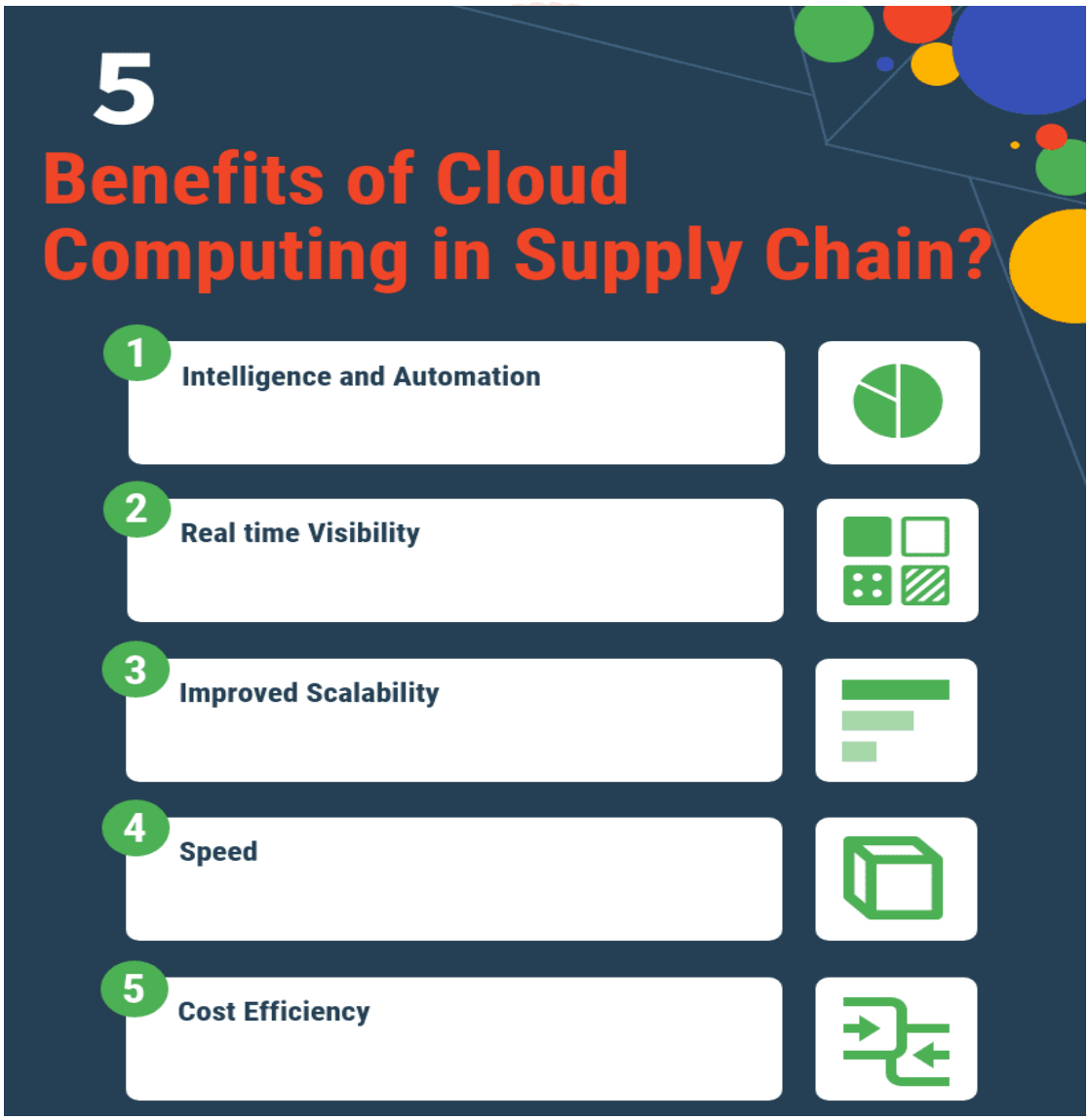

Figure 8 Some of the benefits of cloud computing in supply chain [14].