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JIT supply chain; an investigation through general system theory

O P Mishra[a*], Vikas kumar[a] and Dixit Garg[b]

[a]*Department of Mechanical Engineering, YMCA University of Science and Technology, Faridabad 121006, India*
[b] *Department of Mechanical Engineering, National Institute of Technology, Kurkshetra ,India*

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A B S T R A C T

This paper explains theoretical approach of the four theories of General system Theory (GST) developed by Yourdon (1989) [Yourdon, E. (1989). Modern Structured Analysis. Yourdon Press, Prentice-Hall International, Englewood Cliffs, New Jersey. Senge] while applying it in information technology and subsequently used by caddy (2007) [Caddy I.N., & Helou, M.M. (2007). Supply chains and their management: Application of general systems theory. Journal of Retailing and Consumer Services, 14, 319–327.] in field of supply chain and management. JIT philosophy in core activities of supply chain i.e. procurement, production processes, and logistics are discussed through general system theory. The growing structure of the supply chain poses the implication restrictions and requires a heavy support system, many times a compromise is done while implementing JIT. The study would be useful to understand the general trends generated naturally regarding the adoption of the JIT philosophy in the supply chain.

1. Introduction

The primary objective of this paper is to discuss theoretical approach of the general system theory applied in Just in time (JIT) supply chain. It is considered that the activities of inter-organizational are artifacts as they operate within the real world. We take the reference of the work of von Bertalanffy (1969) and Weinberg (1975) of general system theory. Miller (1978) implemented this theory in field of biology and subsequent Yourdon (1989) to the field of information systems. The main inspiration is taken from the study of Caddy (2007) who used this theory in supply chain and its management for better understanding of the supply networks. An advantage of developing this more fundamental view of JIT supply chains could give greater insight into how supply chains operate and how their management could be applied in JIT environment. Supply chain management (SCM) plays an important role in different types of business. Today's supply chain does the business and not the

*Corresponding author. Tel: +91 9818602901
E-mail addresses: opmishra.m@rediffmail.com (O. P. Mishra)

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product. Taylor (2004) insisted the simple concept such as low inventories with JIT production and deliveries supplied just-in-time (JIT) for any firm has far-reaching effects internal as well as externally throughout the supply chain. Philosophy of JIT in the production system has been clearly sighted in the various literatures. Whereas the application of JIT in the total supply network of the goods (finished, semi-finished and raw materials) is mentioned little in the literatures. The implication problems and benefits of the JIT are also mentioned in respect of the supply chain but becoming a simple system into complex one is not being explored clearly. Here an effort is performed to explore the suitability of General Principal Theory is used in explaining the natural phenomena in adopting of the JIT in SC. The following four principals of Boulding (1956) are being applied to explain applicability of JIT environment for Supply chain in the recent business scenario,

Principle 1: The more specialized or complex a system, the less adaptable it is to a changing environment.
Principle 2: The larger the system, the more resources are required to support it, with the increase being non-linear rather than linear.
Principle 3: Systems often contain other systems or are themselves components of larger systems.
Principle 4: Systems grow over time, both in terms of size as well as structural complexity.

2. JIT applicability in the supply chain

JIT concept is widely covered in the literature and it implies a continuous search for waste reduction and to make only what is needed “just in time” (Toyoda, 1987). Most of the publications on JIT focus on the application of the concept in the manufacturing environment (John & Heriot, 1993). Father of JIT, Taiichi Ohno (1978) states “cost reduction is the goal of JIT. “JIT is a philosophy where all goods are to arrive exactly when they are needed, that is, neither too soon nor too late.” The objectives of JIT are stockless production and elimination of waste (Singh 1989). It can be also defined as a concept, which could be described as “produce and deliver finished goods just in time to be sold, subassemblies just in time to be assembled into finished goods, fabricated and / or produced parts just in time to go into subassemblies, and purchased materials just in time to be transformed into fabricated parts”.

Gunasekaran, (1999) states that no products should be manufactured or shipped until there is a demand for. Researchers have examined many theoretical, as well as practical issues involving buyer–supplier coordination, as a means of attaining successful implementation of just-in-time (JIT)-based decision systems, focusing on material flows, in an effort to minimize the supply chain costs or maximize the entire chain’s profitability (Fawcett & Birou, 1993).

The essence of JIT and supplier-related applied knowledge is the elimination of all forms of ‘‘muda’’ or waste in the upstream supply chain. The literature provides evidence of relationships between applied supply chain knowledge and reduced costs reduced lead times, lower inventories, and increased applied supplier supply chain knowledge. Applicability of JIT in supply chain has been sited at various literatures and JIT purchasing/ JIT –II, JIT production and JIT logistics are the three aspects of the supply chain are taken to explore the JIT role in overall in the supply chain. (SC). The combined study of the three is dealt as applicability of the JIT techniques in the whole supply network, which includes suppliers, manufacturer and distributers.

2.1. JIT purchasing

JIT purchasing is often called JIT-P and it is found in the literature in several instances. The first pioneering works by Schonberger and Gilbert has been seen in 1999. Just-In-Time Purchasing practices, i.e. the practices that create the link between the buyer’s and supplier’s operation chains formed of specific management of procurement for example: activities that encourage the firm to use

advanced practices of vendor-vendee operational interaction, i.e. practices that link the buyer's and supplier's operation chains. Therefore, there is vendor-vendee operational proximity as well as integrated production planning indispensable requirements for creating an effective JIT supply system (Garg et al., 1997). The practice of JIT II reduces administrative costs for both the customer and the supplier at great extent (Claudia, 1996)

2.2. JIT production

This was first implemented in Toyota production system in 1980's and then, it has become a synonymous of the excellence. The manufacturing system is based on longterm relationship with the suppliers and procures the raw materials in lot and processes them to convert in finished goods based on the demand by the distributers/customers on the regular intervals. A production lot size is determined for JIT delivery. The lot size is dependent on retailer's sales volume, inventory holding cost, set up cost, and transportation cost. Productivity is an aggregated concept of overall efficiency/effectiveness of the organization concerned. The overall cost of production in JIT production system is brought down by the firm by minimizing the level of inventory and continual improvement, which could only arise from highly developed problem solving skills, cooperation, communication, and commitment at all levels of the organization(Gunasekaran, 1999).

2.3. JIT logistics

JIT logistics deals the transportation, supplier relationships and purchasing methods (Alternburg et al., 1998). Logistics methods were originally developed primarily for the internal logistics of the firm, but with the increasing distribution of the manufacturing processes the focus today is shifted as much on the external logistics and on the synchronization between the parties in the supply chain. Here with JIT Logistics we refer two activities i. e. warehousing and distribution of goods immediately on the demand (Pull Distribution). A warehousing is positioned at the convenient place for storage to give the finished or semi-finished material a halt before it goes to customer/ retailers. The quick responses to the customers are very necessary to success in the market.

3. Understanding of General systems (GST) theory and management of the system

General systems theory has been initially found in literatures like Boulding (1956), von Bertalanffy (1969) and Mulej et al. (2004). Others contributions to general systems theory have been made by Klir (1969, 1972), Weinberg (1975), Miller (1978), and Yourdon (1989). This paper is all about Yourdon's (1989) work in which author has used the theory in the field of Information technology to show that how adaptability of any theory changes as per the enhancement of the system structure. GST focuses on the system's structure instead of the system's function. It proposes that complex systems share some basic organizing principles irrespective of their purposes which are in exchange and are bounded (Zeng, & Pathak, 2003).

These components constitute a "system", which functions or operates within a field or an environment. Elements can be virtually anything such as, purchasing, production, logistics that exist between elements and the boundary that separates "system" from the background or environment like JIT environment in which things moves with minimum efforts and waste (Zimmer, 2002). It is also suggested that the change in system may be natural, planned or managed. Management of the system can be said to organize the elements in particular environment to ensure that a system or element fits in to accomplish some end or goal (caddy, 2007).

4. The JIT attributes applicable in Supply chains and forming a system

Intensive literature reviews show that JIT concept though is not new but its applicability is still mysterious. Banerjee (2007) claims supply chain as integration of the raw material suppliers, manufacturers, and retailers where inventory of raw materials, work-in-process, and finished goods are involved, respectively. Here it can be thought up that supply of raw material is a procurement process, manufacturing as production processes and retailers and delivery as logistics process. The processes are exercises in the JIT environment, which is based on any kind of waste elimination. For better understanding we have collected important JIT attributes found in the literatures which are listed below in table -1 and a brief discussion is given on the subsequent paragraph (Garg et al., 1997, 1999).

Table 1
JIT attributes in supply chain organs.

S.N.	Purchasing attributes	Production attributes	Logistics attributes
1	Vendor selection	5S	Quick response
2	Supplier evaluation	Setup Reduction	Pull distribution
3	Suppliers training	Standard Work	Cross docking
4	Long term contract	Group technology	Small shipment size
5	Mutual trust	Takt Time	Short delivery time to customer
6	Suppliers participation	Waste eliminations	3rd party logistics
7	Short lead time	Visual Controls	Reliable Transportation
8	Reduce paper work	Pull Production Scheduling	Quality packing
9	Cost competitive	Cross-Trained Workforce	
10	Frequent supplies	Kaizen Events	

4.1. Purchasing attributes

This item is associated with purchase of material following the JIT concept, like proper vendor selection, supplier's evaluation, suppliers training and their participation in product design. The JIT procurement is a long term contract between suppliers and manufacturers for the supply of the material in shortest possible time without failure to maintain the mutual trust. The training and support to the suppliers are extended by the firm to meet the required standard (Kumar et al., 2002).

4.2 Production attributes

This item in JIT environment is associated with the materials. It is also concerned with required keeping minimum inventory to reduce the set up time (tools), following the standard working procedures, using group technology and other attributes mentioned in Table 1. 5S was developed in Japan and it was one of the techniques that enabled what was then termed 'Just in Time Manufacturing and can be defined as workplace organization method that uses a list of five Japanese words: *seiri, seiton, seiso, seiketsu,* and *shitsuke.* Transliterated or translated into English, they all start with the letter "S". The list describes how to organize a workspace for efficiency and effectiveness by determining and storing the items used, maintaining the area and items, and sustaining the new order. The continuous improvement in the processes is the main theme of the JIT production (Kumar et al., 2002),

4.3. Logistics attributes

These are positioning of warehouses and distribution of the finished goods. The finished goods are positioned (warehoused) at the convenient place so that JIT delivery may be possible (Wang et. al.,

2004). Quick delivery, 3rd party logistics, reliable transportation and small shipment of the material are the main attributes of the JIT logistics (Wood, & Murphy, 2004).The flow of the material from the suppliers to the customers is shown in the Fig. 1. At each level of the supply chain information is conveyed back to avoid the waste and to keep the inventory at the minimum at all time.

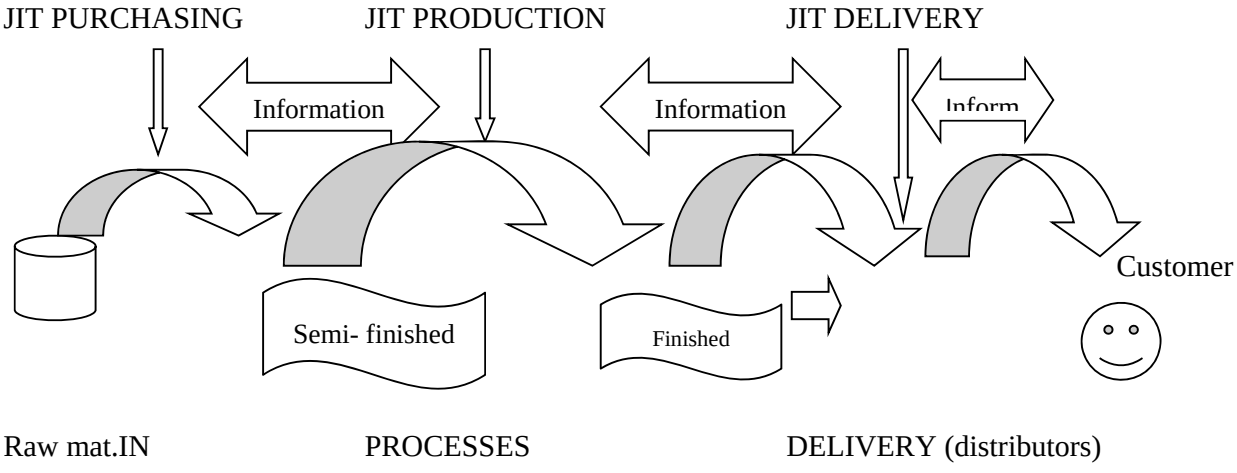

Fig. 1. flow of material and information

5. Application of general systems theory to JIT supply chains

Application of general systems theory to JIT supply chains is very relevant to understand whether the theory holds in procurement, manufacturing and distribution of the supply chain organs while performing these activities under the JIT environment. It is well understood that JIT techniques were first introduced to eliminate all types of non-value added activities in order to minimize the production expenditure. The recent trend of the supply chain focus on overall cost reduction of the chain.

The reduction of cost includes the reduction in material procurement, manufacturing and distribution processes. Recent research has broadened the area of the supply chain to make it more responsive and beneficiary. The JIT techniques applicable in SC have far reaching attempts and the thinking process has travelled long since the inception of the concept. We compare the four general system theory applied by Yourdon (1989) in the field of Information Technology (IT), which has seen a steep inclination in innovations and investments to JIT supply chain. The applicability of the theory can be explored in four paragraphs

5.1 General systems theory—Principle 1 (The more specialized or complex a system, the less adaptable it is to a changing environment.).

Supply chain management operates at three levels; strategic, tactical and operational. At the strategic level, company management makes high level strategic supply chain decisions, which are relevant to whole organization. The decisions made based on the supply chain should reflect the overall corporate strategy that the organization is following. The tactical and operational level decides the breadth of the supply chain. These include product development, customers, manufacturing, vendors and logistics (Zimmer, 2002). Now, first, the task of each level is quite specialized task for the managerial staffs. Secondly, in many industrial sectors, firms are dealing with a demand, which is more and more uncertain often due to the supply chain structure and uncertainty of the market.

In conventional JIT purchasing, customers and suppliers conduct themselves as partners rather than as adversaries. Coordinating producer and supplier is one of the main issues of supply chain management (Kim & Ha, 2003).It is argued that the closer the parties of a supply chain are linked together the more important the coordination of the entire supply chain becomes. (Chan, 2011).The advent of the Internet and related technologies that enable fast transfer of huge amounts of data have tangibly affected supply chains in how both data and items are moved in a Supply chain network. Such information visibility increases to make decisions with more relevant and useful information. In JIT environment supply chain becomes more responsible by use of latest technology which needs more specialization in IT networking and support at the competitive coast. Complicated support system often forbids the firms to adopt the philosophy. However, there are some limitations of JIT philosophy; like market uncertainty, supply break down, workers strikes, transportation facility, government rules and regional constrains.

Generally, firms remain prepared to meet these challenges. In doing so, firms sometimes compromise with the JIT philosophy for an example to keep the buffer stocks violate JIT purchasing, but still it's an urgent to meet the eventuality. It is found that there is an environment of uncertainty in the decision making while practicing the JIT into consideration. Therefore, An intermediary compromise is done to maintain certain level of concept (Christensen, 2005).

Simatupang and Sridharan (2002) report that increased logistics complexity is associated with poor performance of the firm. It is also suggested that if there is a greater degree of integration and a higher level of formality started existing in the system, which restrict the changes, such as meeting new customer demands, compiling with new government regulation, or reacting to new industry entrants, adoptability of the JIT practices in the supply chain is likely to be less adoptive as the principles or philosophy behind the business becomes complex.

5.2 The larger the system, the more resources are required to support it, with the increase being non-linear rather than linear.

JIT supply chain requires a high level of integration and commitment of the working and managerial force (Garg & Deshmukh, 1999). Monden (1993) explained the JIT production systems require both input stock in the form of parts and output stock in the form of products at each stage. To maintain these systems pull-production control mechanism throughout the system is exercised. JIT production systems have been created based on the primary objective of reducing expenditure by removing waste during the production process. The fundamental concept of the system is to implement the ''pull'' control mechanism (Iwase, 2011). The system is to be supported with high technological in puts like automation, flexibility, use of IT, freight consolidation, cross docking etc. for in time delivery of the products.

Kim (2003) stated that increases in the support system for JIT implemented supply chain are non-linear and required lot of planning with utmost accuracy. The network of suppliers, producers, distributors and customers become too large once the supply chain becomes global. JIT suggests using the latest technology to reduce the time and overall cost. Use of flexibility, automation, group technology, ISO certification etc. requires heavy support system like availability of the technology, efficient transportations, skilled manpower, etc. In recent years, the collaboration among partners within the supply chain and e-supply chain has been widely adopted (Garg et.al., 1994).

The transportation and its effect on the entire supply chain are necessary and it is also determined that developing countries suffer from inefficient transportation, so JIT implementation is a big challenges to these countries (Maiga, 2009). It is been considered that once the supply chain becomes more responsive, the supporting facts behind the responsiveness also becomes very vital and getting extension of even smallest activities. In doing so smaller activities are becoming larger and larger of

the supply system requiring greater supports and attentions an urgent need, otherwise it would be a great loss as outcome. Therefore, support system required for the larger system is many times enhanced and thus it is non-linear.

5.3. Principle 3: Systems often contain other systems or are themselves components of larger systems

Supply chain consists of a large number of interacting but un-integrated members. The main focus is on material, information and cash flows from vendors to customers or vice-versa. A key feature of present day business is the idea that it is supply chains (SC) that compete, not companies (Christopher & Towill, 2001), and the success or failure of supply chains is ultimately determined in the marketplace by the end consumer. Getting the right product, at the right time is the JIT assisted activities. The issue of the supply chain is dealt in dividing the different activities alike; production, purchasing and distribution in sub groups of batch, mass, customized and these again into sub groups of types of process and so on.

Fig. 2 shows the full supply system closed network. The JIT applied activities make these subgroup activities more responsive. It has been discussed that a supply chain is made up by multiple actors, multiple flows of items, information and finances and these again subdivided at the minimum level to execute the working. For an example take JIT production system in which many number of sub producer, assemblers, quality checkers, calibration, maintenance etc. exist, further work related to mechanical nature, electronic, electrical, computer related sub group is thought up. Similarly JIT procurement is an integrated effort of vendor management, suppliers training and technical supports, quality assurance of received material, etc. (Kaynak & Pagan, 2003).

JIT logistics is combined efforts of transportation, packaging, distributions, responses to the customers etc. None functioning or partial functioning of any section will dampen the JIT concept in the supply chain. All stakeholders in the business want to be always in win-win positions Therefore; supply chain process contains no. of sub processes and these sub processes are also divided into different processes, so theory the theory three; that *Systems often contain other systems or are themselves components of larger systems* is satisfied and it is fully true.

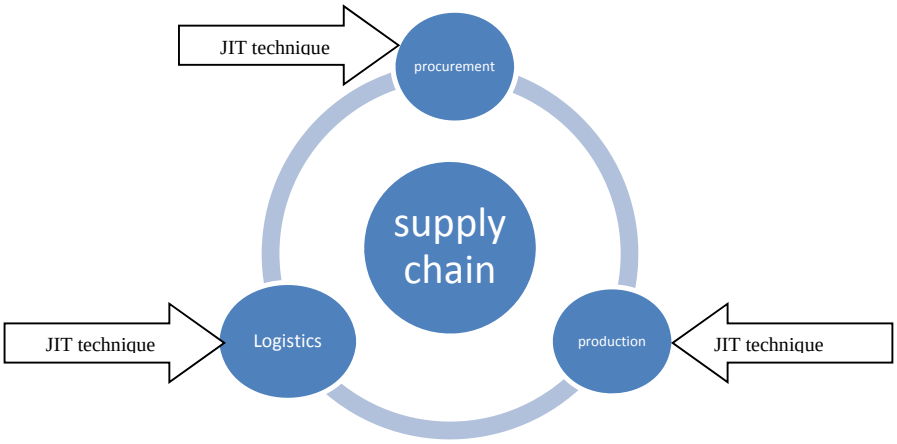

Fig.2. JIT supply chain a chain of procurement, production, distribution.

5.4. Principle 4: Systems grow over time, both in terms of size as well as structural complexity.

Chan & Zhang (2011) discussed there is a need for big collaboration of the collaborative transportation management between trading partners and carriers participating in the supply chain as the chain expand. As per Yourdon (1989) information system started with a small equipment and support system but as time passed the bigness of the information system can now be imagined and how vast it has taken a shape. Similarly supply chain in JIT environment has expanded; as new norms, techniques, philosophy and perception of people (Customers) changes as the time passes. Further, as the business grows in size the activities getting inflated.

More collaboration of groups and activities are seen which requires more cooperation and mutual trust among the stakeholders. The growth of system is seen at multi levels and is an unavoidable phenomenon. JIT has risen from a mere tactical to a more strategic level in supply chain (Farahani, & Elahipanah, 2009). By managing the supply chain in JIT Environment Dell computers, Vishal Megamart, Flipcarts etc. have risen within the short time with a small investment to such a big venture. The supply chain of these firms in due course of time has become complex and modern using all recent technologies. Hence it can be said that Systems *grow over time, both in terms of size as well as structural complexity.* Thus, the theory four of the GST is true.

6. Conclusion and summary

The peer study of the General System theory applicable to the JIT supply chain shows that the principle is well suited in the JIT implemented supply chain. It is understood that JIT supply chain is based on mutual cooperation and mutual trust among the stakeholders to be in win- win position. The stringent norms and uncertainty of the market viability of JIT supply chain becomes complex. Survey shows the reluctance of the adoption of the JIT though JIT supply chain is far reaching results. It is found that hardly any company exits, which follows the true JIT implemented supply chain. So the more complex of the system, the less adaptability of the system proves true to best of the literature findings, confirming the principle -1 true.

For 2nd principle we find that as the business grows the system becomes larger and its up keeping requires more support system. The growing demands of the support systems like manpower, equipment, production planning, material etc. are magnified. Thus, it's a nonlinear increase, hence principle no 2 is found true in case of the JIT supply chain. Supply chain is a part of the activities of the industries or services and this supply chain is sub structured in procurement, production and delivery processes and each these processes are again performed in small activities, making the full system of supply chain easy going. Here we find that supply chain is part of the various activities taking place in a firm and supply chain itself is integration of procurement, production and logistics processes. Thus, principle 3 is suitable the JIT supply chain management.

For principle 4 we say that more collaboration of groups and activities are seen as urgent requirement of the JIT supply chain (Khan & Sarkar, 2002). It is also seen that more cooperation and mutual trust among the stakeholders are necessary. Each players in the network keep on expanding their activities like searching of new market, opportunity, partners etc. which makes the system to expand and become complex. Here principle 4 is found suitable in this field. Therefore, we conclude that General system theory is very relevant to the supply chain in JIT environment.

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