An Empirical Study on The Impact of Environmental Uncertainty on The Lean Practices of Small Manufacturing Firms - A Supply Chain Perspective

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Abstract

Supply chain management is the buzz word in today's business world. All efforts are being made to improve supply chain, practices so that the chain can be well integrated. This is the only way the firms can jointly respond to the whims and fancies of the final customer. This research. Paper is a study of the impact of logistics practices of small manufacturing firmson the integration of the supply chain. The scope of the research is the small manufacturing industries in Coimbatore district. A sample of 75 firms has been selected from a list of 792 firms who are members of Coimbatore District Small Scale Industries Association of India. The environmental uncertainty and the lean practices of these firms have been measured using instruments that have already been validated in similar research papers. Structural equation modeling has been used to empirically validate the hypothesis proposed in the paper. This is one of the first research initiatives on empirical testing of supply chain models in Indian scenario. The reliability of the constructs has been. tested using SPSS package (resulting in purified scales) and the validities have been tested using Visual PLS package. The hypothesis proposed that environmental uncertainty influences the lean practices of a firm has been validated using Visual PLS package. This paper goes a long way in emphasizing the impact of environmental uncertainty on the lean practices followed by small manufacturing firms.

Introduction

Supply chain initiatives over the last decade, while frustrating at times, have proved enormously beneficial to businesses; the most successful innovators viewed the supply chain as a strategic tool for changing the rules of the game (Anderson, J. C. And Narus, J.A.1990). As a result, supply chain management and shareholder value are closely linked, and supply chain management will continue to have a major role in corporate success.

Barratt, M.(2004) defines supply chain as network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and distribution of these finished products to customers. Balsmeier and Voisin (1996) states that supply chains

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exist in both service and manufacturing organizations, although the complexity of the chain may vary greatly from industry to industry, and from firm to firm.

In the 1990s, business leaders were inundated with new supply chain initiatives—from just-in-time inventory management to collaborative product commerce (Anderson, J. C. And Narus, J.A.1990). Most of those programs were well conceived, but their complexity and misalignment with corporate operating models often produced conflicts, delays, and sub optimal results. Other times, competing or overlapping agendas led to inflated budgets and project terminations, leaving executives exhausted and discouraged.

During the same decade, however, supply chain programs saved thousands of companies billions of dollars. Successful initiatives made it possible for companies to meet customer needs more quickly, less expensively, and through more channels, better-quality, more-reliable goods also reached the market sooner. And for the first time, mass-customized products and services became a reality. (Anderson, J. C. And Narus, J.A.1990)

Davis (1993) explains that today's ultra competitive world of short product life cycles, complex corporate joint ventures, and stiffening requirements of customers; it becomes necessary to consider the complete scope of supply chain management in the manufacturing sector. He further adds that successful businesses will need better visibility into their supply chains, they must be better at collaborating with suppliers to meet customer demands. Suppliers will be asked to react quickly to changes in the business environment and perform at higher levels than ever before.

Therefore to achieve optimal performance levels, manufacturers and distributors must have applications to help them communicate and collaborate efficiently, across the entire supply chain. Industries like electronics — with fragmented supplier communities and outsourced manufacturing—need supply chain applications that provide better visibility over multi tiered supply chain operations. Right now, this is not being managed efficiently; research firms estimate that there are trillions of dollars lost to supply chain inefficiencies. (Banfield, E. 1999)

"A supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers and customers themselves".

From the above definitions and discussions the supply chain definition given by Chopra *et al*, (2001) gives the good explanation of what a supply chain is, and a definition derived from all the above and closer to the ones of Chopra *et al*, (2001). According to this research defines supply chain as the chain of suppliers, manufacturers, wholesalers, distributors and stores that enable a product to be made, sold and delivered to the end user.

Environmental Uncertainty

Environmental uncertainty means those events and variables that have a random and unpredictable variation, impacting the very existence of a business (Lenz, 1980; Turner, 1993). Today's markets are becoming hyper competitive and include players from all corners of the globe who are increasingly more demanding in their requirements (Thomas and Griffin, 1996), product life cycles are getting compressed and new manufacturing technologies are cropping up (Krause et al., 1998). This has resulted in the great outsourcing wave (Krause et al., 1998; Ellram, 1990; Fliedner and Vokurka, 1997). Environmental Uncertainty has become the major force impacting the supply chain.

Most of Environmental Uncertainty research is based on the work of Aldrich (1979). Aldrich proposes five sub dimensions of environmental uncertainty- 1) capacity, 2) homogeneity-heterogeneity, 3) stability- instability, 4) concentration-dispersion, and 5) turbulence. A later work by Achrol and Stern (1988), Paswan et al. (1998) came up with four sub dimensions-diversity (among consumers), dynamism, concentration, and capability. Still later works by Milliken (1987) and Oswald et al. (1997) classified environmental uncertainty into seven sub dimensions-stable-turbulent, simple-complex, predictable-unpredictable, static-dynamic, non-threatening- threatening, exciting-dull, and certain-uncertain

Some researchers classify uncertainty on the basis of the source of the uncertainty. Miller and Droge (1986) have classified uncertainty into the following five sub dimensions - volatility in marketing practices, product obsolescence rate, unpredictability of competitors, unpredictability of demands and tastes, and change in production or service modes. Gupta & Wilemon (1990) proposed four uncertainty factors- 1) increased global competition, 2) continuous development of new technologies that quickly cause existing products to be obsolete, 3) changing customer demand needs and requirements which truncate product life cycles, and 4) increasing need for involvement of external organizations such as suppliers and customers. Ettlie & Reza (1992) and Zhang's (2001) envision uncertainty as unexpected changes in customers, suppliers, competitors, and technology.

Lean System is the practice of improving productivity to enable a reduction in inventories across in the plant and hence across the supply chain. Lean implies minimum input and maximum output. Lean involves the elimination of seven types of wastes from the entire supply chain (Taylor, 1999). Womack and Jones (1996) identified five principles of waste elimination in organizations. This was extended by Taylor (1999) to include the supply chain. These five principles are : 1) understand what creates value from customer' s point of view; 2) identify the activities which are necessary to deliver that value across the whole supply chain-the value stream; 3) make value by eliminating waste between value-adding activities and within value-adding activities; 4) only make, or move, what is pulled by the customers and not what production units choose to make and push into the supply pipeline; 5) strive for perfection not only in terms of product quality but also in the physical process, information systems, and management which constitute supply chain activity. Lean thinking is vital in SCM. A prominent example is Wal-Mart who personally visits suppliers' premises to examine every element of their production process and cut wastes to minimize cost of production, so that they can supply at the lowest costs to their customers

Theoretical Framework and Hypothesis

Uncertainty in the environment will affect the ability of a firm to work properly. Constantly changing customer needs, supplier schedules, etc will affect the ability of the firm to schedule and deliver products. To offset any uncertainty, firms must start shedding unwanted fat in the form of inventory. Only a lean operating environment will remove the flab from organizations. If the firms are to survive in a highly dynamic environment, they must follow lean practices in their manufacturing activities. This leads us to the following hypothesis

H1: The higher the environmental uncertainty of a firm, the greater will be the lean practices used by the firm.

Data collection methodology and instrument administered

The instrument consisted of two constructs environmental uncertainty and lean practicesThe lean practices construct was measured using an already validated instrument developed by Suhong Li (2002). The environmental uncertainty construct was measured using an already validated instrument developed by Aldrich (1979)

A list of manufacturing firms was obtained from Coimbatore District Small Scale Industries Association (CODISSIA). Companies with less than 100 employees were considered. The resultant list contained 792 firms. A random sample of 75 firms was requested to fill in the questionnaire

Analysis Methodology

After the data is collected the scales are analysed to achieve the following objectives-Purification of scales, reliability of scales, unidimentionality of scales and validity of the scales. Purification is one using Corrected Item Total Correlation (CITC), Reliability is tested using Cronbach's alpha, Validity and unidimentionality are tested using PLS Path modeling.

Before any type of factor analysis is done (EFA or CFA), it is essential to purify the measuring instruments of variables that do not correlate to the constructs (Churchill 1979). Purification is carried out by inspecting the CITC values of each variable with respect to the construct to which it belongs. CITC indicates whether the variable actually belongs to the construct or not. Variables showing scores lower then 0.5 are deleted, unless there is a compelling reason to keep them in the construct. Some items with CITC values over 0.5 can also be removed if the overall reliability of the construct in question improves as a result of the deletion (Obtained by checking the "alpha if deleted" scores).

Reliability of constructs refers to the accuracy with which the constructs repeatedly measure the same phenomenon without much variation. The reliability of each construct in question was examined using Cronbach's alpha (Cronbach, 1951). An alpha score larger then 0.7 is generally acceptable as sufficient accuracy for a construct (Nunnally 1978). After purifying the constructs one by one, we arrive at purified scales for the constructs. Each construct should display sufficient reliability before being used in a structural equation model.

Unidimentionality is a common trait exhibited by all the indicator variables of any given construct (McDonald, 1981; Hattie, 1985). Unidimentionality is best measured by Confirmatory Factor Analysis (CFA). A combination of CFA and path analysis is Structural Equation Modelling. This is the best method of measuring the unidimentionality of any construct. In this research we will use structural equation modeling to test the unidimentionality of the constructs. There are two approaches to structural equation modeling- Covariance methods and PLS path modeling. Covariance methods make rigid assumptions about the distribution of variables (multivariate normality) and the sample size (at least 200). Another criterion is the degrees of freedom, which means that each construct should have at least three indicators for it to be identified. This makes them unsuitable to use in this research. PLS methods on the other hand are non parametric in nature. They do not make any assumptions about the distribution of the data and the sample size needed is much smaller for model validation and testing (five to ten times the largest number of indicators/construct in the model). The convergent validity of each construct is checked by examining the "Average variance extracted (AVE)" values. Constructs which have AVE values greater than 0.5 are said to have convergent validity or unidimentionality. In some cases values upto 0.4 are also considered if they are central to the model (Chin W W 1995, Chin et al 2003, Chin W W 1998, Chin et al 1999)

The following section will present the large scale validation results on each of the constructs- environmental uncertainty and lean practices. For each construct the instrument assessment methodology described above has been applied.

Measurement results

Environmental Uncertainty

The environmental uncertainty construct was initially represented by 18 variable indicators. The analysis began with purification using CITC values. The

CITC values corresponding to each variable are shown in table 1. At the end of the purification process 11 variables are left (shown in table 1). All except one variable have CITC values greater than 0.5. The resulting reliability of the dimension is 0.9313. The indicator variables left out are unpredictable customer needs, changing customer product preferences, unpredictable supplier engineering level, unpredictable supplier product quality, competition from different industries and competition from different countries. Unpredictable customer needs and changing customer preferences seem to be out of the final list because the number of products produced by the manufacturers is very few in number. Unpredictable supplier engineering level seems to be out because the suppliers to these companies are supplying low tech products to these companies and do not need high degree of technology. Unpredictable supplier quality seems to be out because the quality supplied may be adequate for the industries. Competition from other industries seems to be out because these are niche players. Competition from foreign players seems to be out because the scale of operation of these companies does not warrant international competition. The unidimentionality of the construct is tested in VisualPLS by considering the AVE value. The results are tabulated in table 5. The AVE value of 0.659611 (shown in table.5) shows a good convergent validity and hence unidimentionality for the construct.

Table 1 Environmental Uncertainty Purification

	CITC	
	1	2
Customers' needs are unpredictable	0.3839	
Customers' requirements regarding product features are difficult to forecast	0.9027	0.8886
Customers order different product combinations over the year	0.166	
Customers' product preferences change over the year	0.3935	
The properties of materials from suppliers can vary greatly within the same batch	0.6365	0.6948
Suppliers' engineering level is unpredictable	-0.4818	
Suppliers' product quality is unpredictable	-0.9596	
Suppliers' delivery time can easily go wrong	0.942	0.9635
Suppliers' delivery quantity can easily go wrong	0.7984	0.8018
Competitors' actions are unpredictable	0.7577	0.821
Competition is intensified in our industry	0.5761	0.6055

Competitors are from different industries	0.14	
Competitors are from different countries	0.3075	
Competitors often introduce new product unexpectedly	0.5196	0.4985
Technology is changing significantly in our industry	0.6542	0.6944
Technological changes provide opportunities for enhancing competitive advantage inour industry	0.916	0.9655
Technological breakthrough results in many new product ideas in our industry	0.6438	0.6488
Improving technology generates new products frequently in our industry	0.5413	0.5724
Cronbach's alpha	0.8012	0.9313

Table 2 Environmental Uncertainty Final Measurement Scale

Customers' requirements regarding product features are difficult to forecast	
The properties of materials from suppliers can vary greatly within the same batch	
Suppliers' delivery time can easily go wrong	
Suppliers' delivery quantity can easily go wrong	
Competitors' actions are unpredictable	
Competition is intensified in our industry	
Competitors often introduce new product unexpectedly	ALPHA=0.9313
Technology is changing significantly in our industry	
Technological changes provide opportunities for enhancing competitive advantage in our industry	
Technological breakthrough results in many new product ideas in our industry	
Improving technology generates new products frequently in our industry	

Lean Practices construct was purified using CITC values (shown in table 3). The purified construct has six indicators. three indicators are left out. The first indicator left out is pushing suppliers for shorter lead times. This could be due to the fact that small firms do not have the financial muscle to push large suppliers for shorter lead times. The second casualty is the proximity of suppliers. Small firms often do not have the choice of asking suppliers to locate near them. It is they who have to locate near their customers. The third casualty is the reduction of inspection activities on outbound materials. This is possible only if there is a companywide maturing lean program. Small firms are far from achieving good lean practices, so reduction of final inspection is still to be achieved. All other indicators have CITC values greater than 0.6. The reliability score of the sub-construct is 0.924 showing very good reliability. The unidimentiality of the sub-construct is measured using Visual PLS. The sub-construct has an AVE score of 0.8272 showing good convergent validity and hence unidimentiality (shown in table 5)

Table 3 Lean Practices Purification

Lean Practices	CITC 1	CITC 2
Our firm pushes suppliers for shorter lead-times	0.4159	
Our firm has continuous quality improvement program	0.709	0.641
Our firm uses a “Pull” production system	0.7623	0.879
Our firm streamlines ordering, receiving and other paperwork from suppliers	0.927	0.9902
We involve customers in product and process design	0.7752	0.7861
Our suppliers’ factory/warehouses are located nearby	-0.0355	
We order in small lot sizes from our suppliers	0.9859	0.9501
Inspection of incoming materials/components/products has been reduced	0.8678	0.9344
Inspection of outbound materials has been reduced	0.2759	
Cronbach’s alpha	0.8591	0.924

Table 4 Lean Practices Final Measurement Scale

Our firm has continuous quality improvement program	ALPHA=0.924
Our firm uses a “Pull” production system	
Our firm streamlines ordering, receiving and other paperwork from suppliers	
We involve customers in product and process design	
We order in small lot sizes from our suppliers	
Inspection of incoming materials/components/products has been reduced	

Table 5 Validity of constructs (AVE scores)

Construct	AVE
Environmental uncercertainty	0.659611
Lean practices	0.824928

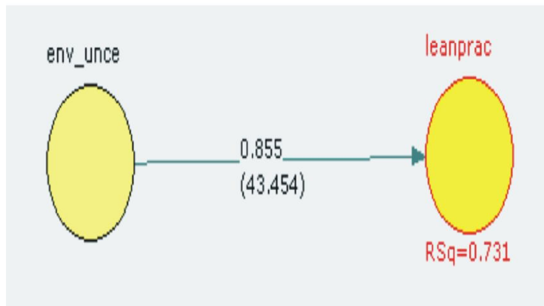
Causal Model and Hypothesis Test

A causal effect of environmental uncertainty on the lean practices of the firms is tested using Visual PLS path modeling software. A rigorous test of the significance of various proposed relations can be tested using the bootstrap function in Visual PLS. PLS path modeling is a non parametric method, and as such cannot be used for performing a t-test. But it is possible to use resampling methods (bootstrap and jack knife) to obtain the significance of the various paths in the model. Bootstrap is more reliable in estimating the significance of paths (Chin W W, 1995). So this research has considered and used bootstrap for the purpose of determining causal relations proposed in the model. In boot strap used in this research, random samples sized 75 (the respondent number) were taken, and 500 such samples were taken (to get best estimates a resample number of 500 is recommended although in theory an infinite resample is needed for the purpose). The Results were examined for significance. At 5% level of significance the cutoff t-statistic is 1.96. In general we assume that if the t-statistic is more than 2, the path is significant.

H1: The higher the environmental uncertainty of a firm, the greater will be the lean practices used by the firm

The hypothesis was found to be highly significant (beta= 0.855, t= 43.454). This proves our presumption that the environmental uncertainty of a firm has an impact on the supply chain integration of the firm. A high R Sq value of 0.731 indicates that environmental uncertainty has a high negative impact on the supply chain integration of the firm.

Model Tested



Implications and Summary

This research paper has identified, tested, purified and validated constructs for measuring environmental uncertainty and lean practices of small manufacturing firms. This paper has also validated the impact of environmental uncertainty on lean practices of a small manufacturing firm. The uncertainty of the environment is found to have a positive impact on the lean practices of firms. This could be because firms learn to use lean practices in order to survive during uncertain times. The implication of this finding for manufacturing firms is that if they are to survive in uncertain times, they should start some form lean practices in their organization.

Keywords Used

Average variance extracted	Indicators
Bootstrap	Information Quality
CODISSIA	Just in time
Construct Validity	Lean practices
Construct Reliabilidity	PLS Path modeling
Corrected Item total correlation (CITC)	Purified scale
Cronbach's alpha	Unidimentionality
Environmental Uncertainty	Visual PLS

References

- Achrol, R. S. and Stern, L. W. (1988), "Environmental Determinants of Decision-Making Uncertainty in Marketing Channels", Journal of Market Research, 25(1), pp.36-50
- Aldrich, H. E. (1979), Organizations and Environments, Prentice-Hall, Inc., Englewood Cliffs, NJ
- Anderson, J. C. And Narus, J.A.1990.A Model of Distributor Firm and Manufacturing Firm Working Partnership. *Journal of Marketing*, **54**(1), pp.42-58
- Balsmeier, P. W. and Voisin, W. (1996), "Supply Chain Management: a Time-Based Strategy", Industrial Management, 38(5), pp. 24-27
- Banfield, E. (1999), "Harnessing Value in the Supply Chain", John Wiley and Sons, New York, NY
- Chin, W. W. (1998). The partial least squares approach for structural equation modelling. In George A. Marcoulides (Ed.), Modern Methods for Business Research, Lawrence Erlbaum Associates
- Chin, W. W., and Newsted, P. R. (1999). Structural Equation Modeling analysis with Small Samples Using Partial Least Squares. In Rick Hoyle (Ed.), Statistical Strategies for Small Sample Research, Sage Publications.
- Chin, W. W. (1995). Partial Least Squares Is To LISREL As Principal Components Analysis Is To Common Factor Analysis. *Technology Studies*. *Technology Studies,* volume 2, issue 2, 315-319
- Chin, Wynne W. and Marcolin, Barbara L. and Newsted, Peter R., 2003, "A Partial Least Squares Latent Variable Modeling Approach for Measuring Interaction Effects. Results from a Monte Carlo Simulation Study and an Electronic-Mail Emotion / Adopion Study", Information Systems Research, volume 14, number 2, June. p 189-217
- Chopra, S. And Meindl, P. 2001. *Supply Chain Management: Strategy, Planning and Operations*, Upper Saddle River, NJ: Prentice-Hall, Inc

- Churchill, G. A. (1979), "A Paradigm for Developing Better Measures of Marketing Constructs", Journal of Marketing Studies, Vol.16, pp.12-27
- Cronbach, L. J. (1951), "Coefficient Alpha and Internal Structure of Tests", Psychometrika, 16, pp.297-334
- Davis, T. (1993), "Effective Supply Chain Management", Sloan Management Review, 34(4), pp.35-46
- Ellram, L. M. (1990), "The Supplier Selection Decision in Strategic Partnerships", Journal of Purchasing and Materials and Management, Fall, pp.8-14
- Ettlie, J. E. and Reza, E. M. (1992), "Organizational Integration and Process Innovation", Academy of Management Journal, 35(4), pp.795-827
- Fliedner, G. and Vokurka, R. J. (1997), "Agility: Competitive Weapon of the 1990's and Beyond", Production and Inventory Management Journal, 38(3), pp.19-24
- Gupta, A. K. and Wilemon, D. L. (1990), "Accelerating the Development of Technology-based New Products", California Management Review, 32(2), pp.24-44
- Krause, D. R., Handfield R. B., Scannel, T. V. (1998), " An Empirical Investigation of Supplier Development: Reactive and Strategic Processes", Journal of Operations Management, 17(1), pp.39-58
- Hattie, J. (1985), "Methodology Review: Assessing Unidimensionality of Tests and Items", Applied Psychological Measurement, 9, pp.139-164
- Lenz, R. T. (1980), "Environment, Strategy, Organization Structure and Performance: Patterns in One Industry", Strategic Management Journal, 1(3), pp.209-226
- Li, Suhong, 2002, An Integrated Model for Supply Chain Management Practice, Performance and Competitive Advantage, Doctoral Dissertation, University of Toledo, Toledo, OH
- McDonald, R. P. (1981), "The Dimensionality of Tests and Items", British Journal of Mathematical and Statistical Psychology, 34, pp.100-117
- Miller, D. and Droge, C. (1986), "Psychological and Traditional Determinants of Structure", Administrative Science Quarterly, 31(4), pp.539-560
- Milliken, F. J. (1987), "Three Types of Perceived Uncertainty about the Environment: State, Effect, and Response Uncertainty", Academy of Management Review, 12, pp.133-143
- Nunnally, J. C. (1978), Psychometric Theory, McCraw-Hill, New York, NY
- Oswald, S. L., Mossholder, K. W., and Harris, S. G. (1997), "Relations Between Strategic Involvement and Manager's Perceptions of Environment and Competitive Advantage Strengths", Group and Organization Management, 22(3), pp.343-365

- Paswan, A. K., Dant, R. P. and Lumpkin, J. R. (1998), " An Empirical Investigation of the Linkage among Relationalism, Environmental Uncertainty, and Bureaucratization", Journal of Business Research, 43(3), pp.125-140
- Taylor, D. H. (1999), "Supply Chain Improvement: the Lean Approach", Logistics Focus, Jan/Feb, pp.14-20.
- Thomas, D. and Griffin, P. M. (1996), "Coordinated Supply Chain Management", European Journal of operational Research, 94(1), pp.1-15
- Turner, J. R., (1993) "Integrated Supply Chain Management: What's Wrong with This Picture", Industrial Engineering, 25(12), pp. 52-55
- Womack, J. and Jones, D. (1996), Lean Thinking, New York, Simon and Schuster
- Zhang, Q. Y. (2001), Technology Infusion Enabled Value Chain Flexibility: a Learning and Capability-Based Perspective, Doctoral Dissertation, University of Toledo, Toledo, OH