

Antecedents and Imperatives of Integrating SCM and ERP in Manufacturing Organizations : A conceptual Perspective with Big Data Analytics

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Abstract : Globalization has forced manufacturing organizations to take cost reduction and productivity improvement initiatives in order to gain competitive advantage. In this drive integration of business processes and systems and improvements in information flow across organization becomes essential which is obtained by adopting Enterprise Resource Planning (ERP) systems which acts as enabler. Effective integration of ERP with Supply Chain Management (SCM) enables sharing of information on order and shipment with multiple organizations and to better manage information, cash and product flows. Changing business environment has turned supply chains (SC) more complex as they are moving into the digital world through multiple initiatives, embracing new technologies such as big data, social media, mobile, Internet of things simultaneously. The convergence of these new technologies has finally resulted into phenomenal growth in the underlying data set not only in volume, but also in variety, veracity, velocity and value. Organizations are trying to use new forms of data to improve supply chain excellence. Big data analytics (BDA) allows to quickly combine structured data such as that in ERP, and combine them with unstructured data for analysis that could lead to increased efficiency and profitability in the SC. Purpose of this paper is to examine the potential of ERP and SCM integrated with BDA contributing to improvement in the performance of manufacturing organizations. The analysis will be beneficial to practitioners and enterprise to evaluate performance.

Keywords : Enterprise resource planning, Supply Chain Management, Supply Chains, Big Data, ERP, SCM, SC, BDA

1. INTRODUCTION

Globalization has made market competition more severe with the result that manufacturing organizations need to develop various strategies to compete in the market. They need to be more agile, flexible and much more responsive to meet changing customer requirements and efficiently coordinate global demand, supply, and production. ERP is increasingly becoming very important in the present highly dynamic and modern business environment because of its ability to integrate the flow of material, information and financials to support organizational strategies and also to enhance its competitive advantage [34][36]. Organizations need to have more efficient integration between internal and external supply chain and for achieving that they are accelerating integration of ERP and SCM.

Influence of IT positively contributes in achieving an effective SCM. In order to provide quality service to customers, organizations need to streamline its operations and integrate the supply chain activities [12]. The advent of Internet technology has changed the manner in which products are bought and sold in the market. Organizations

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need to efficiently manage the challenges of incorporating, integrating and utilizing valuable information incoming from many suppliers in the supply chain. SCM systems and techniques once implemented substantially increase overall productivity, bring improvement in inventory and shipping accuracy rates, forecasting accuracy and also reduction in inventory and lead time [32].

In these business networks of supply chains issues associated with the vast amounts of data is growing up. Manufacturing organizations need to plan and utilize the big data in order to add value for their customers and suppliers. They need to adapt to new business models and rethink their role and position in their value chain which may require some changes in the organizational and information technology view and need to create appropriate technology environment to support their business cooperation [21].

The main objective of this paper is to examine the potential of ERP and SCM integrated with BDA contributing to improvement in the performance of manufacturing organizations. This research draws conceptualization through an in-depth analysis of articles on the emerging literature on ERP, BD, BDA and SCM, as well as their impact on Supply chains. In the next section changing present and future through integration of ERP SCM and BDA is discussed, followed by next section on architecture and conceptual framework. Finally at the end conclusion of explained approach and future research directions are provided.

2. LITERATURE SURVEY

A. ERP SYSTEMS

ERP systems are multi-module highly complex information systems that help organizations to streamline their business processes [35]. ERP system is a kind of information system that manages every aspects of a business and enables linking of back-office and front-office operations of organization and also links internal supply chains with external supply chains [37][33]. Planning system sits at the core of an ERP system [18].

With the help of ERP organizations are able to manage their business in better way which has potential of obtaining benefits such as improvements in process flow, data analysis, customer service, profit margins and reduction of inventories [10].

Product quality and customer responsiveness improve by implementation of ERP systems. Interdepartmental information sharing and information quality improve inside the organization and also outside organization with suppliers, customers and other stakeholders in the supply chain. Internationalization of operations are make it essential to extend the integration across national borders. This integration could extend across Ultimately, this integrated supply chain will enhance overall business performance that helps to achieve competitive advantage in the global economy and improve long term profitability [2][13][36]. ERP implementations enable organizations to achieve the expected level of integration.

B. SUPPLY CHAIN MANAGEMENT

SCM according to [2] “is viewed as a network consisting of suppliers, manufacturers, distributors, retailers, and customers”. There are three types of flows supported by the network which are as described below:

- Flow of material in the form of product sold to customer by supplier and its return
- Flow of information flows representing order transmission and tracking, in coordination with the material flows; and
- Flow of financial in the form of credit terms, payment schedules etc.

This network is supported by processes, organization structures and enabling technologies [2].

SCs according to [11] “perform physical function of transformation, storage and transportation, and also the market mediation function of matching demand and supply”.

The integration process followed by organizations goes through various stages. Logistics is considered in the first stage only a distribution function, which in the second stage gets maturity as an integrated logistics, in which all the activities are coordinated with Supply, Production and Marketing. Eventually this internal integration achieved in the previous stage gets extended to all other stakeholders in the SC [25].

Organizations should enhance efficiency and improve performance of SCM and gain competitive advantages in view of challenges being faced by the external environments and alliance partnerships organizations which is becoming more complex [4].

According to [23] “A supply chain can be viewed as a group of distinct entities (e.g. raw material supplier, manufacturer, transporter, retailers, etc.) which interact seamlessly in order to convert raw material into desired product and deliver the same to the customer to meet their demand at desired level of time and cost”.

Integration and coordination of companies within a supply chain helps them to make improvement in efficiency, quality, productivity, ability to meet deadlines and also reduction in inventory, cash flow cycle time, cycle times, material acquisition costs and logistics costs.

SCM enables manufacturing organizations to efficiently satisfy customer demands most efficiently as they are able to produce the required product, in required quantity and stipulated time for a customer [32]. To make the supply chain efficient it is necessary to provide undisturbed and timely flow of information, materials and finances through integration of supply chain and ERP.

C. ERP/SUPPLY CHAIN INTEGRATION

In order to make advancements in organization’s supply chain ERP processes require customizations and developments, and hiring of consultants, which is not only highly costly proposition but also require long-term commitments by ERP vendors [5]. [18] Has demonstrated ERP system application to internal supply chain coordination and also defined the concept of hierarchical planning and scheduling for internal supply chain scheduling of a manufacturer, i.e. to a part only of the entire supply chain. A model is presented for improving the performance of internal supply chain processes by coordinating three levels of planning and scheduling in just-in-time environment with regard to quantities and dates. ERP systems positively impacts both internal and external supply chain integration [20].

Integration of supply chains is considered to be of strategic as well as operational importance. There is evidence of the relationship between supply chain integration and performance of an organization [8]. Benefits obtained from ERP contribute positively to organization’s competences of SCM in operational process, customer relationship and also in planning and control process [27].

D. BIG DATA

Big data is amalgamation of large scale data which gets generated from large number of small transactions, moving very fast, from various devices which may be unstructured and require much larger processing capability and advanced database management systems [22]. Big data also may have a low value for further usage before processing it [8]. The potential benefits for manufactures are immense as BD provides opportunities to add unprecedented rigor to demand forecasting and supply chain planning activities.

In the big data drive intelligence is gained from data and application of same in business makes it advantageous. Big data is, however, distinguished by the “5 Vs” data-related dimensions [30], such as:

- Volume – Voluminous data and large size of data bases. This increases number of factors taken into analytics models which makes the forecasts more accurate.
- Variety – Different data structures and forms, such as: structured and unstructured, text, sound, video, multimedia, etc.
- Velocity – Very high speed of data availability and high throughput of the data which require very fast data analysis. Data analysis is achieved by embedding it in the business processes.
- Veracity – High quality, correct and accurate data which is suitable, reliable and manageable.
- Value – Increase in value after processing.

Manufacturing organizations are able to make better decisions by gaining insight after processing big data. In addition it can assist in increasing customer engagement, optimizing business operations, prevention from threats and fraud, optimal inventory management and making use of new sources of revenue. According to [6][7] “ This increasing demand for improved insights requires a fundamentally new approach. An approach to extract meaningful

value from big data requires optimal processing power as well as capabilities to analyze the data (analytics) as well as appropriate skills". Big Data is really of strategic importance to the manufacturing organizations as insight drawn from big data can differentiate it from its competitors.

E. BIG DATA ANALYTICS (BDA)

BDA incorporates two dimensions: big data (BD) and business analytics (BA). BD has ability to process high volume and variety of data with high velocity and create veracity and value of data. Analytics helps business organizations make better decisions by gaining insight from data by applying mathematical, statistical, optimization, simulation and other advanced techniques [1][31]. Manufacturing organizations need to focus on the application of BDA in SCM that provides organizations and supply chains with the capabilities for handling variability and uncertainty, thus achieving supply chain integration and coordination. BDA offers new opportunities for competitive advantage by extracting significant value from massive amounts of data. In particular, BDA can help organizations make better decisions and improve their strategy, operations efficiency, and financial performance by predicting competition and scenario at market place.

BDA can not only improve operational and supply chain performance it can also help manage suppliers and customers, as well as logistics and transportation operations. Organization can benefit from improved evaluation of strategy, forecasting capabilities and risk management, safeguard against disruptions.

Big data analytics provides answers to business related questions such as: future outlook, requirement of customer in future, reason behind success, working of strategy, activities to be pursued in future, risks and mitigation plans, protection from business disruptions.

The key questions addressed by analytics, as presented by [6] are reflected in Table 1.

Table 1. Key questions addressed by analytics in SCM

<i>Analytics</i>	<i>Past :</i>	<i>Present :</i>	<i>Future :</i>
Information	What happened ? (Reporting)	What is happening now What will happen ? (Alerts)	What will happen ? (Extrapolation)
Insight	How and why did it happen? (Modelling, experimental design)	What's the next best action ? (Recommendation)	What's the best/worst that can happen ? (Prediction, modelling, simulation)
SCM examples	Product quality, Order performance, Asset utilisation	Dynamic routing, Order continuation, Bottlenecks, Equipment failures	Demand forecasting, Capacity planning, Alternate supply

Source: Davenport et al. (2010)

3. CHANGING PRESENT AND FUTURE THROUGH INTEGRATION OF ERP SCM AND BDA

Efficiency and effectiveness of organizations can be increased by harnessing power of big data analytics. Organizations will be able to perform better with less effort, will be able to produce higher-quality outputs, bring in improvements in products and services. The organizations will be also able to satisfy customer needs by leveraging their data to design products that meets customer requirements.

The prevalent global competition has created pressures on organizations to streamline their supply chains to make them more flexible and respond more quickly which requires extensive inter-organizational collaboration [19]. The competition between one firm with another has generated competition towards one supply chain with another and in turn has made entire market space very competitive [16][29]. Organizations need to harness the

powerful and innovative features available in Information Technology (IT) and utilize them for optimization of their SCs. There is very high expectation from BDA as it can take SC transformation to much higher level than before by providing improved insights and also reduce risk of frauds and other threats [15]. BDA can improve SC execution with increased efficiency and profitability by way of maximizing speed and visibility and enhancing SC agility [28].

Organizations will be able to bring their products to market faster by application of BDA which will enable them to earn more revenue [17].

Furthermore, BDA has been widely applied in supply chain operations, such as demand planning, procurement, production, inventory, and logistics; an improvement in supply chains can considerably contribute to the overall supply chain performance of business organizations [31]. Table 2 presents the analytics required for the strategic processes of SCM.

Table 2 : Analytics in strategic processes of SCM

Strategic Sourcing	Analyze marketing conditions, identifying and assessing supply chain risks, Analyze organizational spend profiles, procurement processes and future demand, Evaluating supply market trends and suppliers' inputs and economics, cost modelling , define appropriate contracting terms, create optimal bid processes and parameters, suppliers' evaluation and selection.
Supply chain network design	Capture changes on demand patterns, product mix, production processes, sourcing strategies, or operating costs
Product design and development	Identifying process bottlenecks, optimizing product trade-offs, increasing sales revenue, Quality and reliability prediction standards to determine clearly what is required of the part and the reliability of the materials used in the part , potential trade-offs by performing what-if scenario analysis to assess the effects of product design and development costs.
Demand planning	Analyze varying demand and processes to meet customer demand. Allocation and aggregation and forecasting at different levels. Improve sales and operations planning. Sharing of information with stakeholders by providing access to sales and inventory data and increase supply chain visibility.
Procurement	Analyze huge amount of procurement data generated through data obtained from spending pattern of buyer, supplier performance assessments and negotiations and facilitate better sourcing by managing supply risks and suppliers' performance.
Production	Analyze production data and obtain insights regarding production cost, production capacity levels, productivity in order to plan right mix of resource allocation to the right production lines to meet demand, inventory management, and budget forecasting, operations scheduling etc.
Inventory	Analyze supply and demand fluctuations, impact on inventory levels, predicting accurately inventory needs and in responding to changing customer demands, appropriate inventory levels while taking under consideration factors such as demand variability at the network nodes as well as performance (e.g., lead time, delays, and service level)
Logistics.	Analyze logistics data generated while shipping of products from supply points through various nodes to the demand points and design flexible supply chain system and optimize sequence of nodes for better distribution of goods. Optimization of routing of goods, vehicles and crew helps reduced transportation cost and increase margin better maintenance and safety.

4. CHANGING ARCHITECTURE AND CONCEPTUALIZED FRAMEWORK

Storing variety of data in conventional IT structures is difficult and problems are encountered in immediately reacting to it. The big data which is mostly unstructured data and arrives very fast requires other solutions [21]. Characteristics of Traditional and Big Data Analytic Environments identified [3] is presented in Table - 3

Table : 3 Changing Data Environment

<i>Traditional Data Environments</i>	<i>Big Data Analytic Environments</i>
<ul style="list-style-type: none"> Centralized data sources that are controlled and monitored (usually enterprise data that can be represented through relational database formats). Usually updated based on a frequency of hour, day, week, month, quarter, year Analytics are designed by rows and columns to be run in a production environment. Predictive analytics are largely optimization and simulation engines 	<ul style="list-style-type: none"> Data from many sources inside and outside the organization including traditional data warehouses. The data sources are often physically distributed and will often contain a variety of data elements both structured and unstructured. There is often a need to iterate to find the best solution when solving business problems. Large memory resources are required to support computational iterations. Every iteration of the problem solving usually requires a complete reloading of the information

Drawing from literature review we propose a conceptual framework of an integrated ERP SCM BDA model depicted in Fig. 1.

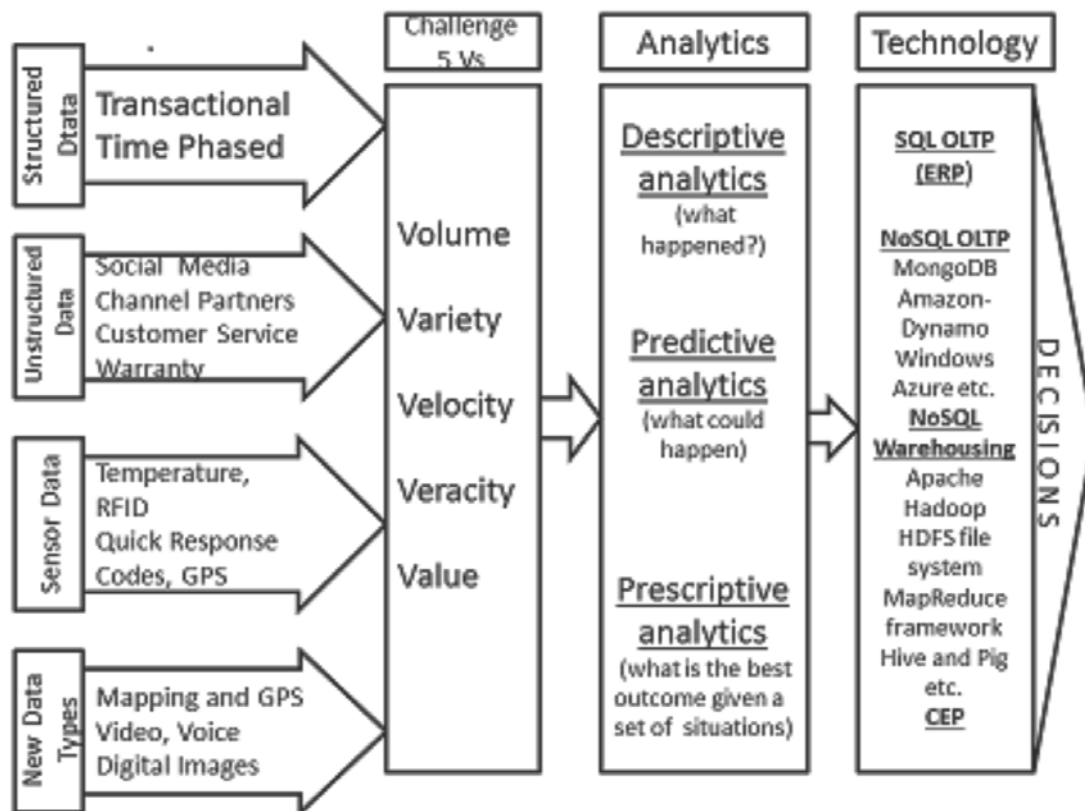


Fig. 1. Conceptual framework of ERP SCM BDA Integration.

5. LIMITATIONS AND FUTURE WORK

While we could focus on understanding the trends and development in the SCM and BDA and could conceptualize a framework we could not propose a model for business value realization for an organizations and improvements in SCM. A model needs to be developed to consider linking the role of BDA and its integration with SCM and ERP in the performance of supply chain and the organization that could be empirically validated.

Metrics need to be developed for organizations to monitor these on regular basis, troubleshoot substandard performance, and perform root cause analysis to identify a root cause. This will also improve business decision making and the improved business processes will result into tremendous benefits to organization [31]. Future research work should evaluate the impact of big data on traditional SCs and their structures and also development of new business models and structures which are big-data-enabled.

6. CONCLUSION

Through application of big data organizations are able to collect, update, store and make use of variety of data structures emanating from various business processes and activities. Application of analytics on big data provides valuable insight which helps organizations make timely, fast, better and effective decisions. Logistics and Supply Chain areas of manufacturing organizations are getting help in different aspects by application of big data. According to [14][26] “Many developments, including ERP, materials requirements planning, customer relationship management, vendor management of inventory, just-in-time, transportation management systems, warehouse management systems, total quality control etc. have made contribution to this advancement”. Major trend observed over the last few years has been on better and effective decision making with the help of accurate data-driven insight obtained from big data. The ‘big data’ era has arrived due to increased and more sophisticated developments in IT, availability of powerful computers and electronic devices. Appropriate application of ‘Analytics’ on these big volumes of powerful data can help businesses succeed. Organizations need to upgrade their existing IT landscape by acquiring knowledge about the capabilities and proposed landscape of big data [24].

Application of predictive and prescriptive analysis on big data can bring in improvement for logistics and supply chain design and management. Insights gained from vast amount of data integrated with ERP and SCM system of an enterprise can help decision making and help improvement in performance of Supply chains. In this article we could discuss various concepts around these developments, and tried to present that integration of SCM ERP and BDA has .positive impact on SCM area and organization performance.

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