Human Metrics Affecting Supply Chain Performance: An Empirical Study of Indian Manufacturing Organizations

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KEYWORDS	ABSTRACT
Supply Chain Management, Supply Chain performance, Human Metrics, Manufacturing	*The manufacturing organizations today are having a competition of supply chain versus supply chain. Existing research work fails to relate human metrics with supply chain performance. The authors intend to empirically assess the effects of human metrics on supply chain performance in the context of Indian manufacturing organizations. A rigorous literature review has identified 12 variables. The variables are individually measured and later on reduced in number by factor analysis. As a pilot study, primary data is collected from 100 manufacturing organizations by means of a questionnaire, both offline and online, which is administered across India and a scale is developed. t-test and factor analysis resulted in 3 factors related to human metrics. The outcomes of the research work provide valuable implications for the Indian manufacturing organizations to understand the factors affecting supply chain performance.*

1. Introduction

The manufacturing sector is growing rapidly in India and China and has shrunk in most advanced economies. The growth will require several changes including significant increase in productivity and quality at the plant levels and pursuit of worldwide competitive manufacturing strategies and operations [1].

A worldwide study of contemporary manufacturing practices reported fair uptake and perceived effectiveness of supply chain management [2]. While observing these modest levels of uptake and effectiveness, one would expect attention in developing measurement systems and metrics for evaluating supply chain performance to be growing. Likewise, it has been argued that measuring supply chain performance can result in understanding of the supply chain and improve overall companies' performance [2].

It is an established fact that many companies have not succeeded in maximizing their supply chain's potential because they have often failed to develop the performance measures and metrics needed to fully integrate their supply chain to maximize effectiveness and efficiency [3]. The contribution of human behavior in performance measurement is mostly neglected.

The present aims to reduce the gap in the existing body of research relating human metrics to supply chain performance. The rest of the paper is divided into 5 sections. The next section is literature review, followed by scale development, methodology, results and conclusions.

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2. Literature Review

In this paper, the authors try to link the relationships of human metrics with SC performance in a single study in the context of Indian manufacturing organizations.

2-1. Human Metrics (HM)

There is a heavy influence of behavioral issues while establishing and implementing the key Performance Measures (PMs) and metrics. Cultural factors also play a significant role in determining the right PMs and metrics. Organizations shared values in terms of extreme trust, commitment and collaboration, organizational capability and top management supports are essential for an effective SCM [4]. It is suggested that human factor is significantly affecting the SCM effectiveness [5] and SCM managers are a critical factor in achieving strategic and operational objectives and changes in the supply chain [6]. It is found that firms lacking in appropriate cultural elements such as shared assumptions, values and artifacts tend to fail when implementing SCM initiatives [4].

On top of that, the organizational commitment and governance for supply chain success are being studied [7].

The findings indicated that four types of managerial support are needed to achieve the highest levels of supply chain success: top management support, broad-based functional support, channels support and infrastructural/governance support.

Few more research works [8] and [9] clearly support the need for a performance measurement system taking the holistic picture, including the human side and organizational issues.

Research has identified a variety of collaboration enablers including the following: aligned objectives, a shared customer-oriented vision, technological connectivity, relationship trust, supplier development, and process redesign and integration [10] [11] [12].

The centrality of human resources is usually accounted for by the fact that nowadays organizations are facing such challenges as a need to increase productivity, expand into global markets, develop new technologies, respond to changes in the highly volatile marketplace, increase revenue and decrease costs, develop skilled and flexible workforce, and introduce changes [11], which, of course, emphasizes the significance of human resources and capabilities.

The present study involves behavioral determinants of SCM viz. continuity, communication, power and trust and related variables are chosen from the existing body of literature.

2-2. Supply Chain Performance (SCP)

Researchers suggested that an appropriate performance measurement system (PMS) is a critical requirement for the effective management of a supply chain [13]. There are studies about the performance measurement systems and metrics of supply chains (SCs) by critically reviewing the contemporary literature and suggesting possible avenues for future research [14].

SCM needs to be assessed for its performance in order to evolve an efficient and effective supply chain [15]. For effective management in a SC, measurement goals must consider the overall SC goals and the metrics to be used. These should represent a balanced approach and should be classified at strategic, tactical and operational levels, and be financial and nonfinancial measures, as well [16].

Tab. 1. Construct definitions & literature support

Construct	Definitions	Literature
Supply Chain Performance	The overall efficiency and effectiveness of a supply chain	Beamon, 1998; 1999; Harland, 1996; Garwood, 1999; Gunasekaran et al., 2001; Holmberg, 2000; Tompkins and Ang, 1999; van Hoek, 1998; Bechtel and Jayaram, 1997; Kiefer & Novack, 1999; Narasimhan and Jayaram, 1998; Hewitt, 1999;

Many research papers that deal with performance measurement in a SC context [6] have appeared in the literature (Tabel -1)

3. Scale Development

Various items or questions used in questionnaire are taken from previous studies (Table -2). There are 12 items for HM.

Tab. 2. Questionnaire Items

1	HM1	The degree of dealings between us and our supply chain partner is very high
2	HM2	The relationship between us and our supply chain partner is very stable
3	HM3	We are quite involved in the marketing and planning efforts of our supply chain partner
4	HM4	We and our supply chain partner seek advice for each other when doing marketing analysis
5	HM5	We and our supply chain know the strengths and weaknesses of each other very well
6	HM6	Our firm is powerful enough to ask our supply chain partner to readjust price strategy
7	HM7	Our firm is powerful enough to ask our supply chain partner to readjust their product
8	HM8	Our firm can provide training support to our supply chain partner
9	HM9	Our supply chain partner perceives that our firm is perfectly honest and truthful
10	HM10	Our supply chain partner perceives that our firm is perfectly having high integrity
11	HM11	We would like to inform our supply chain partner everything about new developments
12	HM12	We willingly share all information that might help your supplier make better decisions

3-1. Development of Hypothesis

Based on the literature review, following hypothesis is proposed:

Hypothesis I

Ho: Human metrics has no effect on supply chain performance.

4. Methodology

This study is part of a larger research project exploring SC related practices, their relevance to managers, and their impact on firm performance and eventually on firm competitiveness. Methodology used in this study is based on the views of [17], that are, PMS should develop a reliable metrics to provide feedback on various performance areas by eliminating the overlapping (duplication) metrics and to include the most important metrics of logistics and supply chain management
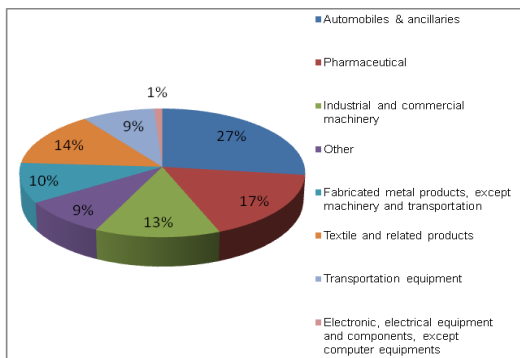
4-1. Sample Profile

The sample (sample size = 100) of this pilot study focuses on departments of purchasing, production, logistics and distribution in the Indian manufacturing companies. The survey covers various cities across India (Fig. 2).
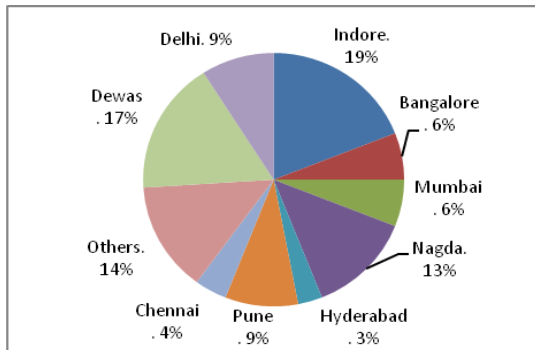
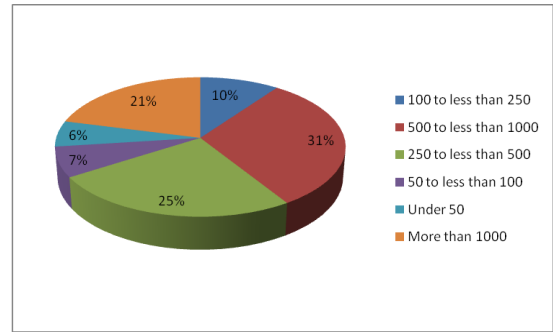
Fig. 1. Sample coverage

The other demographic details are shown in figures 2 and 3 below.

Fig. 2. Industry coverage

Nearly half (44%) of the respondents are from automobile and pharmaceutical industries taken together, and 31% of the industries have employees in between 500 and 1000.

Fig. 3. Number of employees

H_1 **(First alternative hypothesis):** Human metrics has significantly positive effect on supply chain performance.

Questionnaire (both online and offline) is the main instrument of this study. Questionnaire items are designed after an extensive literature review. 5–point Likert scale is used. There are total 29 items or questions. First 12 questions are related to the quantitative aspects (for HM, as shown in Table-2). Next 17 are demographic questions. Questionnaires have been emailed to various respondents and out of 108 responses which are received, 100 responses are complete in all respects and therefore taken for this pilot study. SPSS is used for analysis of the data.

4-2. Sampling parameters

With factor loadings higher than 0.55 (for sample size = 100), it is found that the sample is adequate for 95% confidence level and 5% level of significance [18].

The internal consistency of the questionnaire has been checked and the value of Cronbach's Alpha is found to be 0.599 (Table - 3). It is just equal to 0.6 and can be acceptable for the exploratory research utilizing new scale. Hence the questionnaire can be used for analysis purposes [18].

Table 3: Reliability Statistics (Initial)

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.599	.609	12

5. Results

The hypothesis proposed earlier is now properly phrased and tested. Factor analysis is also performed on HM construct using SPSS to reduce unnecessary items from the questionnaire. Reliability analysis is done eventually to test how well the items in a set are positively correlated to one another.

5-1. Hypothesis Testing

On a sample size of 100, the proposed hypotheses are tested by applying two-tailed tests as both the hypotheses are directional in nature.

Hypothesis I

H₀ (Null hypothesis): Human metrics has no effect on supply chain performance.

H₂ (Second alternative hypothesis): Human metrics has significantly negative effect on supply chain performance.

The hypothesis includes twelve variables as shown in Table - 2. One sample t-test has been applied on these variables. It tests that whether the mean of a distribution differs significantly from our assumed test value. A test value of 3 is chosen as it is the mid value of the five point scale used in questionnaire. Table - 4 summarizes the results of this test.

Tab. 4. Results for Hypothesis I

					95% Confidence Interval of the difference	
Variables	t- value*	p- value**	MD	Remarks***	Lower	Upper
HM1	22.48	0	1.22	SA	1.11	1.33
HM2	8.22	0	0.78	A	0.59	0.97
HM3	7.71	0	0.84	A	0.62	1.06
HM4	9.50	0	0.84	A	0.66	1.02
HM5	9.99	0	0.82	A	0.66	0.98
HM6	13.38	0	1.04	SA	0.89	1.19
HM7	16.34	0	1.06	SA	0.93	1.19
HM8	10.78	0	1.08	SA	0.88	1.28
HM9	12.27	0	1.12	SA	0.94	1.3
HM10	21.66	0	1.36	SA	1.24	1.48
HM11	10.7	0	1.02	SA	0.83	1.21
HM12	18.86	0	1.16	SA	1.04	1.28

One-Sample Test (Test value = 3)

The null hypothesis (Ho) is rejected and the first alternative hypothesis (H1) is accepted for all the variables. Thus, the results show strong influence of HM on SCP.

5-2. Factor Analysis

The previous section leaves us with all the 12 variables as determinants of SCP. The factor analysis is conducted on the variables representing HM.

In a factor analysis of 12 variables, a correlation matrix is obtained. The KMO and Bartlett's test results are shown in Table- 5(a), which shows a value of 0.534 which is more than 0.5, suggesting acceptable value.

Tab. 5 (a). KMO and Bartlett's Test for HM

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.534**
Bartlett's Test of Sphericity	Approx. Chi-Square	223.888
	df	66
	Sig.	.000

The inspection of diagonal values of anti-image correlation matrix obtained results in removal of HM8 (MSA= 0.416) and subsequently of HM11 (MSA=0.460). Again factor analysis is performed. The revised KMO and Bartlett's test results are shown in Table- 5(b).

Tab. 5(b). KMO and Bartlett's Test for HM

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.626**
Bartlett's Test of Sphericity	Approx. Chi-Square	143.079
	df	45
	Sig.	.000

Tab. 6. Total Variance Explained (HM)

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.216	22.158	22.158	2.216	22.158	22.158	1.918	19.182	19.182
2	1.916	19.159	41.317	1.916	19.159	41.317	1.915	19.146	38.328
3	1.231	12.307	53.625	1.231	12.307	53.625	1.530	15.296	53.625
4	.938	9.375	63.000						
5	.834	8.338	71.338						
6	.796	7.955	79.293						
7	.600	6.001	85.294						
8	.594	5.941	91.235						
9	.472	4.716	95.951						
10	.405	4.049	100.00						

Extraction Method: Principal Component Analysis.

The inspection of diagonal values of anti-image correlation matrix now reveals all values above 0.5. Now, the data set is ready for factor extraction. The method of principal component analysis is used, the results of which are shown in Table- 6. A scree plot is also shown in Fig-4.
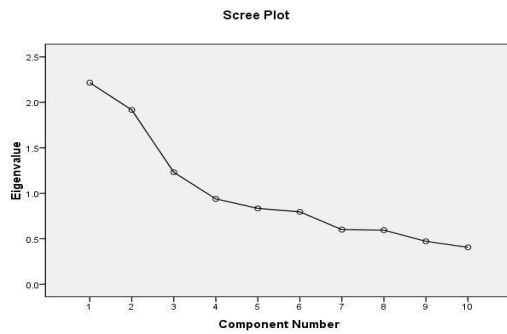
Fig. 4. Scree Plot (HM)

There are 73% non-redundant residuals with absolute values greater than 0.05. The factors are now rotated using Varimax rotation method (Table -7).

Tab. 7. Rotated Component Matrix (HM)

Variables	Component		
	1	2	3
HM1	.679		
HM5	.675		
HM6	.651		
HM2	.587		
HM4		.757	
HM7		.686	
HM3		.659	
HM9			.648
HM12			.615
HM10			.598

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Factor analysis has extracted 3 factors, thereby reducing initial 12 items. On the basis of variables associated with them, the factor labels are now given to the factors. The percentage of variance explained by each factor as obtained from Table -7 is put in parenthesis next to the factor label.

FACTOR 1: Trust and commitment (19.18%)
Associated Variables:

HM1 *(0.679)*	The degree of dealings between us and our supply chain partner is very high
HM5 (0.675)	We and our supply chain know the strengths and weaknesses of each other very well
HM6 (0.651)	Our firm is powerful enough to ask our supply chain partner to readjust price strategy
HM2 (0.587)	The relationship between us and our supply chain partner is very stable

FACTOR 2: Joint strategy and planning (19.15%)
Associated Variables:

HM4 (0.757)	We and our supply chain partner seek advice for each other when doing marketing analysis
HM7 (0.686)	Our firm is powerful enough to ask our supply chain partner to readjust their product
HM3 (0.659)	We are quite involved in the marketing and planning efforts of our supply chain partner

FACTOR 3: Transparency and honesty in information sharing (15.30%)
Associated Variables:

HM9 (0.648)	Our supply chain partner perceives that our firm is perfectly honest and truthful
HM12 (0.615)	We willingly share all information that might help your supplier make better decisions
HM10 (0.598)	Our supply chain partner perceives that our firm is perfectly having high integrity

Thus, all the initial items for HM (12 Nos.) have been reduced to 3 factors and 10 items. The final questionnaire was tested for reliability. The internal consistency reliability will be higher if the Cronbach's alpha is closer to 1. But, for newly constructed scale value above 0.5 is considerable (Hair et al., 2007). The final questionnaire shows the value of Cronbach's alpha as 0.542, which is acceptable for a new scale (Table-8).

Tab. 8. Reliability Statistics (Final)

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.542	.563	10

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6. Conclusions

The increasingly global nature of competition requires that firms should utilize all of their available resources in order to survive and succeed. Consequently, their supply chains need to be very efficient. And for that, the efficiency has to be measured and performance measures be defined.

The present work aims at narrowing down the different variables leading to SC performance. At this stage, pilot study results indicate the need of an exhaustive model to assess the SC performance.

However, the results show that out of total 12 HM variables except HM2, HM3, HM4 & HM5, on all other variables the respondents show **strong agreement.** Overall, the respondents show significant **agreement** towards all 18 initial variables under study. Factor analysis yielded 3 major factors comprising of

10 variables. And, overall reliability of the scale is 0.542.

This study is a part of a larger research project exploring SC related practices. The methodology of critical evaluation involves literature review of empirical research articles on performance measurement and SCM. The authors' intention is to fill up the gap about the lack of research in supply chain management which investigates the role of critical success factors in manufacturing organizations of India. The present study is limited to Indian manufacturing organizations. It can be extended to cover other sectors and organizations too.

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