BENCHMARKING THE SUPPLY CHAIN PERFORMANCE: DEVELOPMENT OF A fRAMEWORK

BY

Janat Shah
&
Nitin Singh*

December 1999

Please address all correspondence to:

Janat Shah
Associate Professor
Indian Institute of Management
Bannerghatta Road
Bangalore - 560 076
India
Fax: (080) 6644050
email:janat@iimb.ernet.in

*Student of the Fellow Program in Management (Production & Operations Management) at the Indian Institute of Management, Bangalore, India.

Benchmarking the supply chain performance:
Development of a framework

Janat Shah[a]
&
Nitin Singh[b]

Abstract

In this study, a framework is developed which uses financial metrics to help a firm benchmark its relative position and identify specific supply chain processes that need improvement. The tools outlined in this study not only highlight areas of opportunity for improvement in the supply chain but also help identify specific reasons behind the performance levels in the chain and stimulate discussion among management. Further, this framework can be used to carry out detailed analyses using publicly held information. Subsequently, the analyst may probe further for additional information to focus on the specific reasons behind a given level of performance of the firm. To illustrate the framework, the proposed tools are applied to the paints industry whereby analysis is done on the business information obtained through an electronic database, which is available in public domain. The framework has proved to be robust. The results have also been supported by the industrial information. Using this framework, a firm should be better placed to come up with suitable policies in line with the industrial and competitive environment it faces.

---

[a] Associate Professor of Production & Operations Management, Indian Institute of Management, Bangalore

[b] Student of the Fellow Program in Management (Production & Operations Management), Indian Institute of Management, Bangalore

Introduction

The inter-related activities responsible for the flow of materials from the supply of raw materials to the delivery of finished goods to the consumers are referred to as the supply chain processes. The activities are inter-related by input and output links through decision points, reports, manual operations and database transfer. If these activities, which are essentially stochastic in nature, are performed in a fragmented and unsynchronized manner, they can cause poor performance and unbalance along the supply chain. Consequently, there is a need to connect these activities coherently.

This discussion points to the fact that the supply chain processes stretch beyond the walls of a single plant or even single firm and embrace the entire distribution/ logistics channel. Since these involve the management of suppliers, distributors, transportation, and storage, there is a need to enhance the focus from individual organizational units to the overall logistics system. If the obsession to improve processes at the firm level is forcing the suppliers/dealers to stock huge amounts of inventory, the overall cost of the product remains unchanged and, in some cases, may increase too. Since the market forces determine the price of the product the companies need to be concerned about the entire supply chain cost. Under this scenario, long-term benefits would accrue by implementing supply chain wide integration and flexibility and not simply by shifting the costs to suppliers/dealers.

Background

In fact, there has been an increased awareness in recent years regarding the role and potential of supply chain management in supporting the corporate goals of the firm. Management theorists have dealt with the problem of how the supply chain processes can be improved in order to use it as a competitive weapon. However, it is essential that the firms initially, develop right performance measurement metrics for the supply chain. Subsequently, they need to identify their relative positioning vis-à-vis other firms in the industry segment using a benchmarking methodology. At the next level, they would need to identify avenues for improvement in their supply chain processes using some sort of supply chain opportunity analysis and diagnostic tools. These tools may further be used to come up with policies leading to improvement in the supply chain processes.

There has also been substantial application of technology and innovative ideas for improving the supply chain performance. However, these have not worked in many cases because of adversarial relations between the partners of the supply chain and the dysfunctional industry practices [6]. Fisher has recommended the design of product specific supply chain that would be ideal for the type of product it is intended to handle. Nevertheless, there is also a need to come up with suitable performance measurement for the supply chain in order to mitigate the disadvantages of adversarial relations between the supply chain partners. It has also been posited that there is a need to mitigate problem of incentive misalignment in a decentralized supply chain through proper performance scheme [9]. Practicing managers also feel that there is a need for a research initiative in this area to determine how companies can take the thought processes of an integrated

supply chain further [10]. Managers also want to know what are the key success factors that make one company successful as compared to its peers.

However, effective performance measurement scheme can only be devised if the firm is able to correctly identify as to what is its performance in general and also target the specific areas that require immediate attention. Indeed, performance measurement is an essential and a powerful management tool but its power relies on the ability of the management to identify those vital measures that really drive supply chain success. Best-practice firms are able to successfully identify and establish the dynamic link between performance measurement systems and their supply chain strategies. In seeking these performance measures, firms need to look at their supply chain strategies and identify the performance measures that support their strategic decisions. The performance measures are also required so that a firm may know its relative positioning vis-à-vis its competitors and then attempt to implement policies and practices that would improve its performance. Benchmarking is one way of identifying the "Best Practice" firms and knowing ones performance based on suitable measures [3]. Various studies have stressed on the need for a research initiative in this area of supply chain management. In one such study, hypotheses were presented and tested on the relationship among benchmarking, strategic purchasing and firms' performance [15]. It was found that benchmarking is related to firm performance and strategic purchasing. According to the study, firms do obtain valuable comparison information and have the opportunity to learn if they use the benchmarking information. This study has also emphasized that future research should help identify specific practices that may be generalized across organizations. It has also been felt in the industry that there is a need for research initiative to develop benchmarking framework that would help the organizations move from a functional orientation to a supply chain orientation [10]. Thus we find that literature on the supply chain management as well as the industry has raised this issue and has also emphasized the need to develop framework that would faithfully capture the performance level of a firm and would benchmark it against the "Best Practice" firm. A need has also been felt to develop framework that would allow the firms to identify specific supply chain processes, which should be targeted for improvement. This paper is an attempt in that direction.

Study objective

The objective of the study is to develop "Best in Class" supply chain metrics, which, when analyzed, will lead the companies to improved performance. A framework is also developed which would allow the firms to identify the "right" financial performance metrics. Broadly, this study is designed to give the firms the knowledge in which they may improve their strategic decisions by exploring how firms may:

➢ Develop the right performance metrics that would help in assessing the opportunity for improvement
➢ Benchmark with other firms in the industry segment and identify gaps in performance with the "Best Practice" firm
➢ Develop supply chain diagnostics tools that would identify specific areas that require attention

➤ Ensure that the performance metrics drive them to improve responsiveness and processes in the supply chain

Study Process

1) Design a framework for supply chain opportunity analysis tool that would allow the firms to assess the performance of the supply chain processes
2) Develop supply chain diagnostic tools that help the firms in narrowing down to specific areas, which require attention. These tools serve as the tests to analyze core supply chain processes and policies and come up with decision alternatives that lead to an improvement in the supply chain processes
3) Benchmark the supply chain processes of the top companies in the industry segment using the performance metrics as given in the supply chain opportunity analysis tool. Choosing an appropriate benchmarking methodology is the essential key in making benchmarking a success. We have used APQC's (American Productivity and Quality Center's) benchmarking methodology that has been successfully applied in numerous other benchmarking studies [1]. This benchmarking methodology is based on a process of continuous improvement: plan, collect, analyze, and adapt. This methodology helps firms identify who performs a certain process best, collect information to thoroughly understand the process, analyze the gaps between the processes, and implement improvements based on the findings.

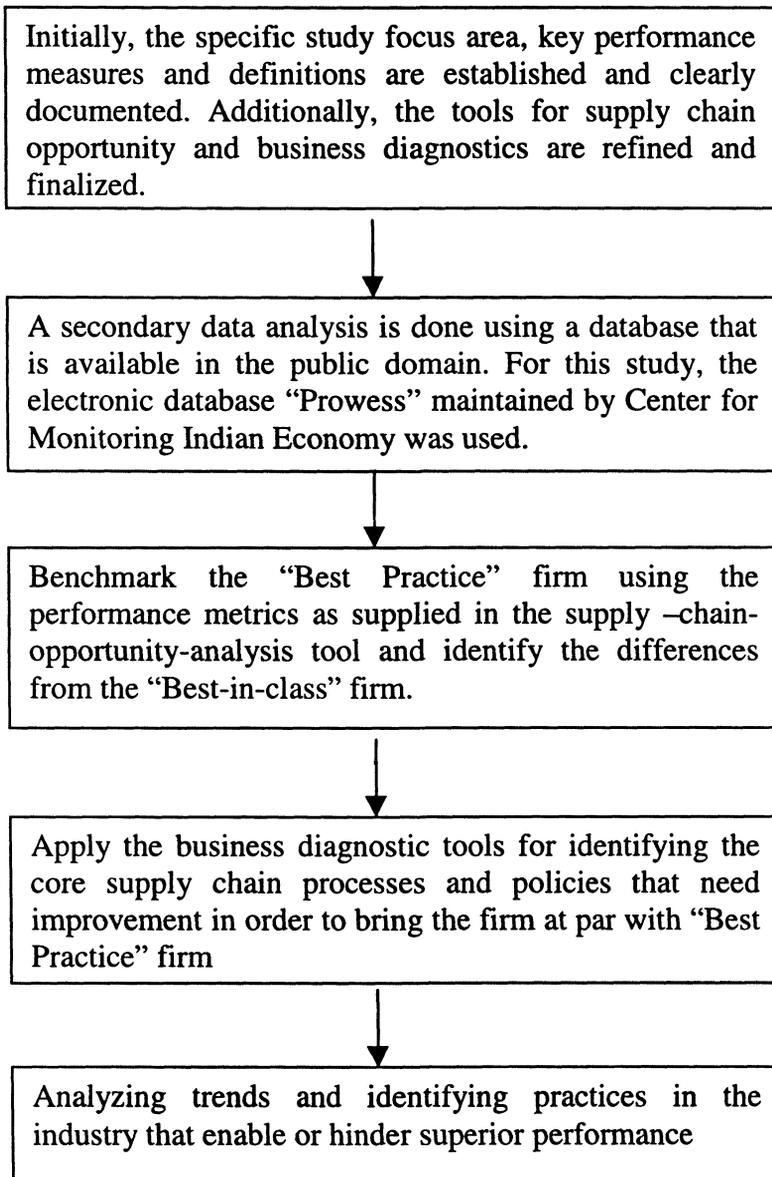A flowchart outlining the study process is provided as figure 1.

Focus of the study

The methodology proposed in this study falls within the framework of competitive benchmarking. The representative firms chosen for the purpose of study belong to the industry type. The industry type is chosen to be the one, which is in the business of producing similar product. The firms having common characteristics are pooled into a specific industry type. Industry types are categorized on a product wise basis due to following considerations:

➤ Firms producing and selling similar kind of products would adopt similar processes for procurement, production and distribution.

➤ Further, these firms would also have, more or less, similar policies for managing their creditors and debtors.

➤ All the firms in a particular industry segment would face similar type of competition

Given the above considerations, specific industry types are initially identified based on the product homogeneity. This is followed by identifying the firms that fall into each industry type. The categorization is done based on the product basis. For business groups that produce and sell totally different kinds of products, specific business areas of such groups are identified. These business areas would correspond to a product type. For

Figure 1
Flow chart outlining the study process

Initially, the specific study focus area, key performance measures and definitions are established and clearly documented. Additionally, the tools for supply chain opportunity and business diagnostics are refined and finalized.

↓

A secondary data analysis is done using a database that is available in the public domain. For this study, the electronic database "Prowess" maintained by Center for Monitoring Indian Economy was used.

↓

Benchmark the "Best Practice" firm using the performance metrics as supplied in the supply –chain-opportunity-analysis tool and identify the differences from the "Best-in-class" firm.

↓

Apply the business diagnostic tools for identifying the core supply chain processes and policies that need improvement in order to bring the firm at par with "Best Practice" firm

↓

Analyzing trends and identifying practices in the industry that enable or hinder superior performance

---

instance, a group may be in the petrochemicals as well as in the petroleum industry type. In this case, the firms operating in these two different industries would be put separately.

To illustrate the framework, paints industry is chosen and the tools proposed here are applied to all the major companies in the paints, varnishes and enamels segment. An analysis is carried out on the data obtained from the electronic database "Prowess" maintained by Center for Monitoring Indian Economy, India (Center for Monitoring Indian Economy, 1999). The information provided in this database is available in the

public domain and one can obtain, through this database, information like background, financials, product profile, raw materials consumed and accounting policies of the firms. Thus one can use publicly held information to carry out detailed analyses for the supply chain performance. "Prowess" database provides authoritative business information on the companies and all the figures used for the application of tools are obtained from Prowess. In this study, a longitudinal analysis for three years (1997 – 1999) is carried out on the paints industry. Top three companies who have the largest sales are singled out for this purpose. Analysis is done on the industry aggregate as well. The expressions taken out from the database are displayed in figure 2.

Figure 2

Expressions for Corporate analysis[a]

1. financial analysis
    1.1. cost analysis
        1.1.1. cost of production
        1.1.2. cost of sales
        1.1.3. Net sales
        1.1.4. Cost of raw materials
    1.2. Assets
        1.2.1. inventories
        1.2.2. raw materials
        1.2.3. semi finished goods
        1.2.4. finished goods
        1.2.5. receivables (excluding loans & advances)
    1.3. Liabilities
        1.3.1. Payables (current liabilities)
    1.4 Key ratios
        1.4.1 Raw materials Holding Period (days)
        1.4.2 WIP Holding Period (days)
        1.4.3 Finished goods Holding Period (days)

[a]Expressions for industry aggregate are taken out from the Industry Research through similar financial statements.

Supply-chain-opportunity-analysis tool

The tool for opportunity analysis is used to ascertain how efficiently the firms are managing the supply chain processes in terms of cutting down the costs and getting the product to the customer fast. We have used financial metrics to study the firm's operational performance [5]. It is the objective of the firms to delay the cost addition process as much as possible. This is achievable if the product differentiation is postponed such that most of the cost addition is done when the product almost reaches the customer. Under these circumstances, lesser amount of firm's capital would be locked up in the product. In an ideal scenario, the firm would start the production as soon as the raw material is received and delay the product differentiation till the point the customer's orders are confirmed. It would also be the endeavor of the firm to speed up the production process such that days of WIP are kept as low as possible. In this case, the raw material and finished goods inventory would be kept to the minimum.

The objective at this stage is to identify the length of various stages in the chain and draw a profile of the cost addition during these stages. This analysis is carried out for all the companies in the industry and also for the industry as a whole. The tool for supply-chain-opportunity-analysis is developed in the following way:

a) Calculating the length of various stages in the chain: This involves the calculation of the length (in days) for which the raw material, WIP and finished goods remain in the firm

b) Calculating the cost addition in these stages: This involves the cumulative cost addition as it takes place on the raw material, WIP and finished goods

c) Making a profile for individual companies and for the industry aggregate: A profile is made which maps the cost structure of the product vis-à-vis the time spent in the raw material, WIP and finished goods stage.

a) *Calculating the length of various stages of the chain*

"Prowess" database supplies the figures for holding period of raw materials, WIP, and finished goods in the key-ratio section of the financial statement. The following formulae are used to calculate the length of various stages in the supply chain.

$$DRM_i = \frac{RM_i * 365}{CRM_i + ERM_i} \qquad (1)$$

Where

i = index for time period which is taken as a year (i.e. 365 days)
DRM_i = days of raw material inventory for time period i
RM_i = raw material inventory for time period i
CRM_i = cost of raw material for time period i
ERM_i = expenses on raw materials for time period i

$$DWIP_i = \frac{SFG_i * 365}{CP_i} \qquad (2)$$

Where

$DWIP_i$ = days of work in process inventory for time period i
SFG_i = semi finished goods inventory for time period i
CP_i = cost of production for time period i

$$DFG_i = \frac{FG_i * 365}{CS_i} \qquad (3)$$

Where

DFG_i = days of finished goods inventory for time period i
FG_i = finished goods inventory for time period i
CS_i = cost of sales for time period i

These expressions are used in the "Prowess" database to calculate the holding period for raw materials, work in process and finished goods of different companies. Therefore, the figures supplied by the database are taken directly for the purpose of analyses.

b) Calculating the cost addition at various stages:

1) cost addition in the raw materials and stores stage: These are the costs associated with holding raw material inventory and may be given by:

$$CRM_i = RM_i * ICC_i^1 \qquad (4)$$

Where

$CRMi$ = cost addition in the raw materials stage for the time period i
ICC_i = inventory carrying cost percentage for the time period i

2) cost addition in the finished goods stage: These are the costs associated with holding finished goods inventory and may be given by

$$CFG_i = FG_i * ICC_i \qquad (5)$$

Where

$CFGi$ = cost addition in the finished goods stage for the time period i

3) cost addition in the WIP stage: These are the costs associated with processing the raw materials so as to turn them into finished goods and are obtained by:

$$CWIP_i = CP_i - CRM_i \qquad (6)$$

$CWIP_i$ = cost addition in the wip stage for the time period i
CP_i = cost of production for the time period i

c) Making a profile for the companies

It is attempted to chart out the comparative duration at various stages as well as the cost addition. This cost addition would ultimately lead to the formation of the profile. The total duration of the cycle is found for all the stages. Maximum total duration is taken to be the benchmark and then backward calculation is done to figure out as to when the companies are starting their cycle and at what points the costs are adding up.

---

[1] While applying the framework to the paints industry, we have taken the Inventory Carrying Cost percentage to be 25%

Two hypothetical companies are taken and calculations are done for these to exemplify the process. The following figure refers to the length of various stages for companies C1 and C2. This exercise is essentially for the purpose of illustration only which lays down the steps in which the profile is made.

	length of raw material stage	Length of WIP stage	Length of Finished goods stage	Total length
C1	44	11	40	95
C2	42	10	61	113

The cumulative figures are given as under:

	length at the end of raw material stage	Length at the end of WIP stage	Length at the end of Finished goods stage	Total length
C1	44	55	95	95
C2	42	52	113	113

The maximum cycle is 113 days, which belongs to the company C2. This figure is used to do the backward calculation. The recalculation would yield the following revised figures:

	Starting from the day	length at the end of raw material stage	Length at the end of WIP stage	Length at the end of Finished goods stage
C1	(62-44) = 18	(73-11) = 62	(113-40) = 73	113
C2	0	42	52	113

Subsequently, the costs are normalized across companies using the usual notation for the normalization:

$$\Re_c = \frac{\nabla_c - XMAX_c}{XMAX_c - XMIN_c} \qquad (7)$$

Where

$\Re_c$ = *Normalized value for company c*

∇_c = *Actual value for company c*

$XMAX_c$ = *Maximum value for company c*

$XMIN_c$ = *Minimum value for company c*

For instance, the normalization for C1 is carried out in the following manner:

➢ Cost of raw materials: 1204

> Cost addition in the raw materials stage: 94
> Cost at the end of raw materials stage: 1204 + 94 = 1298
> Cost addition in the WIP stage: 627
> Cost addition at the end of the WIP stage: 1298 + 627 = 1925
> Cost addition in the finished goods stage: 177
> Cost addition at the end of the finished goods stage: 1925 + 177 = 2102

The normalized values are obtained as under:

> Cost of raw materials: 1204/2102 = 0.57
> Cost at the end of raw materials stage: 1298/2102 = 0.61
> Cost addition at the end of the WIP stage: 1925/2102 = 0.91
> Cost addition at the end of the finished goods stage: 2102/2102 = 1
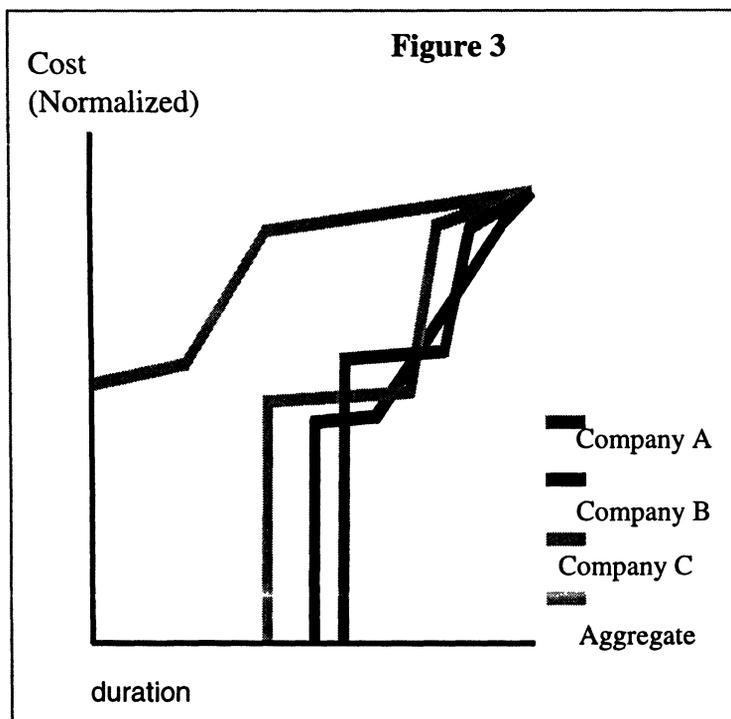
Figure 3

A profile is made with the revised duration of the stages in the X-axis and the normalized costs in the Y-axis. Figure 3 shows this profile for the selected companies in the paints industry for the year 1999.

Supply chain diagnostics tools

At this stage supply chain diagnostic tool is developed that allows the firms to assess the avenues of improvement within their supply chain. The diagnosis involves the comparison of the SCM (supply chain management) costs and an analysis of the supply chain working capital productivity of the firms. Essentially, this kind of analysis would allow the firms to know as to what are the reasons behind a given level of performance. Once a firm knows these reasons then it can go about the job of targeting specific functional areas and implementing policies in order to bring about an improvement in the supply chain processes. This involves the following two analyses:

> Analysis of the supply chain management costs
> Analysis of the supply chain working capital productivity

In the next sub-sections, we provide a rationale for these analyses.

Analysis of the supply chain management costs

We consider total inventory carrying costs and the distribution costs to be the components of the supply chain management costs. We calculate supply chain inefficiency ratio as under:

$$CSCM_i = DC_i + ICC_i \qquad (8)$$

$$SCI_i = \frac{CSCM_i}{NS_i} \qquad (9)$$

Where

SCI_i = supply chain inefficiency ratio for the time period i
$CSCM_i$ = supply chain management costs for the time period i
DC_i = distribution costs for the time period i
NS_i = net sales for the time period i

We terms this indicator as the supply chain inefficiency ratio since the SCM costs would tend to be on the higher side if the operations are not optimal and there is an inefficiency in the system. This ratio provides an insight into the supply chain management efficiency of the firm and is based on the following two premise:

1) The firms, which manage their supply chain processes in an efficient manner, would have fewer stockouts and would have lower levels of inventory as raw materials, semi finished goods and finished goods. The inventory turnovers would be more in such a case since better purchasing, planning, manufacturing and distribution processes would allow the firms to maintain and efficient consumer response. Consequently, such firms incur lesser inventory carrying costs.

2) The distribution costs include the expenses incurred in transportation and material handling. To have an efficient and flexible distribution, the firms try to achieve optimization in activities related to transportation, loading, unloading and warehousing. For instance, in order to achieve this objective, one can implement policies that ensure faster mobilization of vehicles and of the right type at the point of time when the product leaves the manufacturing center. Moreover, the mode of transportation should be suitable in terms of product being transferred. Similarly, a streamlining of loading and unloading system would result into fewer and swifter material handling operations. This would ultimately translate into cost efficiency and flexibility in the supply chain.

Analysis of the supply chain working capital productivity

This analysis provides an insight into the partnering approaches of the firm with the suppliers and the distributors. Literature and the case evidences have cited the importance of the cooperative relationships with the suppliers and distributors. One of several studies

on this aspect has looked into the ways of developing suppliers using a process oriented approach [7]. There have also been studies that have focussed on linking sourcing strategies with specific business units[14]. However, the firms need to objectively determine avenues for improvement in the processes pertaining to the transactions with their suppliers as well as distributors. The tool outlined here is an attempt in that direction.

We consider the following components of supply chain working capital:

1) Accounts receivable: Termed as sundry creditors. These are essentially the distributors and the dealers who buy the products and owe payment to the company

2) Inventories: A composite of inventory of raw materials, semi finished goods and finished goods.

3) Accounts payable: Termed as sundry debtors in the corporate database. These are essentially the suppliers of raw materials whom the firm owes payment.

These asset and liability forms are short lived and are swiftly transformed into other forms. In addition, their life span depends upon the extent to which the basic activities – procurement, production, distribution and collection - are synchronized and carried out in an effective manner such that there are no blockages at any of the transfer points. For instance, if the procurement, production and distribution were totally synchronized the need for inventories would be almost eliminated. By the same logic, if all the customers pay cash then management of accounts receivable becomes redundant. However, the element of uncertainty in the basic activities and the transactions on credit make it necessary that the management of these forms is carried out effectively and efficiently [16].

In a business setting most of the transactions are carried out on credit and the tool that we put forward in this section captures the performance affected by inventories, accounts receivable and accounts payable. In a competitive economy, the companies have to allow credit for attracting sufficient business. This, in turn, also forces them to delay their payments in order to finance their operations. Let us take the case when the products are sold on credit. This depletes the inventories thus increasing the account receivable. To replenish the inventories, the firm commences the production for which it buys raw materials. If the raw materials are bought on credit accounts payable increase. Under these circumstances, the working capital components affect the procurement, production and collection activities and are, in turn, affected by them [12]. For the purpose of analysis, we would simultaneously consider the interaction of accounts receivable, inventories and accounts payable.

Recently, the industry, in general, has also seen the development and implementation of innovative supply chain practices such as vendor managed inventory, turnkey services, point-of-use replenishment, bonded pipelining, invoiceless purchasing, pipeline pay points and zero inventory systems. These practices focus on the supply chain partnering

processes and aim to bring down the total costs by involving the partners of the supply chain in the decision process. The concept behind this approach is to bring about a overall reduction in cost of the product and make the supply chain more responsive at the same time. The big firms need to consider the fact that their suppliers & distributors incur different costs of capital. Normally, small players incur very high costs of capital. Long credit periods for them are very costly and these costs are ultimately passed on to the customers. Therefore, it is mutually beneficial for the suppliers, producers as well as the distributors to ensure better integration in order to bring in cost efficiency [8]. For instance, a client who delays paying invoices for an extended period of time is receiving an interest-free loan from the firm. In such cases, quicker payments must be negotiated [11, 16]. A conceptual base for supply chain working capital analysis is provided in table 1.

Table 1
Supply chain working capital analysis[a]

Scenarios	Accounts Receivable	Accounts Payable	Impact on supply chain working capital Productivity	Remarks
Scenario1	Low	High	Increases	The increase in working capital productivity is attributable to shifting of the costs to the suppliers and the distributors.
Scenario 2	High	Low	Decreases	The working capital productivity decreases because the funds of the firm are totally locked up. It keeps its credit period low but is not successful in getting the receivables fast
Scenario 3	High	High	Remains same	In this case, one needs to look into the components of the supply chain working capital[b]
Scenario 4	Low	Low	Remains same	In this case, one needs to look into the components of the supply chain working capital[b]

[a]Assuming the same levels of inventory in all the scenarios
[b]Refer table 2 for further exposition on this

The policies regarding credit allowed to the dealers and distributors is also affected by the lost sales, experience of bad debts and aging of accounts. Stringent policies for accounts receivables may reduce the volume of receivables but result in increased lost sales. For instance, a firm may not allow any credit extensions and keep the inventory levels low but this may reflect in higher instances of lost sales. Conversely, indiscriminate extensions and stocking high amount of products would result in decreased lost sales but

a larger investment in receivables and an increased bad debt level. This discussion points to the need for arriving at a trade off between different components of working capital. Table 2 lists out few critical scenarios that may exist in a given business setting and the related repercussions that may emanate from having different combinations of working capital components. Using this approach, it would also be necessary to analyze the components of the working capital and their interactions with each other as well as with the lost sales for the all the partners i.e. supplier, the firm and the distributors.

Table 2
Interaction of the working capital components and lost sales

Scenario	Accounts receivable	inventory	Lost sales	Aging of accounts/bad debts	Repercussions
1	high	low	low	High	The firm pushes the product on to the dealer with the effect that collection becomes problematic and the risk of aging of accounts increases
2	high	high	low	High	Same as (1) above but the inventory levels remain the same indicating that the inventory management policies need to be streamlined
3	low	high	low	Low	A strict credit policy is leading to an increase in inventory at the firm
4	low	low	high	Low	The firm seems to be too stringent on the credit policy and so is not getting sufficient business
5	low	low	low	Low	An ideal case in which the firm is able to manage the inventory as well as the credit policy well

At this stage, our objective is to analyze the impact of inventory, accounts receivable and accounts payable on the performance of the firm. The analyst needs to simultaneously consider the components of supply chain working capital as well as its productivity so as to comment upon the effectiveness with which the companies are managing their inventory and the interest rate burden across the years.

The supply chain working capital is calculated for the firms using the following formula:

$$SWC_i = I_i + AR_i - AP_i \qquad\qquad (10)$$

13

Where

SWC_i = supply chain working capital for the time period i
I_i = inventory for the time period i; here the aggregate figure for the inventory is taken and is not decomposed into the component parts
AR_i = accounts receivable from the dealers/distributors for the time period i
AP_i = deferral of payments to the suppliers for the time period i

Subsequently, the working capital productivity is measured as:

$$SWCP_i = \frac{NS_i}{WC_i}$$
(11)

Where

$SWCP_i$ = supply chain working capital productivity for the time period i
NS_i = net sales for the time period i

Statement of results

With the use of the methodology outlined in this paper, the firms can narrow down to the processes and the functions that need to be targeted in order to enhance the supply chain performance of the firm. The comparison of the firms at the industry level also allows identifying the best practice firm and devising strategies in the context of the industry. We have applied the framework to the paints industry. Analysis is done on the industry aggregate as well as the top three companies as per the sales volume for the years 1997-1999. In this section, we report the results that have been obtained through the application of tools.

Opportunity analysis

Refer to table 3 and figure 3 for the supply chain opportunity analysis

Table 3
Holding period for the firms[a]

Holding period (No. of days)	Company A			Company B.			Company C		
	1997	1998	1999	1997	1998	1999	1997	1998	1999
Raw materials	40	38	38	53	55	52	62	58	43
Semi finished goods (WIP)	14	13	12	10	11	10	4	4	4
Finished goods	42	39	38	33	29	30	43	48	42

[a]Source: Prowess; Electronic database maintained by Center for Indian Economy, Bombay, India

14

The following results are reported:

1) Company A has the least days of WIP inventory. Also this company has the lowest aggregate length i.e. the composite figure including days of raw material, WIP and finished goods.

2) Company B has the least days of raw material inventory and finished goods inventory. However, the product stays as the WIP for the longest time in this case.

3) Company C has the longest days of raw material and finished goods inventory

4) The aggregate industry profile shows that for the industry as a whole the product stays in the finished goods inventory for a long time and the companies bear significant cost in terms of keeping the product as the raw material.

It is observable through the results that the companies strive to bring down the duration of raw material and finished goods since there is no value addition in these stages and the company has to unnecessarily bear the inventory carrying cost. Company B seems to be successful in this objective. However, the product stays in the WIP stage for the longest time for this company. This points to the fact that the company attempts to delay the product differentiation to the last stage of the production process such that its final product takes shape very late.

Analysis of the Supply chain efficiency

Refer to table 4 for analysis of the supply chain efficiency.

Table 4
Supply chain management costs and the inefficiency[a]

	SCM costs			SCM costs/net sales		
	1997	1998	1999	1997	1998	1999
aggregate	333.20	371.67	394.34	0.09178	0.09096	0.08656
company A	59.04	69.65	73.17	0.07573	0.07868	0.07435
company B	42.82	44.49	55.29	0.07049	0.06707	0.06961
company C	29.65	33.14	37.45	0.08153	0.07676	0.07939

[a]Source: Prowess; An electronic database maintained by Center for Monitoring Indian Economy, Bombay, India

We note that Company A has been successful in bringing down the supply chain inefficiency ratio from 0.07573 in 1997 to 0.07435 in 1999. For company C, this ratio has decreased from a figure of 0.08153 in 1997 to 0.07939 in 1999. Likewise, the ratio has also decreased for company B too from the figure of 0.7049 to 0.06961. The industry aggregate ratio has also decreased. The percentage increase in supply chain management costs have been the highest for the company B. However, its supply chain ratio has, in

fact, seen a marginal decrease thus indicating that this company has been successful in keeping down the costs while at the same time enhancing the sales volume. This points out to the fact that company B seems to be following an integrated logistic strategy thereby achieving cost efficiency and optimization in the supply chain processes.

It may further be observed that this company has also performed best when subjected to the test of supply-chain-opportunity-analysis. It was found that for this company, the duration for which the product stays in the finished goods stage was the least.

Supply chain working capital productivity analysis

Refer to table 5 and table 6 for analysis of the supply chain working capital & its productivity.

Table 5
Working Capital Productivity[a]

	1997	1998	1999
Company A	6.88	7.22	7.25
Company B	9.53	7.88	6.82
Company C	11.14	12.68	10.79

[a]Source: Prowess; An electronic database maintained by Center for Monitoring Indian Economy, Bombay, India

Table 6
Table showing the values for inventory, Account Receivables and Account Payables[a]

	Company A			Company B.			Company C		
	1997	1998	1999	1997	1998	1999	1997	1998	1999
Inventory	146	140.25	166	64.92	63.41	68.72	101.15	118.45	118.47
Account Receivables	60	67	80.74	45.59	60.3	56.94	91.57	126.72	159.56
Account Payables	55.61	70.9	101.9	61.74	75.45	63.61	198.51	181.7	217.97

[a]Source: Prowess; An electronic database maintained by Center for Monitoring Indian Economy, Bombay, India

We report following results on examining these tables:

1) Company A's working capital productivity has increased steadily over the years but we also find that its Accounts Payables have increased substantially from 55.61 in 1997 to 101.9 in 1999. One can infer from this result that the supply chain working capital increase is attributable to the deferral of payments to the suppliers.

2) For company B the supply chain working capital productivity has decreased substantially. However, we also observe in this case that the company has not allowed its Accounts Payables to increase significantly. The increase has been only marginal from

61.74 in 1997 to 63.61 in 1999. Moreover, this company has been successful in keeping its inventory levels and Accounts Receivables in check and has not allowed them to increase substantially.

3) Company C has allowed its supply chain working capital to decrease from 11.14 in 1997 to 10.79 in 1999. Its Accounts Payables and the inventory levels have also increased but we observe that there has been a significant increase in its Accounts Receivables from 91.57 in 1997 to 159.56 in 1999.

These results point to the fact that looking only at supply chain working capital productivity per se would be myopic and would not capture the real performance of the firm. The performance cannot be simply based on the internal workings of the firm. It needs to take into account the partnering approaches of the firm, which is possible in this case by examining the components of the supply chain working capital too. After all, price is determined by the dynamics of the market and a firm can hope to be competitive only if it keeps the interests of its suppliers and distributors who are important operators of the market.

In pursuance of this objective, its endeavor should be to be prompt on its payments such that Account Payables do not increase enormously. If a firm is very large in comparison to its suppliers then it should be more concerned about this issue since the cost of capital faced by a small player is much higher. In this case, the firm may be able to defer its payments owing to its bargaining power but, ultimately, the higher cost of capital is borne by the firm itself when the supplier adds this on to his price.

In order to acquire greater business a company may be prone to offer extensions of credit and sell more on credit. However, this kind of policy also proves to be detrimental since it results in a restriction in terms of financing the operations. This harms the firms in two ways:

a) The firm is forced to finance its operations on credit and thus incurs unnecessary interest burden.

b) It is forced to defer its payments to its supplies thus resulting in loss of goodwill. Also, the supplier ultimately passes on the extra cost of his interest burden to the firm. This further adds on to the cost of the product.

At this stage, it becomes important that the analyst probes a little deeper to know as to why the companies have different performance levels. This would facilitate the identification of the practices, policies and processes that lead to an improvement in the supply chain performance. Therefore, we go a step further in the next section and explore the specific reasons that have led to the reported results.

Discussion of the results

In this section, we have done a broad analysis of the paints industry and then brought out the examples of the "Best Practice" companies and the ways in which they are trying to improve supply chain performance.

Indian paints industry faces a very competitive environment and the companies operating in this segment struggle to provide high product variety while maintaining the cost efficiency at the same time. Also, they have to manage frequent changes in production volume because of the large and abrupt changes in the demand pattern.

Supply chain opportunity analysis leads us to conclude that the firms would strive to cut down the period of raw material days and finished goods days and keep the WIP days comparatively long. Company B has shorter days in raw material and finished goods and longer days in WIP. Shorter the days incurred in raw material and the finished goods, the lower is the cost for the company. In fact, there is no value addition when the product stays with the factory as a raw material or finished goods. The value is added during the production process only when the product stays as the WIP. However, the days in raw material and finished goods are prolonged because it is difficult to anticipate the demand quite in advance. Hence, the production process cannot be started immediately on receipt of the raw material. Similarly, the finished goods stocks are maintained in anticipation such that the demand can be met as soon the demand arises. Nevertheless, this strategy is sub optimal and results in unnecessary costs. Under these circumstances, the firms need to delay the product differentiation such that the final product is configured very near the customers' end [2]. This strategy, termed as postponement, would allow the firms to achieve flexibility and cost efficiency in a competitive environment. We have probed deeper into the supply chain processes of Company B in order to get insight into the reasons for its superior performance. Industrial information reveals that company B employs Point of sale manufacturing to provide a high level of product variety while maintaining the cost efficiency. This is achieved by enabling the retailers to make the desired shade by mixing the base oil and the pigment using the Tinting machines at the retail level itself. Innovative packing techniques are also utilized that allow the retailers to store pigments, thinners, base oil etc. in the outlets such that these chemicals do not deteriorate in quality. There is another benefit attributable to the postponement strategy. This benefit is manifested in lesser amount of waste in terms of products, which can not be sold if postponement is followed. Frequently, the firms dealing with high product variety face the risk of products not getting sold. This risk is averted by delaying the production process and giving the product a final shape only when the orders are more or less confirmed.

One observes through this discussion that the objective of the "Best Practice" firm would be to delay the production process till the customer's orders are confirmed. Once the order is confirmed the firm can go ahead with the production process. Manufacturing in advance and in anticipation captures the necessary resources and thereby makes it difficult for the firms to achieve flexibility [17]. The companies that can outperform others are those, which possess the flexibility to quickly, adjust to customer demand without the expensive burden of overproduction. Overproduction drains available resources of labor, materials and space. If an unexpected shift in demand occurs, the firm

may not have enough resources available to accept a new order. By the same logic, the firm should be able to tone down the production rate once an unexpected downward shift in demand occurs.

An examination of the distribution function of company B reveals that it has the largest distribution system and follows policies in order to cut down the distribution related costs and also to improve the responsiveness of the chain. This company also holds lesser inventory though it has a larger sales turnover and thus spends less on the inventory carrying costs. These are specifically the reasons that it has low supply chain cost ratio. Therefore, using this diagnostic tool the firm would be able to know where does it stand in terms of inventory management and distribution. Also, this analysis would allow the firms to identify the magnitude of improvement it needs in these processes.

To probe further on this issue, a profile of supply chain cost ratio against sales was drawn for all the companies in this industry for the year 1999. This is essentially the curve denoting the relation between the supply chain cost ratio and the sales for each company. Figure 4 exhibits this profile.
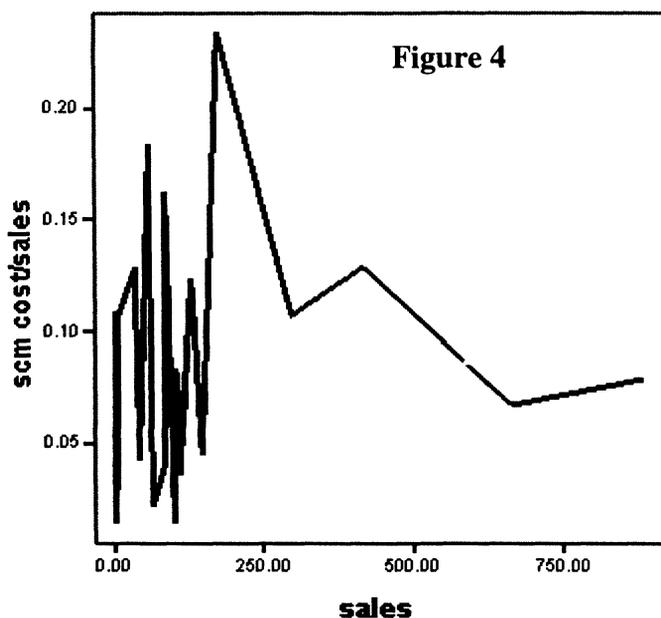
Figure 4

It is observed through the figure that this curve is concave. The ratio seems to increase initially but after a certain point this ratio decreases with the increase in the sales. This goes on to show that the larger companies are able to utilize the benefits associated with managing the operations on a wider base. Optimal inventory management policies yield benefits if the company deals with larger volumes and has a large distribution system. In this case, it can reap the advantages of following optimal ordering and storage policies. For instance, larger companies establish a multi-echelon structure and identify right inventory levels at different echelons. Likewise, companies dealing with large or mid-volume turnovers in the distribution are in a better position to achieve cost efficiency using freight consolidation, form postponement and time postponement. On the other hand, small-scale companies operate in local or regional markets. Their sales volumes are less and have fewer product varieties to offer. This does not allow them to exploit scale economies and really reap the benefits of product commonality, freight consolidation and a multi-echelon structure. Examination

of figure 4 also leads one to conclude that the companies need to arrive at an optimal size such that they do not spread themselves too thin thereby increasing the supply chain management costs in a larger proportion to the sales volume.

It may be gathered by examining table 6 that the firm A does not allow long credit periods to its distributors while at the same time delaying its payables to its suppliers.

In such circumstances, the suppliers have to finance their operations at a very high cost of capital since their capital is locked up with the firm for an extended period of time. Ultimately, this cost is passed on to the firm as an add-on to the services and physical goods provided by the supplier. The supplier adds this additional interest rate burden to the bundle of goods and services that it provides to the firm. At the end of it all the cost of the finished product increases as it is passed on to the customer. Therefore, a high working capital productivity may not be always optimal in terms of cost efficiency.

We also observe that the firm B faces a high interest rate burden since its capital is locked up with the distributors (Ref Table 6).

In this case, the distributors seem to be financing their operations at the cost of the firm. This is counter productive in two ways:

1) The distributors would lose the objective of being cost competitive since they are able to delay their accounts payables and
2) The firm would have to unnecessarily finance their operations from external sources at an interest

Under these circumstances too, the cost of inefficiency and the additional interest rate burden would add to the cost of the product.

To overcome this problem, there have been a specification and design of several non-traditional practices such as pay-on-receipt, credit card purchasing, EDI, co-located suppliers and ship to point-of-use. These aim to bring down the cash cycle. In addition to this more transparent customer-supplier business processes would also result in reduction of non-value transactions. It is in the interest of the firm to adopt one or more of these practices which would be compatible with its business setting. Industrial information reveals that Company B has combined the policy of having co-located suppliers and shipping to point-of-use in order to control its Accounts Receivables and Accounts Payables. And the results report that the company has been successful in this endeavor.

Managerial Implications

This discussion brings forward several implications:

1) The companies need to focus on to the production processes and find out ways and means of improving operational effectiveness and efficiency. This can cut down the

costs at the WIP stage. This attains huge importance since the firms aim to maintain higher WIP rather than to overstock raw materials and finished goods

2) The distribution networks should be strengthened to achieve wider customer base.

3) Better coordination between the production and logistics interface in order to lower the inventory at the stocking points and the factories and also to improve supply chain wide flexibility. This would also bring down intransit inventory and would allow the firms to respond faster.

4) The organized and unorganized sectors can work out synergy in operations for which the small-scale sector can be used as a sourcing base. This would help to cut down the raw material days

5) Bringing in new and innovative ways of postponing the production such that the product gets its final shape once the firm receives an order

Conclusions

The framework proposed in the study may be used by the firms to benchmark their supply chain processes and to assess their relative strengths and weaknesses. The tools outlined in this study would, not only, highlight areas of opportunity for improvement in the supply chain but also help identify specific reasons behind the performance levels in the chain and stimulate discussion among management.

To illustrate the framework, paints industry is chosen and the tools proposed here are applied to the major companies in the paints, varnishes and enamels segment. The business and economic information is obtained from an electronic database, which is available in the public domain. Therefore, this framework can be used to carry out detailed analyses using publicly held information. Subsequently, the analyst may probe further for additional information to focus on the specific reasons behind a given level of performance of the firm. The framework has proved to be robust when it is applied to the paints industry. Subsequently, the industrial information has also supported the results. The discussion of results has also brought out the advantages of using postponement strategy in this industry such that the product differentiation is delayed to the last point. The issue of cutting down the costs in the inventory at various stages is also discussed. It has been observed through the diagnostic tests that there is a scope for reduction in the costs pertaining to distribution and inventory management for the companies operating in the paints industry. This may be achievable by following integrated logistics strategy. The supply chain working capital analysis reveals that the company, which follows better partnering approaches with the suppliers and the distributors, would be in a better position to manage inventories, Accounts Receivables and Accounts Payables. Consequently, it is of interest to all the partners in the chain to achieve a supply chain wide integration instead of just concentrating on their individual functions.

It may be posited here that the framework brought out through this paper uses financial metrics to help the firm benchmark its relative position and identify specific supply chain processes that need improvement. Using this tool, the firm should be better placed to come up with suitable policies in line with the industrial and competitive environment it faces.

Reference:

1) American Productivity & Quality Center "The Benchmarking Management Guide" American Quality Press, Portland, 1992.
2) Balram A, Shah J "Improving Supply Chain Performance using Postponement Strategy" *IIMB Management Review*, vol. 11, no. 2, 1999
3) Bogan C, English M "Benchmarking for best practices" McGraw-Hill, New York, 1994.
4) Center for Monitoring Indian Economy, Bombay "Prowess User's Manual: vol. 1,2,3" 1999, pp. 1-13.
5) Chandra, P "Financial Management" Tata McGraw-Hill, New Delhi, 1997.
6) Fisher M "What is the Right Supply Chain for your Product?" *Harvard Business Review*, Boston; vol. 75, no. 2, 1997, pp. 105-116.
7) Harlety J, Jones G. "Process Oriented Supplier Development: Building the capability for change", *International Journal of Purchasing and Materials Management,* summer 1997.
8) Jensen M, Meckling W, "Theory of firm: Managerial Behavior, Agency Costs and ownership Structure" *Journal of Financial Economy*, vol. 3, 1976, 305-360.
9) Lee H, Whang S "Decentralized Multi-echelon Supply Chains: Incentives and Information" *Management Science*, vol. 45, no. 5, 1999
10) Lester M "An interview with Bill L. Ramsey: One on one" *Journal of Supply Chain Management,* vol. 35, no. 4, 1999, pp. 2-6.
11) Lewellen W, Johnson R "Better Way to Monitor Accounts Receivables" *Harvard Business Review,* May/June, 1972, pp. 101-109
12) Mehta D.R. "Working capital management" Prentice-Hall, Inc., Engelwood Cliffs, New Jersey, 1974
13) Parking K, Kellberg J "Current asset management :cash credit and inventory" John Wiley & Sons, Newyork, 1984
14) Ram Narasimhan, Joseph R Carter. "Linking business unit and material sourcing strategies" *Journal of Business Logistics*, vol.19, No. 2, (1998).
15) Smeltzer L, Carr A "The relationship among purchasing benchmarking, strategic purchasing, firm performance, and firm size" *Journal of Supply Chain Management*, vol 35, no. 4, 1999, pp. 4-16.
16) Smolen G "Appraisal company status and direction for survival" *The Appraisal Journal*, Chicago, vol. 65, no. 2, 1997, pp. 156-165
17) Steele D, Papke S, Karen E "Capacity slack: Strategic alternative to lead-time" *Production and Inventory Management Journal*, vol. 34, no. 4, 1993, pp. 1-12.