

V. Narasimham ¹
K. Venkatasubbaiah
P. S. Avadhani

IDENTIFICATION OF CRITICAL SSCM ACTIVITIES THROUGH CONFIRMATORY FACTOR ANALYSIS

Article info:
Received 21 August 2012
Accepted 16 January 2013

UDC – 628.477.4

Abstract: As a developing country, economic and environmental performance has to be balanced in India. Green supply chain management (GSCM) is emerging as an important proactive approach for Indian enterprises for improving environmental performance of processes and products in accordance with the requirements of environmental regulations. This study examines the consistency approaches by confirmatory factor analysis that determines the construct validity, convergent validity, construct reliability and internal consistency of the items of Sustainable supply chain management (SSCM) requirements. This study examines the consistency approaches by Confirmatory factor analysis that determines the adoption and implementation of Sustainable supply chain management activities in small & medium scale industries. The requirements include Management commitment, customer coordination, sustainable design & production, green procurement and eco logistics for sustainable supply chains. This study suggested that the five factor model with eighteen items of the sustainable supply chain design had a good fit. Further, the study showed a valid and reliable measurement to identify critical items among the requirements of sustainable supply chains.

Keywords: sustainable, green supply chain, factor analysis, reliability

1. Introduction

A consensus is growing with the increased environmental awareness and concerns during the past decade that environmental pollution issues accompanying industrial development should be addressed together with supply chain management, thereby contributing to Sustainable supply chain

management (SSCM) (Sheu *et al.*, 2005; Sharma *et al.*, 2012). Nowadays, similar practices and regulations have been spread throughout the world in the US, Europe and major Asian countries as well; the emerging issue of green product seems to be quickly picked up in India. Some countries such as Japan, Taiwan and Korea in Asia are the heralds in terms of green products (Boysère and Beard, 2006). Thus, it is inferred that SSCM practice can be viewed as the primary strategy capable of complying with the requirements of legislations and maintaining

¹ Corresponding author: V. Narasimham
email: narasimham_v@yahoo.com

the competitive advantage. The issue of SSCM is significant for India's industry as recent studies have shown that most of the world's manufacturing will be relocated to Asia within the next two decades (US-AEP, 1999). Therefore, SSCM is an operational initiative on the part of many organizations, including those in Asia and South Asian region which are adopting to address such environmental issues (Rao and Holt, 2005). India is one of the most prospective industrialized countries in the South Asia region. Most manufacturers in India are involved in Original Equipment Manufacturing (OEM) and Original Design Manufacturing (ODM), which constitute mostly small and medium scale industries. These companies play important roles in global markets as their products share a substantial portion in the market. India is poised to take over as one of the largest producer of products in the world. Nevertheless, these industries are subject to customer requests for green products and green manufacturing that comply with emerging environmental directives. More than 3,000 companies were affected by the directives of the EU. These directives also have a far-reaching influence on supply chain partners for multinational enterprises (Huang, 2005). Although, to the best of our knowledge, various investigations have proposed different approaches to implement SSCM (Lamming and Hampson, 1996; Lippmann, 1999; US-AEP, 1999; Bowen *et al.*, 2001; Yuang and Kielkiewicz-Yuang, 2001; Rao, 2002; Evans and Johnson, 2005; Zhu *et al.*, 2005), there have been far less research on identifying the consistency and priority approaches to SSCM implementation with the systematic analysis, particularly in small and medium industry. This is because the complexity of SSCM practices, customer and cost pressures and regulation uncertainty, implementing SSCM is considered as a thankless task that increases overall product cost. These shortcomings result in significant problems when implementing SSCM. Furthermore,

increased regulations result in difficulties executing SSCM practices. Hence, enterprises cannot determine whether their executive strategies conform to regulations or ensure that current management approaches are working and have a low risk. Consequently, enterprise embraces the appropriate approaches for implementing SSCM practice and it is significant to mitigate potential risks from green supply chain. The central purpose of this study is to establish the consistency and priority approaches for implementing SSCM in response to environmental regulations.

Sustainable supply chain management has emerged as a proactive approach for improving performance of business processes and products in accordance with the requirements environmental regulations. Various approaches for implementing sustainable supply chain management practices has been proposed and recognized in previous literatures, yet little investigation has identified the reliability and validity of such approaches particularly in manufacturers of small & medium scale. This study examines the consistency approaches by confirmatory factor analysis that determines the adoption and implementation of items for sustainable supply chain management.

2. The conceptual model

The proposed model is based on five main constructs- (i) Management commitment (MC), Customer Coordination (CC), Sustainable Design & Production (SDP), Green procurement(GP) and Eco Logistics (EL) for sustainable supply chains. In this study, in order to determine the domain that encompasses SSCM dimensions for Sustainability, exhaustive theoretical, empirical and practitioner literature (Zhu *et al.*, 2008, Zhu and Sarkis 2006, Hsu and Hu, 2008, Lamming and Hampson, 1996, Gonzalez-Benito, 2008) were reviewed. Incorporating ideas, theories and studies

from literature, the above constructs operationalised by its indicators are explained below.

2.1 Management Commitment (MC)

One of the key factors for improving the performance of an enterprise is Internal environmental management. Senior management support is a necessary and key driver for successful implementation of sustainable supply chain management and responsible for the most of innovations, programs, technology and activities (Zhu *et al.*, 2005). Zsidisin and Siferd (2001) also point that commitment from top managers plays a significant role, with the aim to ensure complete environmental excellence. Positive relationship between mid-level managers facilitates the adoption of environmental practices. Involvement at every level of management including the worker level and inter disciplinary interaction in encouraging environmental practices will improve the performance of the enterprise (Zhu *et al.*, 2005; Zhu *et al.*, 2007). The following items are considered under management commitment.

- MC1 : Support for SSCM from managerial level
- MC2 : Workers involvement
- MC3 : Cross-functional cooperation for environmental improvements
- MC4 : Environmental compliance and auditing programs

2.2 Customer Coordination (CC)

With the public environmental awareness promoted recently, companies have noticed the importance of achieving their environmental objectives. Compared with green purchasing, less attention has been paid on cooperating with consumers as observed by literature (Zhu *et al.*, 2005). It is a way of more efficient travelling energy and saving raw materials for supporting the opportunities of suppliers to cooperate with customers. By the effect of selection of

materials and processes at the design stage, eco-design has become a critical factor to achieve the environmental objectives. Eco-design is defined as an approach to design of a product with special consideration for the environmental impacts of the product during its whole lifecycle.

CC1: Cooperation with customers for eco design

CC2: Cooperation with customers for green packaging

CC3: Coordination from customers for green usage & disposal of the product

2.3 Sustainable Design & Production (SDP)

The fate of a product whether or not it would produce any pollution or unsafe levels of certain chemicals is decided “at the design stage when materials and processes are selected” in the product life cycle, as emphasized by Zhu and Sarkis (2006). Gonzalez-Benito (2008) also pays attention to the “ecologically responsible design of new products.” Hence, ecologically responsible design or eco-design is one of the key SSCM practices that helps accomplish the objectives such as replacing toxic and hazardous substances with more environmentally friendly materials, reducing resource consumption, and raising organizational commitment to the product (Gonzalez-Benito, 2008). The following factors have been considered to evaluate the emphasis given for sustainable design and Production.

SDP1: Design of products for reduced consumption of material/energy

SDP2: Design of products for reuse, recycle, recovery of material, component parts

SDP3: Design of products to avoid/reduce use of hazardous products and/or their mfg. process

SDP4: Design of products considering life cycle assessment (LCA)

2.4 Green Procurement (GP)

Green Procurement is another main SSCM factor that applies environmental assessments not only to the immediate suppliers of the focal firm but also to the suppliers' suppliers (Zhu and Sarkis, 2006). On this matter, the manufacturers monitor both the first-tier and the second-tier suppliers regarding their compliance with environmental regulations. Lamming and Hampson (1996) stated that the buying firm should apply environmental standards in purchasing so that suppliers are encouraged to carefully conduct their operations as well as to keep an eye on their own suppliers' business activities. Other studies (Hsu and Hu, 2008) also address that green purchasing practice should be comprised of environment-based initiatives such as supplier environmental audit and assessments, supplier's environmental certification, and so on.

GP1: Cooperation with suppliers for environmental objectives

GP2: Environmental audit for suppliers' internal management and ISO certification

GP3: Implementing green purchasing

GP4: Eco labeling and Supplier evaluation and selection

2.5 Eco-Logistics (EL)

The response to the environmental problem is a major issue not only in India but also on a global level. 'Eco-Logistics' is the implementation of logistics with 'minimum environmental impacts'. In the logistics field, an important objective is to reduce the amount of CO₂ exhausts generated from the activities of transportation and to decrease the amount of packaging and wrapping materials used. As a method to realize this, consolidated fully-loaded distribution, through small-lot frequent pickup from each supplier and shortening of lead time, can be adopted after production leveling has been performed. It is designed to collect goods

from two or more suppliers at the same time which increases the amount of cargo sufficient enough for fully loaded distribution.

Three types of consolidation systems (Milk run logistics, Consolidation at departure facility and Consolidation at transfer facility) can increase the loading rates of trucks, then reducing their number on urban roads. Therefore they have the same effect as the cooperative delivery system involving many shippers or consignees with a public consolidation center, which is one of the most common city logistics policies. If there is a big shipper or consignee like a car manufacturing company, the urban traffic condition could be improved to some extent by their own consolidation efforts.

EL1: Green transportation

EL2: Green storage & handling

EL3: Green Distribution

Hypotheses

The hypotheses regarding sustainable supply chain activities are presented in the study's research questions, are given below.

Research Question: What are the Dimensions of Sustainable supply chain activities?

The results from our literature review, the following hypotheses are introduced.

Ha: Issues relating to the Management Commitment (MC) constitute dimension of Sustainable supply chain.

Hb: Issues relating to the Customer Coordination (CC) constitute dimension of Sustainable supply chain.

Hc: Issues relating to the sustainable design and production (SDP) constitute dimension Sustainable supply chain.

Hd: Issues relating to the Green Procurement (GP) constitute dimension of Sustainable supply chain

He: Issues relating to the Eco-Logistics (EL) constitute dimension of Sustainable supply chain.

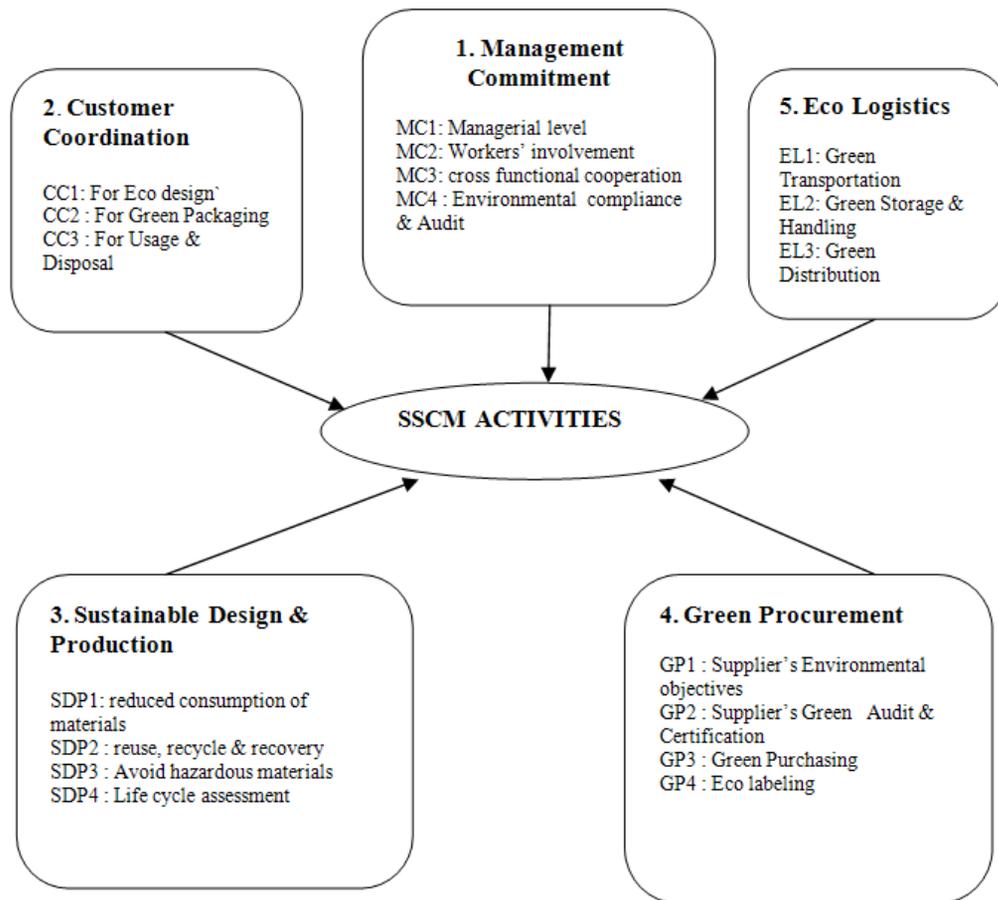


Figure 1. The Conceptual Frame work

Methodology

Confirmatory factor analysis: CFA requires the specification of a factor model, including the number of factors and the pattern of zero and nonzero loadings on those factors. A small number of theory-driven competing models might be specified as well. CFA provides information on how well the hypothesized model explains the relations among the variables. CFA has the advantages of allowing hypothesis testing on the data .The confirmatory factor analysis was done using LISREL 8.52. The measurement model fit with the data was checked with model chi-square goodness-of-fit, and approximate fit indexes. Insignificant

model chi-square goodness-of-fit (set at 0.05) signifies model fit. For approximate fit indexes, Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Normed fit index (NFI), relative fit index (RFI), incremental fit index (IFI), Tucker-Lewis fit index (TFI) and comparative fit index (CFI) of above 0.9 would indicate model fit . For another approximate fit index, root mean square error of approximation (RMSEA), a value less than 0.08 Root Mean Squared Residual (RMR) value less than 0.05 would signify reasonable model fit. Significance of standardized regression weight (standardized loading factor) estimates signifies that the indicator variables are significant and representative

of their latent variable. The threshold values of the measures are shown below.

3. Results and analysis

3.1 Survey Questionnaire

Survey questionnaire is developed from an extensive literature review which examined a number of streams of research, including green supply chains, supply chain strategies. Eighteen questions on the constructs such as Management commitment (MC), Customer Coordination (CC), Sustainable Design & Production (SDP), Green procurement (GP) and Eco Logistics (EL) are developed. The survey was sent to the medium and small organizations of Andhra Pradesh. The survey was addressed to personnel involving purchasing, production, marketing & sales, logistic providers with mailing and personal contacts,

Respondents were asked to rate each item under a five-point Likert-type scale (e.g. 1 = not at all important, 2 = not important, 3 = moderate, 4 = important, 5 = extremely important) to indicate the extent to which each item was practiced in their respective organization. This investigation focused on sampling the perceptions and experiences of SSCM-based companies in the local small & medium scale industries. Data collection involved distributing questionnaires involved in firms. Target respondents were selected from among the garment industries, bottling companies, engineering industries electronic industries, automotive industries etc.. Questionnaires were addressed to the senior executives of the target organizations. This was done because most of the sample companies do not have SSCM representatives or departments. A total of **300** questionnaires were mailed out and **87**

were returned, of which 84 were valid, representing a response rate of 28%. According to the study on development and validation of critical factors and environmental management, its response rate is **21.9%** (Wee and Quazi, 2005). Furthermore, Antony *et al.* (2002) also pointed out that their research got **16.5%**, which was normal and reasonable. This implies that the response rate of this study is acceptable and it reflects the virtue of novel issue of the SSCM practice.

The authors utilized confirmatory factor analysis to identify the dimensions under the specified constructs.

3.2 Descriptive Statistics

Table 1 represents the characteristics of the responding companies as well as respondents' job title and work experience. Respondents' job titles ranged from the employee in charge of GSCM to top executives. Middle (51.1%) and senior (27.8%) managers were the most frequently reported job titles in charge of SSCM. This result can be seen that the SSCM practices often require the supervisions of middle-level or higher-level management team and also these SME supplier firms show their will to succeed in keeping up the SSCM practice. In addition, majority of the respondents (83.9%) have worked less than 10 years. One thing needed to be pointed out is that the

Question on the work experience was not clear whether it asks work experience in the industry or only in the current company. Hence, it is possible that many of the respondents with work experience less than 5 years may have longer career in the industry.

Table 1. Characteristics of the responding companies

Feature	Category	Frequency	Percentage (%)
Managerial Level	Top executives	63	21
	Managers	92	31
	Employee in charge	145	48
Type of Industry	Garment	58	19
	Engineering	47	16
	Process	88	29
	Automobile	46	15
	electronics	61	20
Size of the Firm	<50	122	41
	50-100	119	40
	100-200	59	20
Customer Type	Retailer	78	26
	Bulk Manufacturer	72	24
	Distributor	63	21
	Customer direct	87	29

Analysis of Reliability and Validity

The study tested the measurement properties of the constructs by confirmatory factor analysis. CFA was used to evaluate how well the measurement items reflect latent variables in the hypothesized structure, due to the fact that this study is based on the theoretical basis from the previous research. Average Variance Extracted of each latent variable was more than 0.5 which showed that latent variables had reasonable reliability and convergence validity. The data of Average Variance Extracted (AVE) of Squared Multiple Correlation (SMC), Construct Reliability (CR) and latent variables are presented in Table 2. The above overall propriety test of measurement model and reliability and validity analytical results showed that 18 questions of sustainable Supply chain implementation in this research could actually efficiently measure the criticality of sustainable supply chain management activities.

The fit indices of the structure model of confirmatory factor analysis are shown in table 3. The value of $\chi^2/d.f$ is 3.9 indicates the close fit of the model. As to the propriety of model, GFI value was 0.82, AGFI was 0.74, CFI was 0.94 indicates the moderately close fit. Therefore, there were enough evidences to accept all the propositions (Ha, Hb...He) were supported.

It is an established fact that root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR) are also measures for model fitness. SRMR values less than 0.08 and RMSEA values less than 0.06 imply very good models (Brown, 2006; Hu and Bentler, 1999). The values of RMSEA (0.106) and SRMR (0.047) obtained in the study indicates the satisfactory fitness of the model. Therefore, the measurement model of these sustainable supply chain management activities suggesting a reasonably acceptable fit to the data.

Table 2. Reliability and validity analytical results of measurement model

Latent Variable	Item	Standardized Factor Loadings	Error	Composite Reliability (C R)	AVE
Management Commitment (MC)	MC1	0.83	0.31	0.8400	0.5700
	MC2	0.8	0.37		
	MC3	0.7	0.5		
	MC4	0.69	0.52		
CUSTOMER COORDINATION (CC)	CC1	0.8	0.36	0.8200	0.6000
	CC2	0.67	0.55		
	CC3	0.85	0.28		
SUSTAINABLE DESIGN & PRODUCTION (SDP)	SDP1	0.9	0.19	0.9000	0.6900
	SDP2	0.9	0.19		
	SDP3	0.76	0.42		
	SDP4	0.76	0.43		
GREEN PROCUREMENT (G S)	GS1	0.97	0.05	0.9400	0.8600
	GS2	0.93	0.14		
	GS3	0.98	0.03		
	GS4	0.81	0.35		
ECO-LOGISTICS (E L)	EL1	0.96	0.07	0.9300	0.8200
	EL2	0.84	0.29		
	EL3	0.91	0.17		

Table 3. Fit indices of structure model

	Propriety Indicators	Ideal Figures (Bagozzi and Yi, Y, 1988)	Research Findings
Absolute Propriety Indicators	$\chi^2/d.f$	1.0 - 3.0	3.90
	GFI	>0.90	0.82
	AGFI	>0.90	0.74
	SRMR	≤0.05	0.04
	RMSEA	≤0.08	0.106
Relative Propriety Indicators	NNFI	≥0.90	0.96
	NFI	≥0.90	0.96
	CFI	≥0.90	0.94

4. Conclusion

The path loadings of items of management commitment, customer coordination,

sustainable design & production, green procurement and eco-logistics are above 0.7 and are significant for design requirements of leAgile supply chain suggesting that these

areas are dimensions of above constructs. Hence, this study suggested that the five factor model with 18 items of design requirements of leAgile supply chain had a good fit. It is a valid and reliability measurement to identify items of design requirements of leAgile supply chain. The present findings provide evidence to support

that this is a valid instrument to determine strategic design requirements among the organizations implementing lean and agile supply chains. This study can be extended to identify sensitivity of the factors and their relative weights basing on the dimensions of the respective constructs.

References:

- Antony, J., Leung, K., Knowles, G., & Gosh, S. (2002). Critical success factors of TQM implementation in Hong Kong industrials. *International Journal of Quality & Reliability Management*, 19(5), 551-566.
- Bowen, F. E., Cousine, P. D., Lamming, R. C., & Faruk, A. C. (2001). Explaining the gap between the theory and practice of green supply. *Greener Management International*, 35, 41-59.
- Boysere, J., & Beard, A. (2006). Halogen-free laminates: worldwide trend, driving forces and current Status. *Circuit World*, 32(2), 8-11.
- Brown, T. (2006). *Confirmatory factor analysis for applied research*. New York, NJ: Guilford Press.
- Evans, H., & Johnson, J. (2005). 10 Steps toward RoHS directive compliance. *Circuits Assembly*, 16, 68-70.
- Gonzalez-Benito, J. (2008). The effect of manufacturing pro-activity on environmental management: An exploratory analysis. *International Journal of Production Research*, 46(24), 7017-7038.
- Hsu, C. W., & Hu, A. H. (2008). Green supply chain management in the electronic industry. *International journal of environmental science and technology*, 5(2), 205-216.
- Hu, L., & Bentler, P. (1999). Cutoff criteria for fit indices in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 6, 1-55.
- Huang, J. (2005). The ministry of economic affairs establishes a RoHS service corps to help the electrical and electronic industries build green supply chains. *Taiwan Cleaner Production Newsletter*, 1(1), 2-3.
- Lamming, R., & Hampson, J. (1996). The environment as a supply chain management issue. *British Journal of Management*, 7(Specialissue 1), 45-62.
- Lippmann, S. (1999). Supply chain environmental management: elements of success. *Corporate Environmental Strategy*, 6(2), 175-182.
- Rao, P. (2002). Greening the supply chain a new initiative in south East Asia. *International Journal of Operations & Production Management*, 22(6), 632-655.
- Rao, P., & Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance? *International Journal of Operations & Production Management*., 25(9), 898-916.
- Saaty, T. L. (1980). *The Analytic Hierarchy Process*. New York: McGraw-Hill.

- Sharma, A., Garg, D., & Agarwal A. (2012). Quality management in supply chains: The literature review. *International Journal for Quality Research*, 6(3), 193-206.
- Sheu, J. B., Chou, Y. H., & Hu, C. C. (2005). An integrated logistics operational model for green- supply chain management. *Transportation Research*, 41(4), 287-313.
- Tabachnick, B. G., & Fidell, L. S. (1989). *Using multivariate statistic*. London: HarperCollins.
- US-AEP, Supply chain environmental management lessons for leader in the electronic Industry. Clean Technology Environmental Management (CTEM) Program, 1999. US-Asia Environmental Partnership.
- Wee, Y. S., & Quazi, H. A. (2005). Development and validation of critical factors of environmental Management. *Industrial Management & Data Systems*, 105(1), 96-114.
- Yuang, A., & Kielkiewicz-Yuang, A. (2001). Sustainable supply network management. *Corporate Environmental Strategy*, 8(3), 260-268.
- Zhu, O., Sarkis, J., & Geng, Y. (2005). Green supply chain management in china: pressures, practices and performance. *International Journal of Operations & Production Management*, 25(5), 449-468.
- Zhu, Q., & Sarkis, J. (2006). An inter-sectoral comparison of green supply chain management in China: Drivers and practices. *Journal of Cleaner Production*, 14(5), 472-486.
- Zhu, Q., & Sarkis, J. (2007). The moderating effects of institutional pressures on emergent green supply chain practices and performance. *International Journal of Production Research*, 45(18-19), 4333-4355.
- Zhu, Q., Sarkis, J., & Lai, K. (2008). Confirmation of a measurement model for green Supply chain management practices implementation. *International Journal of Production Economics*, 111, 261-273.
- Zsidisin, G. A., & Siferd, S. P. (2001). Environmental purchasing: a framework for theory development. *European Journal of Purchasing & Supply Management*, 7(1), 61-73.

V. Narasimham

Andhra University,
Department Of Mechanical
Engineering,
India
narasimham_v@yahoo.com

K. Venkatasubbaiah

Andhra University,
Department Of Mechanical
Engineering,
India
drkvsau@yahoo.co.in

P. S. Avadhani

Andhra University,
Department Of Computer
Science & System
Engineering,
India
psavadhani@yahoo.com
