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Evaluating Distribution Process of a Supply Chain in Just-in-Time Environment Using Application of Graph Theory

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Summary

Distribution process of a supply chain management is very important and strategic. To stay efficient in delivering the finished goods in the hands of end user, the speed and responsiveness of distribution mechanism are most essential. Just in Time (JIT) has proved result oriented in the manufacturing systems since 1985. Since then its applicability in several fields are being investigated. Low inventory, small lot size, least lead time and quality product are some desirable features of JIT, which proves beneficiary to the firm. This paper highlights JIT applied distribution process in order to shorten the lead time, inventory holding costs. Application of Graph theory (GTA) methodology has been used to investigate the interdependencies of dimensions and its attributes of JIT implemented distribution. Then an empirical value of JIT distribution process (JDP) of an organisation has been derived , subsequently coefficient of distribution dissimilarity and similarity have been found for two organisation and based on these values comparison 0f any two organisation can be done. Approach can be used to know the lacks of various organizations based on their feasibility index of transition (FIT) value and which is required to develop to transform the organisation applying JIT in distribution process.

Keywords

supply chain management, distribution process, JIT, GTA, interdependency

1. Introduction

The globalization of businesses in the recent years, delivering products quickly and on time has become more and more challenging. The research on the problems of distribution network has attracted significant attention in recent years. A Supply chain is an integration of purchase of material; its transformation into intermediate and end-products and then distribution among the customer to maximize the profit and satisfaction (Bowersox, Closs, & Bixby, 2007). Scanning the recent SC literature, one may see that it is a scene of rapid change. The recent trends in the SC literature have focused on distribution process to maximize the market value. It remains a hot topic as firms are now customer oriented (Chan & Zhang, 2011). Korepla and Lehmusvaara (1999) presented a customer oriented approach to select a warehouse network that satisfies the preferences of customers. Companies can take advantage of the just-in-time (JIT) approach to achieve goals such as cost reduction, lead-time reduction, quality assurance, and respect for humanity (Monden, 2002).In meeting these above requirements it is necessary to Stay economical and profitable in Long-range which must be constantly evaluated and configure their production systems, distribution systems, and strategies (Zimmer, 2002). When a retailer places replenishment orders on products, cost and delivery are the two key factors. In order to minimize cost and speed up the delivery applicability of JIT in DP has been explored in this paper. To justify its applicability the important dimensions and affecting attributes are to be understood well for their interrelationship. Therefore, the purpose of this study is to provide SC practitioner with distinct delivery factors and sub factors which can be used to strategize the manufacturing firm's delivery policy. For the purpose of evaluation of distribution process in JIT environment we will use JIT distribution process (JDP).

The rest of the paper is organized as follows: The literature survey is very important to know the work done in this field. Section 2 deals with literature reviews and helps us to recognise the factors and attributes of DP in JIT environment. Section 3, is a brief of methodology applied in this paper. This gives a brief idea of GTA and step wise solving technique. To illustrate the GTA an organisation is chosen of which FIT value has been found in section 4. Using the GTA dimensions and attributes are correlated with the help of directional nodes and then relational values are put in forms of matrices. The mathematical equation is developed to solve the matrices and values of JIT Distribution Index (JDI) are derived. The computational results of the model are given in Section 5, while conclusions are drawn in Section 6.

2. Literature review

Zhuang, (1994), reports an economic production and just-in-time delivery System for the better supply chain. The author finds ways of matching supply with demand, while maintaining minimum levels of inventories throughout supply chain.

Steele, (2000) has mentioned in his study that distribution network consists of multi warehouses and multi-retailers where the finished goods are temporarily stored prior to reaching the end users. Its responsibility of the top management to replenish the stored product of warehouse as quickly as possible and helds the minimum inventory at all time.

Wang, Fung, and Chai., (2004) has focused his study on Quick delivery, 3rd party logistics, reliable transportation and small lot size as means of meeting the JIT distribution requirement. Accurate information for forwarding the demand quickly are utilised nowadays for better services.

Park, et.al. (2010); Chan & Zhang (2011) report that Quick response is possible only when we have the efficient transportation mode and transporting regulatory policy.

Chan & Zhang (2011), have mentioned in their study to reduce the delivery time by Cross docking in which unloading materials from an incoming semi trailer, car and loading these materials directly into outbound trucks, trailers, or rail cars, with little or no storage in between.

Sykes, (1994) finds in his study that Material handling in or out of the firm is very much responsible to the customers as well as to the manufacturers in terms of getting the right material at the shortest possible time. This may be done to change type of conveyance, to sort material intended for different destinations, or to combine material from different origins into transport vehicles (or containers) with the same, or similar destination.

Zimmer, (2002) argue to deliver superior customer value at less cost to customer by improving responsive distribution system. It is also argued that the SC can give maximum value when the quick, reliable and efficient transportation are easily available and all stakeholders will be acting in coordination.

Taylor, (2004) has documented his research saying that the competency of SC performs in market and not the product. Hence, organisation should pay its attention to correct its supply chain. JIT can be tool in excellence of a SC(Mason & Lalwani, 2006)

Though the SC literature is very rich still due attention on JIT implemented DP is not given. Implication of JIT in DP has been dealt by Zimmer, (2002); Zhuang, (1994); Chan and Zhang (2011), but clear listing of dimensions and their attributes are not seen in the literature. The interdependency and their relational quantifications are not found in the literatures. The indexing of various attributes by the use of Graph theory application (GTA) is of first kind of the attempt to quantify the dimensions of JDP. The approach would be very useful to assess the distribution efficiency of a firm and can be used to compare its supply chain with others.

2.1. Identification of distribution factors in JSCM

To establish the relation and relative importance of the various dimensions of JDP we contacted team of experts from academia and industries. With the help of them and our experiences we recognize six dimensions of the JDP. Each dimension was again split into various attributes for simplicity. The following six dimensions in the present study are given in Tab.1.

Table 1 Recognition of factors and sub factors of distribution system.

S.N.	Dimensions	Attributes	References
1	Order processing	1.Quick order 2.Accurate forecasting	Takahashi et al. (2004) Soni, and Kodali,,(2012
2	Responsiveness	1.Short delivery time to customer 2.Quick response to changing supplier needs 3.Short promised lead time	Mason ,& Lalwani, (2006): Korepla, and Lehmusvaara (1999), Roger & Roy (2005) Yina et al. (2011).
3	Quick delivery	1. Reliable transportation 2. High Delivery speed 3. Pull distribution	Zimmer (2002) Mason & Lalwani, (2006) Wang (2004)
4	Use of technology	1. Material tracking devices 2. Information sharing 3. Electronic Data interchange 4.GPS	Chan and Zhang, (2011) Sezen, (2008) Mistry (2005) Expert opinion
5	Ware housing	1.centrally located 2.Follow of 5S 3.Material Handling 4. Quality packaging 5. Cross docking 6. Small shipment size	Korepla and Lehmusvaara (1999), Bowersox et al. (2007); Chan and Zhang, (2011), Zimmer (2002); Sohrabpour et.al (2012); Kumar and Singh, (2012)
6	Human factors	1.involvement of top management 2.JIT as a culture 3. Multi-functional worker	Bushuev and Alfred (2012), Zhuang, (1994), Kannan, and Tan, (2010)

3. Methodology

To interlink the dimensions along with their attributes we take a help of Graph theory application (GTA). A GTA approach is designed to synthesize the inter-relationship among different variables or subsystems and provides a synthetic score for the entire system. It also takes account of directional relationship and inter-dependence among variables. The application of GTA can be seen at various instances (Grover, Agrawal, & Khan, 2006; Rao & Gandhi, 2002; Wani & Gandhi, 1999). Grover et al. (2006) have used this approach to develop a mathematical model of TQM environment of an industry. Rao and Gandhi (2002) have utilized the digraph and matrix approach in failure cause analysis of machine tools.

A methodology for the evaluation of Feasibility index of transition (FIT) to JIT distribution process (JDP) for an organization is proposed here. FIT for JDP may be defined as the ease with which a conventional distribution process in a supply chain can be converted into a JIT implemented Distribution process.

FIT = Per (F*) = Permanent function JDP Dimension matrix.

As the multinomial expression (1) contains only positive terms, therefore higher values of D_i and d_{ij} will result in an increased value of the FIT. The FIT is a very useful term in comparing different organizations for their possibility of converting their conventional SCM into JSCM. The main steps of this methodology are as follows:

1. Identify the various enabling elements in an organization responsible to affect JDP.
2. Develop the JDP Dimensions' digraph considering the JDP dimension categories and their interdependence. The number of nodes should be equal to the number of major dimensions categories and the magnitude and direction of edges should correspond to their interdependence (d_{ij}) (Figure 1).
3. Identify the attributes for each category of Dimension.
4. For each Dimension category, develop digraphs among the Attributes based on the interactions among them.
5. Based on the above-mentioned digraphs among Attributes, develop the variable permanent matrix for each Dimension category.
6. Calculate the permanent function at each Dimension level. For avoiding the complexity, the numerical values of inheritance and interactions are used.
7. Develop a P × P matrix with diagonal of Di and off-diagonal elements of d_{ij}. The value of the permanent function at each Dimension level provides inheritance (diagonal elements of D_i) for each Dimension. The value of interaction among these Dimension (i.e. off-diagonal elements of d_{ij}) are to be decided by the experts on the basis of scale of 1-5.as table no 2.
8. Calculate the permanent function of JDP dimension 'Matrix' using equation (1) at the system level. This is value of FIT to DPI which mathematically characterizes the feasibility of any organization to convert its SC into JSCM, based on the availability of different Dimensions and their interdependence.
9. List the different organizations in ascending order of their FIT values. The organization having the highest value of FIT has the best chance of its transition to JDP.
10. Record and document these results for future analysis.
11. Comparison of various firms can be done on DPI indexes.

4. Illustration

To illustrate the proposed methodology, a case of an industry" A" is taken. The FIT value of this organization is determined by substituting the values of inheritance (Di) and interdependencies (dij) of dimensions in JDP matrix equation (1).To assign quantitative measure to different categories of Dimension (i.e. D_1, D_2, D_3, D_4, D_5 and D_6) a questionnaire was floated in this organization at top, middle, and lower management level. A total of seventeen 17 responses were collected from these people and the same is verified through our four experts of the field. It is found the answer scale was suitable. To apply the GTA in this organization we proceed as follows.

Step 1: Recognition of the factors and sub factors affecting the JDP in the supply chain has been done from the literature and expert opinions as table no .1.

Step 2: Development of graph theoretic model of JDP. Model is developed using (a) Digraph representation (b) Matrix representation; and (c) Representation of Permanent function.

The six dimensions and their attributes are identified in the previous section. These are utilized here to evaluate the possibility of converting a conventional DP into JDP by finding an index, known as "FIT". It is an index to know how much extent an organization is "fit" for JIT environment for its DP in its supply chain management. Fig. 1 shows the interrelationship among the dimensions of the JDP. The directed edges are drawn according to interdependence of these dimensions. For example, behavioural enablers affect all other enablers; hence directed edges are drawn from D1 toD2, D3, D4, D5, and D_6. Fig. 2-7 shows the interdepencies of the attributes for each dimension.

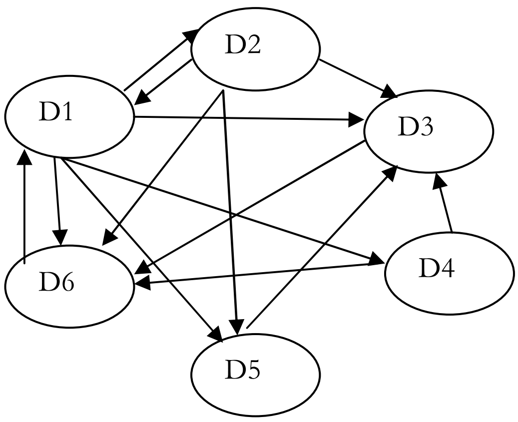

Figure 1. Diagraph showing the relationship among dimension categories.

Matrix representation of JDP Dimension diagraph. The matrix corresponding to Distribution Dimension digraph (Fig. 1) is given as: i.e. matrices 1. Based on the suggestions of Deo (1999), let us represent a digraph of P Dimensions, containing no self-loops, by matrix D = [dij], where dij represents the interaction of the ith dimension with jth Dimension. Here, dij ≠ dji because JDP Dimension are directional and e = 0, as there is no self-loop, i.e. a dimension is not interacting with itself:

F* =

$$\begin{pmatrix} D_1 & d_{12} & d_{13} & d_{14} & d_{15} & d_{16} \\ d_{21} & D_2 & d_{23} & 0 & 0 & d_{26} \\ 0 & 0 & D_3 & 0 & 0 & d_{36} \\ 0 & 0 & d_{43} & D_4 & 0 & d_{46} \\ d_{51} & 0 & d_{53} & 0 & D_5 & 0 \\ d_{61} & 0 & d_{63} & 0 & 0 & D_6 \end{pmatrix}$$

Step 3: Recognition of attributes of each dimension

The attributes of the each dimension are recognized through intensive literature review which are already been discussed in section 2.1 and Tab.1 shows the dimension along with the attributes.

Step 4: For each dimension category, develop a digraph among the Attributes based on the interactions among them.

This is the digraph at each sub-system level. Fig. 2-7 is the representation of the graph showing nodes and their connectivity among them.

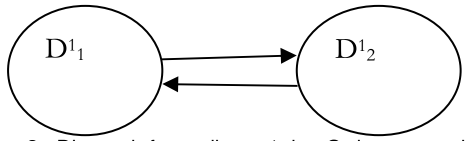

Figure 2 Diagraph for attributes1, i.e. Order processing nodes; 2 Accurate forecasting

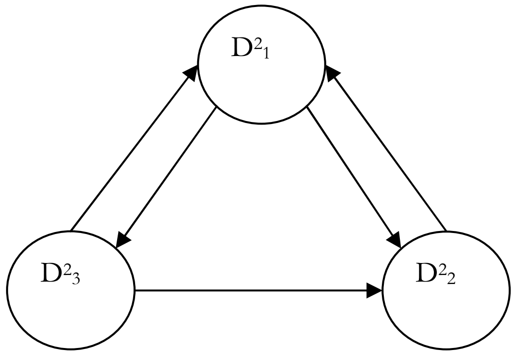

Figure 3 Diagraph for dimension 2 (Responsiveness); D^2_1. Short delivery time to customer; D^2_2 Quick responses to changing supplier needs; D^2_3 Short promised lead time

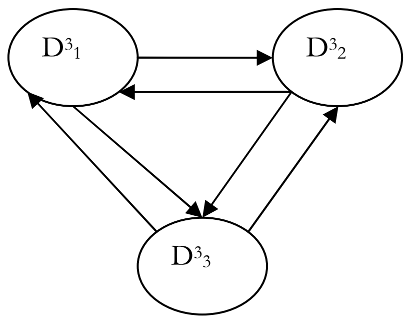

Figure 4 Diagraph for dimension 3 (Quick delivery): 1. Reliable transportation; 2. High Delivery speed; 3. Pull distribution

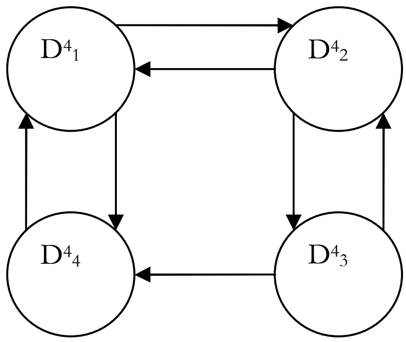

Figure 5 Diagraph for dimension 4: (Use of technology); 1. Material tracking devices; 2. Information sharing; 3. Electronic Data interchange; 4.GPS

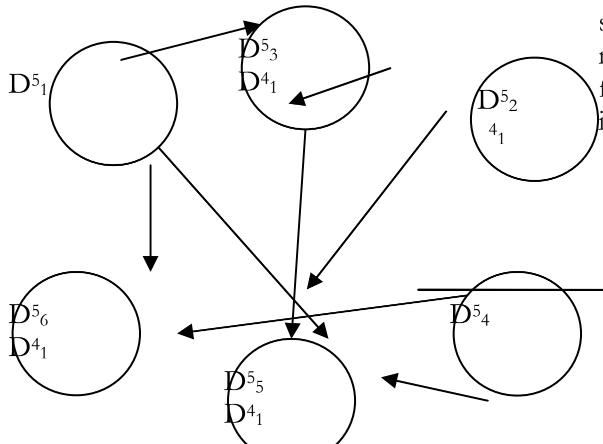

Figure 6 Diagraph for dimension 5 :(Warehousing); 1..Centrally located; 2.Follow of 5S; 3. Connectivity; 4. Quality packaging; 5. Cross docking; 6.Small shipment size

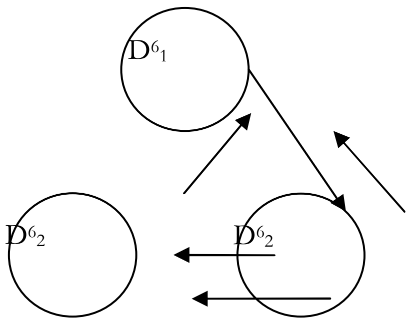

Figure 7 Diagraph for dimension 6; (Human factors); 1 Involvement of top management; 2. JIT as a culture; 3. Multi-functional worker

Step 5: Based on the above-mentioned digraphs among attributes, development of the variable permanent matrix (VPM) for each dimensional category is done. Quantitative Value of feasibility for DP in any organization is obtained from this permanent function by substituting the values of Di and d_{ij} in matrix which are obtained analytically or by comparing with ideal case.

$$\prod_{i=1}^{n} D_i + \sum_{ijklm}(d_i d_j) D_k D_l D_m D_n + \sum_{i,j,k,l,m,n}(d_{ij} d_{jk} d_{ki} + d_{ik} d_{kj} d_{ji}) D_l D_m D_n$$

$$+\left(\sum_{i,j,k,l,m,n}(d_{ij} d_{ji})(D_m D_n) + \sum_{i,j,k,l,m,n}(d_{ij} d_{jk} d_{kl} d_{li} + d_{il} d_{lk} d_{kj} d_{ji}) D_m D_n\right)$$
$$\left\{\sum_{i,j,k,l,m,n}(d_{ij} d_{ji}) + (d_{kl} d_{lm} d_{mk} + d_{km} d_{ml} d_{lk}) D_n + \sum_{i,j,k,l,m,n}(d_{ij} d_{jk} d_{kl} d_{lm}\ d_{mi} + d_{im} d_{ml} d_{kj} d_{ji}) D_n\right\} + \left[\sum_{i,j,k,l,m,n}(d_{ij} d_{ji})(d_{kl} d_{lm} d_{mn} d_{nk} + d_{kn} d_{nm} d_{ml} d_{lk}) + \sum_{i,j,k,l,m,n}(d_{ij} d_{jk} d_{ki})(d_{lm} d_{mn} d_{nl}) + \sum_{i,j,k,l,m,n}(d_{ij} d_{ji})(d_{kl} d_{lk})(d_{mn} d_{nm}) + \sum_{i,j,k,l,m,n}(d_{ij} d_{jk} d_{kl} d_{lm} d_{mn} d_{ni} + d_{in} d_{nm} d_{ml} d_{lk} d_{kj} d_{ji})\right] \quad \text{------} \quad (1)$$

Step 6. Calculate the permanent function at each sub-system level. For avoiding the complexity, the numerical values of inheritance and interactions are used. The calculations are done as per equation 1 written for each dimension category. Using Eq. 1, the variable permanent matrices for different sub-systems (based on their diagraphs) are written in matrices 2-7. The Interdependencies between sub factors are assigned using Tab.3, while the inheritance is assigned in next step.

VPM for dimension 1 (Order processing):

$$\begin{pmatrix} D_1^1 & 5 \\ 4 & D_2^1 \end{pmatrix} \quad \text{-----------------------------} \quad (2)$$

VPM for dimension 2 (Responsiveness)

$$\begin{bmatrix} D_1^2 & 4 & 3 \\ 2 & D_2^2 & 5 \\ 5 & 0 & D_3^2 \end{bmatrix} \quad \text{------------------------} \ (3)$$

VPM for dimension 3 (Quick delivery)

$$\begin{pmatrix} D_1^3 & 4 & 3 \\ 3 & D_2^3 & 4 \\ 2 & 2 & D_1^2 \end{pmatrix} \quad \text{------------------------} \ (4)$$

VPM for dimension 4 (Use of technology)

$$\begin{pmatrix} D_1^4 & 3 & 3 & 4 \\ 4 & D_2^4 & 3 & 3 \\ 5 & 4 & D_3^4 & 0 \\ 0 & 4 & 4 & D_4^4 \end{pmatrix} \quad \text{---------------} \quad (5)$$

VPM for dimension 5 (Warehousing)

$$\begin{pmatrix} D_1^5 & 0 & 4 & 0 & 3 & 4 \\ 0 & D_2^5 & 3 & 3 & 0 & 0 \\ 4 & 0 & D_3^5 & 0 & 3 & 4 \\ 0 & 4 & 0 & D_4^5 & 0 & 4 \\ 0 & 0 & 0 & 0 & D_5^5 & 0 \\ 4 & 0 & 4 & 0 & 0 & D_6^5 \end{pmatrix} \quad \text{----} \ (6)$$

VPM for dimension 6 (Human factors)

$$\begin{pmatrix} D_1^6 & 5 & 0 \\ 4 & {}^{6}_{2} & 4 \\ 3 & 3 & {}^{6}_{3} \end{pmatrix} \quad \text{--------------------------} \quad (7)$$

Table 2 Scale of measure of dimensions affecting the JDP

Sr. No.	Qualitative measure of factors at sub- system level affecting JIT distribution	Assigned value of factor at sub level
1	Exceptionally	1
2	Very low	2
3	Low	3
4	Below average	4
5	Average	5
6	Above average	6
7	High	7
8	Very high	8
9	Exceptionally high	9

Table 3 Quantification of interdependencies off-diagonal elements

Sr. No.	Quantitative measure of interdependencies	D_{ij}
1	Very strong	5
2	Strong	4
3	Medium	3
4	Weak	2
5	Very Weak	1

Step 7: 6 matrices of PXP (2-7) are developed and evaluated.

The quantification of relationship among the dimensions is done as per table no 3. The value of diagonal elements in matrices 4-8 is assigned as given below.

$D^1_1 = 7$; $D^1_2 = 8$
$D^2_1 = 7$; $D^2_2 = 8$; $D^2_3 = 8$;
$D^3_1 = 6$; $D^3_2 = 7$; $D^3_3 = 8$;
$D^4_1 = 7$; $D^4_2 = 8$; $D^4_3 = 7$; $D^4_4 = 6$;
$D^5_1 = 6$; $D^5_2 = 7$; $D^5_3 = 5$; $D^5_4 = 7$; $D^5_5 = 6$; $D^5_6 = 7$
$D^6_1 = 6$; $D^6_2 = 5$; $D^6_3 = 7$;

The value of permanent function for each category is calculated. For example, value of permanent function for the first category is given as.

$$D_1D_2D_3D_4D_5D_6+(d_{12}d_{21})D_3D_4D_5D_6+(d_{16}d_{61})D_2D_3D_4D_5+(d_{35}d_{53})D_1D_2D_4D_6+(d_{34}d_{43})D_1D_2D_5D_6+((d_{12}d_{26}d_{61})D_3D_4D_5+(d_{13}d_{36}d_{61})D_2D_4D_5+(d_{35}d_{54}d_{43})D_1D_2D_6+(d_{36}e_{64}e_{43})D_1D_2D_5)+((d_{12}d_{21})(d_{34}d_{43})D_5D_6+(d_{35}d_{53})(d_{61}d_{16})D_2D_4+(d_{36}d_{61}d_{12}d_{23})D_4D_5)+\{(d_{12}d_{21})(d_{35}d_{54}d_{43})D_6\}+[(d_{61}d_{12}d_{26}) + (d_{35}d_{54}d_{43})] \text{--------eqn2}$$

The value of PFM = D_1 = 76. Similarly, permanent function for each category is calculated as above for matrix 2-7 and is written as under:

$D_2 = 732$; $D_3 = 572$; $D_4 = 7506$; $D_5 = 27008$; $D_6 = 482$

Step 8: JDP matrix at the system level is developed as per the matrix (1). In this matrix, values of the diagonal elements are taken from the sub-system level as explained below: The variable permanent matrix (VPM) for JDP is written in eq (1). The values of diagonal elements (D_1, D_2 , D_6) are taken from above results and the values of off diagonal elements are taken from table 3. The VPM would be the FIT value of the JDP which is shown in matrix (8).

VPM_{DP} = F*=

$$\begin{bmatrix} 76 & 5 & 4 & 2 & 0 & 4 \\ 0 & 732 & 5 & 3 & 2 & 4 \\ 3 & 5 & 572 & 2 & 5 & 3 \\ 4 & 5 & 3 & 7506 & 4 & 5 \\ 0 & 2 & 5 & 4 & 27008 & 5 \\ 3 & 5 & 4 & 5 & 4 & 482 \end{bmatrix} \text{-------- (8)}$$

The FIT value of JDP for above matrix is D = 2.71944×10^{16}.

Step 9: List the different organizations in ascending order of their FIT values. The organization having the highest value of FIT has the best chance of its transition to JDP.

Step 10: the result can be tabulated and used for future analysis in finding out the JIT distribution Index (JDI) of the organisation and this can be utilised to compare the two DP of the firms as discussed by Raj, Shankar, & Suhaib, 2010.

5. Comparison

For comparing two firms let us say A and B Raj et. al.(2010), proposes the following equation using the FIT value mentioned in above steps. In equation coefficient of similarity or dissimilarity are to be taken between 0 and 1. If the two organizations are similar from their JDP dimension environment point of view, then, the coefficient of similarity (c_s) is 1 and the coefficient of dissimilarity (c_d) is 0 and in the same manner, if two organizations are dissimilar from their JDP dimension environment, then the coefficient of dissimilarity is 1 and the coefficient of similarity is 0.

$$\text{Cd} = \left(\frac{1}{U}\right) \sum_{ij} \mu ij \text{ ------------- eqn(3)}$$

Where, U = maximum of [FIT value of the JDP among the organization]

And μi= difference of FIT values of the two organization. The coefficient of similarity is calculated as $c_s = 1 - c_d$.

Let PFM of organization B is 1.3×10^{16}. Therefore, to find out c_d we take maximum FIT value as of organization A i.e. equal to 2.71944×10^{16}. And using equation 3 we find $C_d = 0.357 \times 10^{-16} (1.41944 \times 10^{16}) = 0.508$.

Therefore, coefficient of similarity i.e. c_s = 1-0.508 =0.492.

The results of this study show that organizations 1 and 2 have similar coefficient of dissimilarity and similarity between them and require less effort to the organization B to bring up to the mark of A.

Step 11: DPI can vary firm to firm as per the practices prevailing there. The higher DPI will show the greater and better distribution mechanism in the JSCM.

6. Discussion

This paper presents a methodology to evaluate the applicability of JIT in distribution process of a supply chain. This is based on influence schemata a of dimension. Data regarding the available resources in the company and other enablers of FMS have been obtained through a questionnaire floated in the case industry. The six dimensions of DP are "Order processing, Responsiveness, Quick delivery, Use of technology, Warehousing and Human involvement" are recognised through literature reviews and prevailing practices in the industries. These are the main base to form the diagraphs and matrices depending on their interdependencies.

To quantify the relationship among the dimensions and their attributes as per their inter-dependencies a group of experts was selected from academic and industries (Raj, et.al. 2010, Grover 2006) that impartially suggested the interdependencies and values on the basis of their recommendation the matrices were formed.

To solve the matrices we form a PMF equation taking all terms in the equation for all matrices are positive. The attributes under each Dimension are categorised and their interdependencies are again shown through diagraph and matrices. The matrices 2-7 are solved based on equation 1 format. The values of each dimension based on their attributes interdependences are $D_1 = 76$; $D_2 = 732$; $D_3 = 572$; $D_4 = 7506$; $D_5 = 27008$; $D_6 = 482$. The FIT value is determined for an industry shows the ranking of importance of the dimensions. Warehousing dimension in JDP is scoring the maximum permanent function value i.e. 27008 which indicate the importance of dimension in the particular firm. The introduction of 5S, proper material handling equipments, small shipment size and quality packaging to avoid the damage of finished goods on route are some important attributes depending upon the "company maturity". This may give hints to the firm, for further course of action in these fields. Next major category is Quick delivery dimension of the JDP introduction. Consideration of Reliable transportation, High Delivery speed, Pull distribution as major attributes of the dimension would boost the customer satisfaction. The transportation factors in India are not found very satisfactory throughout the literature and in opinion of our expert so the attribute is affecting this dimension greatly. The due care may improve this factor to match the JDP requirement.

7. Conclusion

In this paper, we deal with multi dimensional distribution attributes for a SCM in JIT environment with establishment of relationship among them. Under the quantitative value of relationship among the dimensions and attributes the graphical notations and matrices are created using GTA. Based on matrices we develop a Permanent function equation (PF) which is further used to find out the value of the distribution system of a SCM in JIT environment. We can compute JIT distribution process Index (JDPI) for a SCM, which are tools to compare one's SCM with others. Numerical results are very useful to a manager to rank its SCM and give an insight of the weaker area of his Distribution process. In above example warehousing and use of technology for JIT distribution process are very important dimensions for this firm and therefore should focus on their weak area such as order processing, quick response, quick delivery and involvement of human factors.

Implications and future scope

The DP is the strategic decision in which positioning of ware houses, selection of transportation means, and selection of key partner to deliver the product as and when required by customers safely are very vital. As SC management is the ability to develop long-term, strategic relationships with SC partners, so taking right decision is very important for the managers. The quantification of the factors enables the manager to take right steps in DP and necessary improvement to transform the DP into JDP for better services and business. The managers can compare their organization on the empirical value of the various dimensions responsible for their distribution process.

Limitations

Though companies are becoming reluctant to adopt this highly beneficial concept still every-thing is not lost and there is a ray of hope which will prevent this highly beneficial improvement tool to disappear before its inception in many countries. Firms adopt JSCM as a means for meeting the finished product into the hands of end user as quick as possible. Whereas meeting this problem is not so easy and even it becomes very difficult in those developing countries where transportation facilities are struggling due its poor infrastructure.

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