Empirical Study

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MNE Financial Flexibility and Operational Performance: Evidence from Taiwan

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Abstract

This research constructs a framework to measure a multinational enterprise's financial flexibility containing three dimensions: (1) operational ability, (2) financing ability, and (3) liquidity ability. We then build a panel dataset of 100 information technology firms and 167 non-information technology firms in Taiwan during 1999-2003. Our major findings are as follows: (1) Export ratio, debts from foreign countries, spontaneous short-term debt ratio, and quick ratio have significantly positive effects on operational performance. (2) Foreign assets ratio has a significantly negative effect on operational performance. (3) Equity from foreign countries, mainland China investment, and external short-term debt ratio have no significant effects on operational performance.

Keywords: financing ability, liquidity ability, operational ability.

Introduction

With the international environment turning more competitive due to regulations of the World Trade Organization (WTO), multinational enterprises (MNEs) continue to seek suitable resources and low costs. Changes in the international operations have led to higher uncertainties for firms, and the risks undertaken by international enterprises are higher than those domestically (e.g., Vernon, 1985; Ghoshal, 1987; Miller and Bromiley, 1990; Werner et al., 1996). Therefore, when confronting a high and risky operational environment, MNEs must apply appropriate strategies that lower the fluctuations of profits and performance in order to achieve their operational goals.Flexibility is a necessary condition for MNEs to obtain advantages of degree of internationalization.

An MNE contains a network of activities located in different countries. Kogut and Kulatilaka (1994) suggest that the value of MNEs' networks drives from the opportunity to benefit and from uncertainty through the coordination of geographically-dispersed subsidiaries. In other words, the benefits from multinationality include the ownership of dispersed international operations that provide valuable operating flexibility through multinational coordination. Allen and Pantzalis (1996) find that returns to multinationality are maximized for firms with networks that are in a number of foreign countries in which the MNE has operations, but not when the concentration of foreign subsidiaries is in a few countries. Therefore, an increase in foreign subsidiaries may positively contribute to an MNE's operational performance.

MNEs have both advantages and disadvantages. Hymer (1976) notes that an MNE operates at a disadvantage relative to a domestic company since a foreign company needs to control operations over longer distances and it is at a handicap in a foreign culture. This implies that MNEs have to confront higher risks than domestic companies. Hence, flexibility is a necessary condition for MNEs to obtain advantages of degree of internationalization (DOI).

Flexibility has been discussed in the literature for a long period of time. Kogut (1985) writes that MNEs can utilize an international activity network to provide operational flexibility. MNEs need not only operating and product abilities, but also flexibility in order to achieve the maximum profit and minimum risk.

Buckley and Casson (1998) define flexibility as the ability to reallocate resources quickly and smoothly in response to changes. The larger the significance is for

flexibility, the larger the amplitude and frequency of change will be in the environment. They indicate that flexibility can effectively eliminate the fluctuation of operational performance caused by environment changes, and firms' strategies have to be flexible. The volatility of profit that would occur if the firm made no response to change summarizes the impact on the firm of any volatility in its environment.

Kuo et al. (2003) find that MNEs use flexibility to deal with any change to their operating environment, generating a positive contribution to their operation performance. This research thus assumes that MNEs should have sufficient financial flexibility before engaging in international activities. If MNEs had no sufficient financial flexibility, then they would not operate for very long.

This research proposes that MNEs have sufficient flexibility to deal with change in their business environments. Therefore, we adopt a DOI index to measure flexibility. Sullivan (1994) believes *measuring the* DOI with a linear combination of FSTS (Foreign Sales as a Percentage of Total Sales), FATA (Foreign Assets as a Percentage of Total Assets), OSTS (Overseas Subsidiaries as a Percentage of Total Subsidiaries), PDIO (Psychic Dispersion of International Operations), and TMIE (Top Managers' International Experience) can reduce the error that results from sample, systematic, and random biases. Therefore, this research follows a part of Sullivan's result to measure firms' level of internationalization.

Flexibility is a necessary condition for MNEs to obtain advantages of degree of internationalization.

Previous research focuses on the operating aspects of financial flexibility. A goal of this research is to build a framework containing operational and financial aspects and to explain how financial flexibility affects operational performance. Singh and Hodder (2000) define financial flexibility as the ability to shift income and/or tax shields between subsidiaries and discuss flexibility from the financial aspect. Our research proposes that financial flexibility is composed by both operational and financial decisions. Singh and Hodder (2000) find that MNEs use the liquidity of funds between subsidiaries located in different countries to increase their financial flexibility and lower the volatility of firm value. Our research takes various financing sources as key factors of a firm's financial flexibility and discusses what relationship between financial flexibility and operational performance. For operational performance indices, both return on assets (ROA) and return on equity (ROE) are used.

The globalization of capital markets has accelerated dramatically in the past years in Taiwan. An increasing number of firms have chosen to raise capital through global equity markets (e.g., GDRs) and Euro-convertible bonds. Foreign debt has several advantages such as improving a firm's international reputation, low cost of capital, and an increase in financial flexibility (e.g, Adhikari et al., 1991; Biddle and Saudagaran, 1991). There are also several benefits for a foreign equity issuer, including an enlarged investor base, an enhanced local market for shares, the opportunity to raise new capital, and a liquidity secondary market in other countries. Foreign financing sources hence can help improve financial flexibility.

Amihud and Mendelson (1986) propose the illiquidity premium hypothesis. It states that the market-observed expected return should be an increasing and concave function of liquidity (typically measured by the bid-ask spread). The intuition is that the present value of all future trading costs should be reflected in the security price. Since securities with wider bid-ask spreads involve higher trading costs, investors should demand higher rates of return for holding them. Therefore, a pair of otherwise identical securities differing only in liquidity should also differ in price. In summary, foreign financing sources can increase trade range and liquidity, hence having a positive influence on the firm's stock price and operational performance (e.g., Sanger and McConnell 1986; Dharan and Ikenberry, 1995).

The financing sources of firms can be categorized into short-term and long-term debts. Short-term debt is naturally more flexibility. Enrica and Antonio (2004) use a standard model of optimal borrowing without creditor runs, finding a significantly positive relation between short-term and financial crises. This means that a large amount of short-term debt is a fundamental source of financial fragility. On the other hand, Rodrik and Velasco (2000) show that the ratio of short-term debt to reserves helps predict large reversals of capital cash flow. Although the short-term debt ratio may increase operational risk, it does provide sufficient liquidity for firms. Buch and Lusinyan (2003) show that the share of short-term debt is positively related to GDP per capita and to the size of the financial system of the recipient country. Moreover, economic development has a significantly positive effect on the share of short-term debt due to lower costs from rolling over short-debt debt. Diamond and Rajan (2000) suggest that short-term debt can play a beneficial role in improving an enterprise's operational performance.

In the research of working capital, short-term debt plays a role to provide liquidity and flexibility. Working capital is equal to current assets minus current liability. Firms with sufficient working capital have advantages such as paying expenditures by cash easily, being regarded as having a high credit rating, and getting financing from financial institutions easily. In the other hand, firms with too much working capital will decrease investing opportunities and then low return on investment. Short-term debt is one part of current liability. It means that firms using higher short-term debt will decrease working capital and then increase their efficiency to use funds.

This research distinguishes short-term debt into two parts. One is spontaneous short-term debt and the other is external

short-term debt. Spontaneous short-term debt includes accounts payable, notes payable, advance receipts, and tax payable. Higher spontaneous short-term debt implies that firms will not pay cash in the short term and hence firms increase their efficiency to use funds. External short-term debt includes short-term liability, commercial paper, and acceptance bills. Higher external short-term debt implies that firms have a higher ability to collect funds.

Although too a high short-term debt ratio is likely to cause financial crises, it also helps to provide sufficient liquidity for firms. There is no explicit conclusion in previous research about short-term debt and operational performance. Therefore, the short-term debt ratio is an interesting factor to discuss.

A firm's ability to switch assets to cash indicates financial flexibility. Davis and Peles (1993) find that high liquidity for a company's assets helps stabilize its net values when facing external shocks. Liquidity is indeed an important concern of management. If firms have insufficient current assets to satisfy current liabilities as they come due, then firms may be forced into bankruptcy. If the current or quick ratio decreases dramatically, then managers must take measures to ensure that future cash flows are available to pay current liabilities as they mature. The currency and quick ratios hence become a financial flexibility index.

An MNE runs business in a more volatile environment and hence needs to increase its financial flexibility to improve operational performance.

Previous researches of flexibility focus on operational or financial decision. The goal of this research is to combine three dimensions and find out how the financial flexibility affects firms' operational performance. The definition of financial flexibility in this research is firms' financial ability to hurdle past sudden changes. Financial flexibility is composed of three dimensions: DOI, financing sources, and liquidity ability. This research examines how these variables of financial flexibility affect operational performance. This research also compares the result of different industries.

This research is organized as follows: Section 1 introduces the background and motivation at first, defines what financial flexibility is, and describes framework and process of this research. Section 2 provides a framework for measuring financial flexibility and proposes three hypotheses in this section. Section 3 describes data sources, definition of variables, and the empirical model. Section 4 presents descriptive statistic analysis, empirical results, and discussion. Section 5 concludes this paper and proposes future research.

A Framework for Measuring Financial Flexibility

By reviewing existing studies, this research constructs a framework to measure an MNE's financial flexibility as Figure 1 shows. Financial flexibility can be decomposed into three domains: globalization ability, financing ability, and liquidity ability.

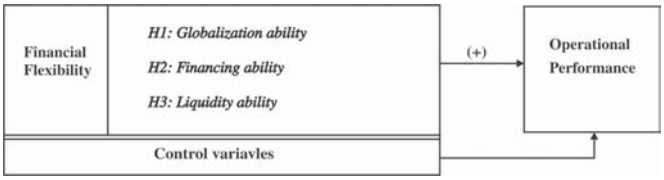

Figure 1: A Framework for Financial Flexibility and Operational Performance

Globalization Ability

First, the international diffusion of modern production technology has increased the number of industrial powers. It has hence increased the number of countries in which political and social disturbances can significantly impact global supplies of manufactured products. Liberalization of trade and capital markets makes the ripple effects of shocks travel farther and wider than in the past.

A much wider range of disturbances than ever before now affects any domestic market in the world. Every subsidiary of an MNE experiences a multiplicity of shocks from around the world. The shocks come from new sources of import competition and new competitive threats in export markets. While most shocks reveal themselves to firms as competitive threats, new opportunities for cooperation may sometimes be presented as well.

In order to conform to internationalization, MNEs should have the operating ability to deal with changes in their business environment (Kogut and Kulatilaka, 1994; Tannous, 1996; Buckley and Casson, 1998). Therefore, this research proposes that DOI is an operational ability for a MNE. Thus, there is an indirect relationship between DOI and operational performance (Hymer, 1976), and financial flexibility has a positive influence on MNEs' operational performance.

The existing literature has used some variables and approaches to measure a firm's DOI (Sullivan, 1994). Previous research on DOI has different results: DOI may have a positive, negative, U-shape, or inverted U-shape relationship with operational performance.

This research suggests that MNEs with a higher DOI will have a higher financial flexibility to use funds to increase operational performance. Hence, operational ability has a positive influence on MNEs' operational performance. We choose the following variables of financial flexibility to measure the DOI of MNEs and present the operational ability. Three hypotheses about operational performance are also proposed.

The first variable to measure DOI is ESTS. The index FSTS is used by many researchers for measuring DOI (Vernon, 1971; Grant, 1987). They all indicate that FSTS has a positive influence on firms' operational performance.

However, Tallman and Lu (1996) believe that an enterprise's export and sales by its foreign subsidiaries cannot be measured by FSTS. This paper adopts ESTS (Export Sales as a Percentage of Total Sales) to replace FSTS. Hence, we propose that ESTS has a significantly positive influence on MNE's operational performance.

The second variable to measure DOI is FATA. Daniels and Bracker (1989) indicate that performance improves significantly when FSTS and FATA are increased to 50%. While not a significant association, the performance seems to fall when FSTS and FATA increase beyond this threshold. It is difficult to calculate the sales amounts of foreign subsidiaries, because these are not disclosed in financial reports. This research assumes OSTS has a high relation with FATA. Therefore, the OSTS variable is omitted. Because we focus on the financial aspect, the DOI index of Sullivan's result such as TIME and PDIO will not be considered. We then propose that FATA has a positive influence on MNE's operational performance.

The third variable to measure DOI is MCTA (Investment in mainland China as a percentage of total assets). In the case of Taiwan, MNEs' DOI should consider investing in mainland China. The 1999 census from the *Chung Hua Institute for Economic Research* shows that the reason to invest in mainland China includes sufficient labor sources, cheap land, tax advantages, and a large-scale market. According to the statistics of the Investment Commission of the Ministry of Economics Affairs, investment into mainland China from Taiwan is increasing in both the number of cases and their amounts.

The short-term debt is a better index for financing ability than the long-run debt.

From 1999 to 2003, the annual investment flow into mainland China from Taiwan went up from 488 to 1,387 cases and from 1.252780 billion USD to 4.594985 billion USD. Therefore, mainland China investment is an important index to measure DOI. Therefore, investment into mainland China should be a DOI index for the case of Taiwan. This research hypothesizes that MCTA has a positive influence on MNEs' operational performance.

In summary, DOI is a part of variables to explain financial flexibility. This research hypothesizes that DOI has positive influence on MNEs' operational performance. Then, we expect that the three variables should have positive contribution to MNEs' profitability.

Financing Ability

The second dimension of financial flexibility is financing ability. Singh and Hodder (2000) suggest that multinational firms can make facility investment decisions without tax rate differences across countries as a primary consideration. Financing sources are categorized by two ways: One is the term of the loan and the other is the origin of the loan. Short-term and foreign financing sources are more flexible than long-term and domestic financing sources (Allayannis et al., 2003; Enrica and Antonio, 2004). This research collects flexibly financing sources to represent the financial flexibility of MNEs.

Short-term debt provides liquidity for funds. If firms use short-term debt properly, then they will get more investment opportunities. Hence, this research proposes that different financing sources have a positive influence on MNEs' operational performance.

Investors require a higher return when securities have low liquidity (Amihud and Mendelson, 1986; Brennan and Subrahmanyam, 1996; and Datar et al., 1998). MNEs use foreign funds to lower their financing cost and increase their financial flexibility. Then, this research thus proposes that foreign financing sources will have a positive influence on MNEs' operational performance. Therefore, financing ability has a positive influence on MNE's operational performance. This research adopts four variables to measure the financing ability of firms.

The first variable to measure financing ability is that firms use equity from foreign countries. Similar to debt from foreign countries, GDRs are popular financing sources for MNEs. For the example of GDRs, almost all non-U.S. companies that list their shares on U.S. exchanges do so by creating GDRs. GDRs were developed by JP Morgan in 1927 as an instrument for investors to register and earn dividends on non-U.S. stock without direct access to the overseas market itself. Investors therefore bear all currency risk and indirectly pay fees to the depositary bank. There are advantages to GDRs for issuers, including an enlarged investor base, an enhanced local market for shares, an opportunity to raise new capital, and a liquid secondary market in the United States or other developed countries. No doubt firms using equity from foreign countries will improve their financial flexibility. This research proposes that equity from foreign countries has a positive influence on MNEs' operational performance.

The second variable to measure financing ability is that firms use debt from foreign countries. Due to the liberalization of capital markets and the internationalization of firms' operations, governments initiate regulations of financial markets to open them up to public access. Debt from foreign countries becomes one of the more important financing tools for firms. Adhidari et al. (1991) and Biddle and Saudagaran (1991) indicate that firms collecting debt from foreign countries have several reasons for doing so, such as improving their international presence, lowering financing costs, and having more flexibly in using funds. This research proposes that debt from foreign countries has a positive influence on MNEs' operational performance.

The third variable to measure financing ability is that firms use spontaneous short-term debt. Spontaneous short-term debt includes accounts payable, notes payable, advance receipts, and tax payable, which are different kinds of 'trade credit'. They are a trade credit without any cost if firms pay expenses in the limited time. If firms use spontaneous

short-term debt appropriately, then the benefit from trade credit will higher than the market return. Besley and Osteryoung (1985) indicate that 90% products of 87% firms are sold by trade credit in a sample of 1982. Hence, spontaneous short-term debt is an important source of financing. This research proposes that spontaneous short-term debt will have a positive influence on MNEs' operational performance.

The fourth variable to measure financing ability is that firms use external short-term debt. External short-term debt includes short-term liability, commercial paper, and acceptance bills. Calomiris et al. (1994) indicate that high credit quality is a requirement for entry into the commercial paper market, but long-term credit quality (bond rating) is not a sufficient statistic for short-term quality. These characteristics allow firms to issue nearly riskless short-term debt and supply a near-money asset to the market, thereby reducing their interest costs by the amount of the commercial paper's liquidity premium. Calomiris et al. (1994) suggest three explanations for using external short-term debt such as commercial paper. First, firms of high credit quality can use commercial paper to finance inventory accumulation during downturns. Second, they also can use commercial papers to finance counter-cyclical increases in receivable accounts. This suggests that commercial paper issuers serve as intermediaries for other firms during downturns. Third, it may be that portfolio demand for commercial papers, which is a highly liquid and safe asset, increases during downturns.

The liquidity ability affects an MNE's flexibility to change the contents of assets and liabilities.

Firms use external short-term debt to increase their financial liquidity and that external short-term debt is a financing ability to overcome a shortage of funds. Hence, the external short-term debt should have a positive influence on operational performance. In summary, flexible financing sources will have positive influences on firms' operational performance. We then propose the four variables will have positive contribution for firms' operational performance as well.

Liquidity Ability

The final dimension of financial ability is liquidity ability. The current ratio and quick ratio represent the ability to switch assets to cash. If the firm has insufficient current assets to satisfy current liabilities, then managers must take measures to ensure that future cash flows are available to pay current liabilities as they mature. We hypothesize that liquidity ability can stabilize operational funds and has a positive influence on firms' operational performance. The current ratio and quick ratio are incorporated to represent the liquidity of a firm's funds (Davis and Peles, 1993). This research proposes that the current ratio and quick ratio have positive influences on MNEs' performance.

Control Variables

In order to control the disturbance from other variables, we use four control variables: firm size, capital structure, R&D expenses, and advertisement expenses.

Large-size MNEs have more resources to engage in international activities. We then propose that firms' size will has positive influence on operational performance. (eg: Riahi-Belkaoui, 1998; Gomes and Ramaswamy, 1999). There are different results in previous research for the firm size. Fama and French (1992) find that small-sized firms have better operational performance. Han et al. (1998) also show that large-sized firms have complex organizations and have worse operational performance. This research adopts firms' size as a control variable which affects firms' operational performance. The logarithm of employees as a result is used to represent the size of an MNE (Contractor et al., 2003).

Capital structure is an important factor to firms' operational performance. MNEs with a high debt ratio should have higher cash flows to pay interest expenses. An increase in the debt ratio decreases net income as well as increases default risk. However, agency theory suggests that the financing decision will avoid the bad behavior of management and create growth opportunities if debt is used appropriately (Brigham and Ehrhardt, 2005).

Research and development (R&D) activity is very important, especially for the information technology (IT) industry. Caves (1982) finds that a firm's growth can be forecasted by its R&D activities. Some scholars suggest that advertising intensity should also be considered. Lu and Beamish (2004) indicate that marketing activity will increase an enterprise's notoriety. Thus, R&D and advertise expenses are adopted in our model.

Data and Empirical Method

Data Sources and Description

The data of sample firms' financial characteristics are collected from the equity databases of *Taiwan Economic Journal* and *Market Observation Post System*. The study period is from 1999 to 2003. However, for consideration of the data's completeness of the sample firms during the period, we adopt 100 IT and 167 non-information technology industry (non-IT) companies, which are listed, as the research objects. Taiwan's IT industry has dominated other domestic industries since the 1990s, playing an important role in the global market. The IT industry is chosen for this study because many of Taiwan's new MNEs are mainly from the IT industry.

These non-IT industries include photoelectric manufactures (23 firms), electro-components (18 firms), IC manufactures (17 firms), motherboard (15 firms), PC and NB manufactures (6 firms), software and services (21 firms) companies. In order to discuss the difference across industries, the financial flexibilities of the IT and non-IT industries are compared. non-IT industries include spin and weave (22 firms), mechanical (18 firms), chemical and

medical (15 firms), plastic (15 firms), food (13 firms), metallic (10 firms), rubber (9 firms), wholesale and retail (7 firms), electric equipment (7 firms), glass and ceramics (7 firms), constructer (7 firms), cement (6 firms), papermaking (4 firms), traffic (2 firms), tourism (1 firm), and other (24 firms) industries.

Variables

This study explores the influences of financial flexibility on the operational performance of a firm. We use the return on assets as the dependent variable to evaluate operational performance, and financial characteristics as independent variables. Many scholars use operational performance to estimate the impacts of DOI. This research suggests that financial flexibility such as DOI will affect an enterprise's operational performance. Return on equity is more sensitive to the debt ratio than return on assets. ROA is adopted to measure an enterprise's operational performance.

MNEs with a higher degree of internationalization should have a higher financial flexibility to efficiently allocate funds for increasing operational performance.

For the operational performance variable, we use return on assets as the proxy variable to measure the operational performance. DOI originates from Sullivan (1994) in which FSTS, FATA, OSTS, TMIE, and PDIO are used for forming the principal component of internationalization. It is difficult to calculate the sales amounts of foreign subsidiaries, because they are not disclosed in financial reports. This research assumes that OSTS (oversea subsidiary as a percentage of total subsidiaries) has a very high correlation with FATA (foreign assets as a percentage of total assets). Therefore, the OSTS variable is omitted. Because we focus this research on the financial aspect, TIME and PDIO are not considered. The third index of DOI is mainland China investment as a percentage of total assets (MCTA).

Table 1: Operational Definition of Variables

Variable (Symbol)	Proxy (Symbol)	Measurement
Operational performance (FP)	Return on assets (ROA)	Net income / Total assets
	Return on equity (ROE)	Net income /Total equity
Globalization ability- Degree of internationalization (DOI)	Export sales as a percentage of total sales (ESTS)	Export sales / Total sales
	Foreign assets as a percentage of total assets (FATA)	Foreign assets / Total assets
	Investment in mainland China as a percentage of total assets (MCTA)	Mainland China investment / Total assets
Financing ability - Financing sources (FS)	Foreign equity (FE)	GDRs / Weighted average of capital
	Foreign debt (FD)	Dummy variable; if publish foreign convertible bond, then FD = 1
	Spontaneous short-term debt ratio (SD1)	Spontaneous short-term debt / Total debt
	External short-term debt ratio (SD2) debt	External short-term debt / Total
Liquidity ability- Financial ratios (FR)	Current ratio (CR)	Current assets / Current liabilities.
	Quick ratio (QR)	(Current assets – inventory – advance payment) / Current liabilities.
Control variables (CV)	Firm size (SIZE)	Natural logarithm of employees
	Debt ratio (DR)	Total debt / Total assets
	Advertisement expense (AE)	Advertisement expense / Net income
	Research & development expense (RD)	Research & development expense / Net income

Singh and Hodder (2000) point out that the financing decision can be adjustment instruments for MNEs. The debt period and region of loaners are also a part of financial flexibility. MNEs' quick ratios show a fast adjustment to equilibrium value. Therefore, sufficient flexibility, such as the quick ratio, is incorporated into the framework (Davis and Peles, 1993).

Table 1 is the operational definitions of these variables. The operational performance is used as the dependent variable, and the financial characteristics are independent variables. The financial flexibility includes three dimensions: (1) internationalization, including export sales as a percentage of total sales (ESTS), foreign assets as a percentage of total assets (FATA), and investment in mainland China as a percentage of total assets (MCTA); (2) financing sources, including foreign equity (FE), foreign debt (FD), spontaneous short-term debt (SD1), and external short-term debt (SD2); and (3) financial ratio, including current ratio (CR), and quick ratio (QR). The control variables affecting the information technology industry's operational performance are also taken into account, including firm size (SIZE), debt ratio (DR), advertising expense ratio (AE), and R&D expense ratio (RD).

Investment into mainland China from Taiwan has been increasing in both the number of cases as well as amounts.

Panel-data Regression Models

A longitudinal, or panel, dataset is one that follows a given sample of individuals over time, and thus provides multiple observations on each individual in the sample. Panel datasets for economic research possess several major advantages over conventional cross-sectional or time-series datasets. First, they usually give the researcher a large number of data points, increasing the degrees of freedom and avoiding the multicollinearity problem among explanatory variables. Second and more importantly, longitudinal data allow a researcher to analyze a number of important economic questions that cannot be addressed using cross-sectional or time-series datasets. This research hence utilizes the method of panel data.

There are three distinct types of panel data. The first type shows panel data with a constant intercept item; that is, the traditional ordinary least squares (OLS) model. The second type is a fixed-effects (FE) model in which its intercept varies over individuals. The third type is the random-effects (RE) model or variance component model in which the intercept is random (Hsiao, 2003).

Based on the adopted variables as above, the initially proposed empirical model is in Equations (1) and (2):

$$ROAit = ã0 + ã1ESTSit + ã2EATAit + ã3MCTAit + ã4FEit + ã5FDit + ã6SD1it + ã7SD2it + ã8CRit + ã9QRit + ã10SIZEit + ã11RDit + ã12AEit + ã13RDit + uit. \quad (1)$$

$$ROEit = ã0 + ã1ESTSit + ã2EATAit + ã3MCTAit + ã4FEit + ã5FDit + ã6SD1it + ã7SD2it + ã8CRit + ã9QRit + ã10SIZEit + ã11RDit + ã12AEit + ã13RDit + uit. \quad (2)$$

Since the panel data consist of both cross-sectional and longitudinal aspects, errors may occur in the ordinary least squares (OLS) estimation method if these firms do not have truncation terms. Panel data models may be classified into a fixed-effects model and a random-effects model. The fixed-effects model and random-effects model follow as below (Hsiao, 2003): fixed-effects model: $y_{it} = \alpha_i + \beta\chi_{it} + \upsilon_{it}$ and random-effects model: $y_{it} = \alpha_i + \beta\chi_{it} + \upsilon_{it}$. In both the fixed-effects and random-effects models, y_{it} is the dependent variable and χ_{it} is the independent variable. The identified difference between each firm is reflected in the intercept item of the regression model. The fixed-effects model uses a fixed intercept to represent the difference in inter-firm structures, while α_i indicates the independent fixed intercept in each firm. The random-effects model uses a random intercept to represent the different structures in each cross-section, while α'_i refers to the intercept in each firm being random.

Empirical Results and Discussion

This section contains the results of descriptive statistics analysis, the multicollinearity test, panel data analysis, and comparison of results for different industries.

Descriptive Statistical Analysis

Table 2 reports the descriptive statistics for the financial flexibility and control variables for whole samples over the 1999-2003 time periods. The whole samples include 100 IT industry firms and 167 non-IT industry firms. ROA and ROE are independent variables. The mean of ROA is higher than ROE's, but the risk and maximum of ROE is higher than ROA's results. ESTS's mean value equals to 46.39% represents that half of MNE's products export to foreign countries instead of selling to domestic consumers. The maximum of FATA is 2.4941 indicates that the MNE put more of their assets in foreign countries than in domestic firms. The mean of SD2 is higher than SD1 indicates that firms use more external short-term debt than spontaneous short-term debt to deal with short-term financing gap.

Table 3 reports the descriptive statistics for the financial flexibility and control variables for IT industry and non-IT industry over the 1999-2003 time periods. The ROA and ROE of IT industry are both equal to 1.43% and the standard deviations are 3.39% and 8.41%, respectively. The ROA and ROE of non-IT industry equal to 2.2% and -0.9% and the standard deviation equal to 3.39% and 8.41%. This indicates that the IT industry has higher profit and risk than non-IT industry.

The IT industry has higher ESTS and FATA and lower MCTA than the non-IT industry. The mean of ESTS for the IT industry equals to 70.15% which is much higher than 32.16% for the non-IT industry. Mean values of the IT

Table 2: Descriptive Statistics of Whole Samples

This table shows the descriptive statistic of whole samples. ESTS: Export sales / Total sales; FATA: Foreign assets / Total assets; MCTA: Mainland China investment / Total assets; FE: or GDRs / Weighted average of capital; FD: Dummy variable; if publish foreign convertible bond, then FD = 1; SD1: Spontaneous short-term debt / Total debt; SD2: External short-term debt / Total debt; CR: Current assets / Current liabilities; QR: (Current assets – inventory – advance payment) / Current liabilities; SIZE: Natural logarithm of employees; DR: Total debt / Total assets; AE: Advertisement expense / Net income; RD: Research & development expense / Net income.

	Mean	Std. Dev.	Minimum	Maximum
ROA	0.0067	0.0373	-0.3056	0.2338
ROE	-0.0003	0.0899	-0.9190	0.3086
ESTS	0.4639	0.3576	0.0000	1.0000
FATA	0.1091	0.1337	0.0000	2.4941
MCTA	0.0331	0.0476	0.0000	0.3037
FE	0.0418	0.3127	0.0000	5.3421
FD	0.0524	0.2230	0.0000	1.0000
SD1	0.1166	0.1090	0.0000	0.9392
SD2	0.4634	0.2221	0.0040	0.9420
CR	0.0191	0.0173	0.1755	0.0011
QR	0.0134	0.0157	0.0001	0.1681
DR	0.4114	0.1529	0.0495	0.9268
SIZE	6.4468	1.0948	3.0445	9.8543
AE	0.0274	0.1029	-0.0050	2.8332
RD	0.0232	0.0483	-0.2071	0.6598

industry's financing ability such as FE, FD, SD1, and SD2 are higher than the non-IT industry. This explains that IT industry needs more financial flexibility than non-IT industry. Both the IT and non-IT industries use more SD2 than SD1. The mean values of QR for IT and non-IT industries equal to 1.75% and 1.09% and the standard deviation value of QR for IT and non-IT industries equal to 1.86% and 1.30%. Therefore, firms keep the liquidity at the similar level. There are similar mean values of DR, SIZE, and AE for the IT and non-IT industries. The most different mean value is RD. The mean value is 4.66% for IT industry and 0.92% for the non-IT industry. After analyzing the descriptive statistics, we then use multicollinearity tests and correlation Analysis to select appropriate.

Multicollinearity Test and Correlation Analysis

This study manipulates variance inflation factors (VIF) to examine if collinear variables exist among the research variables before the selection of variables in a regression model. If the VIF value of an explanatory variable is greater than 10, then this variable has a problem of multicollinearity with other explanatory variables. In order to avoid the problem of multicollinearity, we must delete any explanatory variable with VIF > 10 from the regression model. Appendix I has three data groups to calculate VIF and has the same result.

An increase in financing sources and instruments will increase an MNE's financial flexibility and hence improves its operational performance.

Table 3: Descriptive Statistics of IT and Non-IT Industries

This table shows the descriptive statistics of the IT and non-IT industries. ESTS: Export sales / Total sales; FATA: Foreign assets / Total assets; MCTA: Mainland China investment / Total assets; FE: GDRs / Weighted average of capital; FD: Dummy variable; if publish foreign convertible bond, then FD = 1; SD1: Spontaneous short-term debt / Total debt; SD2: External short-term debt / Total debt; CR: Current assets / Current liabilities; QR: (Current assets – inventory – advance payment) / Current liabilities; SIZE: Natural logarithm of employees; DR: Total debt / Total assets; AE: Advertisement expense / Net income; RD: Research & development expense / Net income.

	Mean	Std. Dev.	Minimum	Maximum
ROA	0.0143[a.] (0.0022)[b.]	0.0414 (0.0339)	-0.3056 (-0.2964)	0.2338 (0.1578)
ROE	0.0143 (-0.0090)	0.0972 (0.0841)	-0.9190 (-0.8738)	0.3086 (0.1856)
ESTS	0.7015 (0.3216)	0.2810 (0.3211)	0.0000 (0.0000)	1.0000 (1.0000)
FATA	0.1293 (0.0971)	0.1291 (0.1350)	0.0002 (0.0000)	0.9730 (2.4941)
MCTA	0.0109 (0.0465)	0.0192 (0.0541)	0.0000 (0.0000)	0.1388 (0.3037)
FE	0.1094 (0.0013)	0.5036 (0.0156)	0.0000 (0.0000)	5.3421 (0.3540)
FD	0.1220 (0.0108)	0.3276 (0.1033)	0.0000 (0.0000)	1.0000 (1.0000)
SD1	0.1285 (0.1095)	0.1111 (0.1072)	0.0000 (0.0000)	0.9392 (0.9067)
SD2	0.5179 (0.4308)	0.2351 (0.2074)	0.0040 (0.0066)	0.9420 (0.9345)
CR	0.0230 (0.0168)	0.0198 (0.0153)	0.1755 (0.1710)	0.0029 (0.0011)
QR	0.0175 (0.0109)	0.0186 (0.0130)	0.0015 (0.0001)	0.1681 (0.1553)
DR	0.3810 (0.4296)	0.1466 (0.1537)	0.0495 (0.0655)	0.9041 (0.9268)
SIZE	6.4989 (6.4156)	1.1755 (1.0430)	3.4657 (3.0445)	9.8543 (9.7837)
AE	0.0125 (0.0363)	0.0559 (0.1218)	0.0000 (-0.0050)	1.1795 (2.8332)
RD	0.0466 (0.0092)	0.0694 (0.0181)	-0.0263 (-0.2071)	0.6598 (0.1411)

Note: a. IT industry; b. non-IT industry.

The result shows every CR's VIF value greater than 10

in step 1. The CR variable is then omitted to avoid the problem of multicollinearity. In total, we adopt ESTS, FATA, FD, SD1, SD1, LD, QR, DR, SIZE, AE, and RD as explanatory variables in our regression model. The result in step 2 does not have any variable with multicollinearity.

After eliminating the CR variable which has a multicollinearity problem, the empirical model can be expressed by Equations (3) and (4):

$$ROAit = \tilde{a}0 + \tilde{a}1ESTSit + \tilde{a}2EATAit + \tilde{a}3MCTAit + \tilde{a}4FEit + \tilde{a}5FDit + \tilde{a}6SD1it + \tilde{a}7SD2it + \tilde{a}8CRit + \tilde{a}9QRit + \tilde{a}10SIZEit + \tilde{a}11RDit + \tilde{a}12AEit + \tilde{a}13RDit + uit. \quad ..(3)$$

$$ROEit = \tilde{a}0 + \tilde{a}1ESTSit + \tilde{a}2EATAit + \tilde{a}3MCTAit + \tilde{a}4FEit + \tilde{a}5FDit + \tilde{a}6SD1it + \tilde{a}7SD2it + \tilde{a}8CRit + \tilde{a}9QRit + \tilde{a}10SIZEit + \tilde{a}11RDit + \tilde{a}12AEit + \tilde{a}13RDit + uit. \quad ...(4)$$

Empirical Results

To adopt the above variables in our model, through testing for multicollinearity and conducting a correlation analysis, this study then manipulates the export ratio, foreign assets ratio, mainland China investment ratio, foreign equity, debt from foreign countries, spontaneous short-term debt ratio, external short-term debt ratio, quick ratio, debt ratio, size, advertisement ratio, R&D ratio, as independent variables in the panel data model. Appendix I shows the fixed-effects panel data regression results of all samples included IT and non-IT industry.

MNEs with a higher debt ratio need to pay more interest expenses, hence decreasing their operational performance.

We first examine all samples and present the results in Appendix II. The results show that at the 1% significance level, according to the F-test and LM test, the panel data model is more appropriate. The p-value of Hausman test is less than 1%, showing that the fixed- effect model is should be adopted. SD1 and QR significantly improve ROA but have no significant effect on ROE.

We secondly examine only the IT industry and the results are presented in Appendix III. According to the F-test and LM-test, the panel data models are more appropriate than the OLS approach to estimate the effects of explanatory variables on ROA and ROE. The P-value of the Hausman test is less than 1%, showing that the random-effects model should be used. SD1 and QR significantly improve ROA but have no significant effect on ROE. This is a similar result as with Appendix II.

We thirdly examine only the non-IT industry and present the results in Appendix III. According to the F-test, the fixed-effects model is more appropriate, but according to the LM-test, the OLS approach is more appropriate. Based on the two tests, the panel data models should be used. The P-value of the Hausman test is less than 1%, showing that the random-effects model should be used. ESTS, SD1, and QR have different results on ROA and ROE.

From result of control variables, the debt ratio has a significantly negative effect on operational performance at the 1% level. Firms with a higher debt need to pay more interest expenses, hence decreasing their operational performance. The firm size has no significant effect on operational performance in all samples (Appendix II) and the IT industry (Appendix III). This result is inconsistent with Fama and French (1992), Han et al. (1998), and Gomes and Ramaswamy (1999). This may be because firm sizes are relatively closer in our dataset. In the result of Appendix III, firm size has a significant positive effect on operational performance and this result is consistent with Gomes and Ramaswamy (1999). The R&D expense ratio has a significantly negative effect on operational performance at the 1% level in the IT industry, but not in the non-IT industry. The result is consistent with Lantz and Sahut (2005). The growth of IT firms is based on the innovative products and services; therefore, they invest heavily in research and development. If the R&D expenditure signals strategic positioning of a firm, then it can also significantly decrease the operational performances. The advertisement expense ratio has a significantly negative effect on an MNE's operational performance at the 1% level in the IT industry. Other things being equal, a higher AE ratio will generate a lower operational performance. This result is inconsistent with Lu and Beamish (2004) and Han et al. (1998). This might be because Taiwanese firms usually make profits from their manufacturing ability rather than their brand image.

For the result of globalization ability, ESTS has a significantly positive effect on an MNE's operational performance at the 5% level. This is consistent with *Vernon (1971), Grant (1987), and Daniels and Bracker (1989). EATA* has a significantly negative effect on an MNE's operational performance at the 5% level. Our result is consistent with Collins (1990) who indicates that EATA has a negative influence on firms' operational performance. This does not support Hypothesis 1. Internationalization does not provide MNEs with the absolute positive flexibility. According to Contractor et al. (2003), too much investment into a foreign subsidiary will increase connection and communication costs, hence lowering an MNE's operational performance. According the result of this research, DOI cannot directly affect firms' performance. MCTA for both the IT and non-IT industries has an insignificant effect on ROA and ROE. The result of MCTA does not support Hypothesis 1. In summary, the result of this research supports part of Hypothesis 1.

For the result of financing sources from foreign countries, debt in foreign countries has a significantly positive effect on an MNE's operational performance in whole samples, which supports Hypothesis 2. This is consistent with Allayannis et al. (2003) and Stephen and Karolyi (1999). Although debt and equity from foreign countries have several advantages, the result in this research finds only a

contribution of debt from foreign countries to operational performance. Financial flexibility seems to be not the most important reason to issue foreign equity. When firms issue GDRs, the major reasons are for capital cost, international reputation, etc.

For the result of financing ability, SD1 and SD2 have significantly positive effects on an MNE's operational performance at the 5% level for the IT industry, which supports Hypothesis 2. SD1 has a significantly positive effect while SD2 has no significant effect on an MNE's operational performance for the non-IT industry and for all samples.

This means that the MNEs of the IT industry need more short-term debt than the non-IT industry and financial flexibility is more important in the IT industry than non-IT industry. The cost of short-term debt is lower than long-term debt, but the reinvestment risk is higher than long-term debt. Firms use short-term debt to increase flexibility and performance, and to avoid bankruptcy, which is consistent with Enrica and Antonio (2004) and Allayannis et al. (2003). Therefore, the result of this research also supports part of Hypothesis 2.

For the result of liquidity ability, the quick ratio has a significantly positive effect on an MNE's operational performance in the whole sample and the IT industry, but has an insignificant effect on an MNE's operational performance in the non-IT industry. This is consistent with Davis and Peles (1993). The different results between the IT and non-IT industries mean that IT industry firms need more financial flexibility in order to switch assets to cash in a short period of time. Hence, the result of this research support full of Hypothesis 3.

Degree of internationalization has both positive and negative effects on operational performance. Increasing export can significantly improve an MNE's operational performance, while increasing the foreign assets cannot.

Discussion

Previous research about flexibility mainly focuses on operational decision. The contribution of this research is to construct a three-dimensional framework to measure an MNE's financial flexibility.

Vernon (1971) uses the sample of fortune 500 in 1964 and finds that MNEs earn higher ROS and ROA than non-MNEs. Grant (1987) uses 304 British firms for 1968-1984 and finds that FSTS is positively associated with super profitability over a period of thirteen years. This research's findings of ESTS are consistent with Vernon (1971) and Grant (1987).

Since 2000, MNEs in Taiwan start invest even more in mainland China because of the following reasons: First, their policy to canvass foreign firms is energetic. Firms from Taiwan enjoy tax reductions in mainland China. Second, mainland China has relatively more abundant natural resources than Taiwan

However, MCTA have no significant affect on an MNE's operational performance. Although the mainland China market is prominent, Taiwanese MNEs face strong competition from Japanese, Korean, and local firms. Therefore, the result of MCTA has no significant influence on operational performance in the sample period.

Pinegar and Wilbricht (1989) use 137 U.S. firms as samples and find that firms can lower financing costs by issuing Euro-convertible bonds. The Ministry of Finance in Taiwan makes issuing Euro-convertible bonds open to public access in 1989. There are 97 Euro-convertible bonds cases until 2001 include currencies of Euro-dollar (83 cases), Swiss France (11 cases), and Japanese Yen (3 cases). The total number is 94 hundred millions USD, 6 hundred millions SFR, and 70 hundred millions JPY. The most cases are issued by the IT industry which has 57 cases.

The characteristics of the IT industry are technology intensive, short life cycle, and need sufficient for factory buildings, R&D expense. Therefore, the IT industry uses foreign financing sources more energetic than non-IT industry. This research collects dataset from 1999 to 2003 and the number is limited. Further research can collect longer time series to exam the same problem.

Enrica and Antonio (2004) find a significantly positive relation between short-term debt and financial crises, implying that the large short-term debt is a fundamental source of financial fragility. Rodrik and Velasco (2000) instead show that the ratio of short-term debt to reserves helps predict large reversals of capital cash flow. Although the short-term debt ratio may increase operational risk, it does provide sufficient liquidity for firms. Buch and Lusinyan (2003) show that the share of short-term debt is positively related to GDP per capita and to the size of the financial system of the recipient country. This research shows that both SD1 and SD2 have significantly positive influences on an MNE's financial performance. Although short-term debt provides firms sufficient financial flexibility, it implies risk for firms also. Further research can find out the optional point of short-term debt.

Finally, we hypothesize that liquidity ability can stabilize operational funds and has a positive influence on firms' operational performance. Davis and Peles (1993) indicate that current ratio and quick ratio are incorporated to represent the liquidity of a firm's funds. The result of this research shows that QR has a significantly positive influence on MNEs' operational performance.

Concluding Remarks

With the international environment turning more competitive due to WTO regulations, MNEs continue to seek suitable resources and low costs. Changes in the international operations have led to higher uncertainties for firms, and the

risks undertaken by international enterprises are higher than those domestically. Therefore, when confronting a high and risky operational environment, MNEs must apply appropriate strategies to lower the fluctuations of profits and performance in order to achieve their operational goals.

This research discusses how the financial flexibility variable affects operational performance. We have built a panel dataset of 100 IT firms and 167 non-IT firms in Taiwan during 1999-2003 for empirical study. The contribution of our research is to find financial flexibility variables which can affect operational performance and to compare the difference between the IT and non-IT industry. We have made some proposes for MNEs' management and further research.

First, export sales as a percentage of total sales (ESTS), foreign debt (FD), spontaneous short-term debt (SD1) and the quick ratio (QR) contribute to operational performance in all samples, while foreign debt makes no contribution to the IT industry and non-IT industry. The ESTS have a positive effect on operational performance, meaning that domestic demand is not sufficient for manufactures. MNEs should increase exports to increase operational performance and sustainable development. SD1 has a significantly positive effect with operational performance, and it includes payment by credit and accrual expenses which provide financial flexibility to MNEs. The QR provides MNEs with the ability to cover current liability.

Second, foreign assets as a percentage of total assets has a significantly negative effect on operational performance. According to Contractor et al. (2003), too much investment into foreign subsidiaries will increase connection and communication costs, hence lowering its operational performance. Third, investment in mainland China as a percentage of total assets (MCTA) and foreign equity (FE) have no significant effects on operational performance.

We make three suggestions for further researches. First, this research does not consider macroeconomics aspects such as business cycles. The operational performance can be affected by business cycles in different firms and different industries. Second, we only consider the degree of internationalization to measure operational ability. More research can show how managers react to financial crises and how long it takes for them to solve problems. Globally, further research can add a variable for human resources. Third, this research discusses financial flexibility and operational performance. Previous research shows that flexibility can limit the volatility of operational performance and hence can lower risk. Future research can simultaneously take into account financial flexibility and operational risk.

References

Adhikari A., Coffman E.N. and Tondker R.H. (1991) 'Going Global-A Toronto to the Intricacies of Foreign Stock Listing', *CA Magazine*, July, 24-31.

Allayannis G., Brown G.W. and Klapper L.F. (2003) 'Capital Structure and Financial Risk: Evidence from Foreign Debt Use in East Asia', *Journal of Finance*, 58, 2667-2709.

Allen L. and Pantzalis C. (1996) 'Valuation of the Operating Flexibility of Multinational Corporations', *Journal of International Business Studies*, 27, 633-653.

Amihud Y. and Mendelson H. (1986) 'Asset Pricing and the Bid-Ask Spread', *Journal of Financial Economics*, 17, 223-249.

Brennan M.J., and Subrahmanyam A. (1996) 'Market Microstructure and Asset Pricing: on the Compensation for Illiquidity in Stock Returns', *Journal of Financial Economics*, 41, 441-464.

Besley S. and Osteryoung J.S. (1985) 'Survey of Current Practices in Establishing Trade-Credit Limits', *Financial Review*, 20, 70-82.

Biddle G.C. and Saudagaran S.M. (1991), 'Foreign Stock Listings: Benefit, Costs, and the Accounting Policy Dilemma', *Accounting Horizons*, 5, pp.69-80.

Brigham E. F. and Ehrhardt M. C. (2005) *Financial Management: Theory and Practice*, 11th ed., Mason: Thomson South-Western.

Buch C.M. and Lusinyan L. (2003) 'Determinants of Short-term Debt: A Note', *Journal of International Financial Markets, Institution, and Money*, 13, 157-170.

Buckley P.J. and Cassion M.C. (1998) 'Models of the Multinational Enterprise', *Journal of International Business Studies*, 29, 21-44.

Calomiris C.W., Himmelberg C.P. and Wachtel P. (1994) 'Commercial Paper, Corporate Finance and the Business Cycle: A Microeconomic Perspective', *NBER Working Paper*, No.4848.

Collins J.M. (1990) 'A Market Performance Comparison of U.S. Firms Active in Domestic, Developed and Developing Countries', *Journal of International Business Studies*, 2, 271-87.

Contractor F.J., Kundu S.K. and Hsu C.C. (2003) 'A Three-stage Theory of International Expansion: The Link between Multinationality and Performance in the Service Sector', *Journal of International Business Studies*, 34, 5-18.

Daniels J.D. and Bracket J. (1989) 'Profit performance: Do Foreign Operations Make a Difference?' *Management International Review*, 29, 46-56.

Datar V.T., Naik N.Y. and Radcliffe R. (1998) 'Liquidity and Stock Returns: An Alternative Test', *Journal of Financial Markets*, 1, 203-219.

Davis H.Z. and Peles, Y.C. (1993) 'Measuring Equilibrating Forces of Financial Ratios', *Accounting Review*, 68, 725-747.

Dharan B.G. and Ikenberry D.L. (1995) 'The Long-Run Negative Drift of Post-Listing Stock Returns', *Journal of Finance*, 5, 1547-1574.

Diamond D.W. and Rajan R. (2000) 'Bank, Short-Term Debt and Financial Crises: Theory and Policy Implications', *NBER Working Paper*, No. 7764.

Enrica D. and Antonio S. (2004) 'Empirical Models of Short-term Debt and Crises: Do They Test the Creditor Run Hypothesis?', *European Economic Review*, 48, 379-389.

Fama E. and French K. (1992) 'The Cross-Section of Expect Stock Return', *Journal of Finance*, 47, 427-465.

Ghoshal S. (1987) 'Global Strategy: An Organizing Framework', *Strategic Management Journal*, 8, 425-440.

Gomes L. and Ramaswamy K. (1999) 'An Empirical Examination of the Form of the Relationship between Multinationality and Performance', *Journal of International Business Studies*, 30, 173-188.

Grant R.M. (1987) 'Multinationality and Performance among British Manufacturing Companies', *Journal of International Business Studies*, 18, 79-89.

Han K.C., Lee S.H. and Suk D.Y., (1998) 'Multinationality and Firm Performance', *Multinational Business Review*, 6, 63-70.

Hymer S.H. (1976) *The International Operations of National Firms: A Study of Direct Foreign Investment*, Cambridge (MA): MIT Press.

Kogut B. (1985) 'Designing Global Strategies: Profit from Operational Flexibility', *Sloan Management Review*, 27, 27-38.

Kogut B. and Kulatilaka N. (1994) 'Operating Flexibility, Global Manufacturing, and the Option Value of a Multinational Network', *Management Science*, 40, 123-139.

Kuo H.C., Li Y. and Ting M. (2003) 'Can Flexibility Improve Operational Performance? A Risk Analysis of the Asian Financial Crisis', *International Journal of Risk Assessment and Management*, 4, 263-281.

Lantz J.S. and Sahut J.M. (2005) 'R&D Investment and the Operational Performance of Technological Firms', *Journal of International Business and Studies*, 10, 251-270.

Lu J.W. and Beamish P.W. (2004) 'International Diversification and Firm Performance: The S-curve Hypothesis', *Academy of Management Journal*, 47, 598-609.

Market Observation Post System, website: http://newmops.tse.com.tw/.

Miller K.D. and Bromiley P. (1990) 'Strategic Risk and Corporate Performance: An Analysis of Alternate Risk Measures', *Academy of Management Journal*, 33, 756-759.

Pinegar J.M. and Wilbricht L. (1989) 'What Manager Think of Capital Structure Theory: A Survey', *Financial Management*, 18, 82-91.

Rodrik D. and Velasco A. (2000) 'Short-Term Capital Flows', *NEBR Working Paper*, No.7364.

Sanger G.C. and McConnell J.J. (1986) 'Stock Exchange Listings, Firm Value, and Security Market Efficiency: the Impact of NASDAQ', *Journal of Financial and Quantitative Analysis*, 21, 1-25.

Singh K. and Hodder J. (2000) 'Multinational Capital Structure and Financial Flexibility', *Journal of International Money and Finance*, 19, 853-884.

Sullivan D. (1994) 'Measuring the Degree of Internationalization of a Firm', *Journal of International Business Studies*, 25, 325-342.

Taiwan Economic Journal, website: http://www.tej.com.tw/.

Tannous G.F. (1996) 'Capital Budgeting for Volume Flexibility Equipment', *Decision Sciences*, 27, 157-184.

Vernon R. (1971) *Sovereignty at Bay: The Multinational Spread of U.S. Enterprises*. New York: Basic Books.

Vernon R. (1985) 'Organizational and Institutional Responses to International Risk', in Wortzel, H.V. and Wortzel L.H. (Ed.), *Strategic Management of Multinational Corporations*, pp.112-128, New York: John Wiley Press.

Werner S., Brouthers L.E. and Brouthers K.D. (1996) 'International Risk and Perceived Environmental Uncertainty: The Dimensionality and Internal Consistency of Miller's Measure', *Journal of International Business Studies*, 27, 571-587.

Appendix I: Multicollinearity Tests

ESTS: Export sales / Total sales; FATA: Foreign assets / Total assets; MCTA: Mainland China investment / Total assets; FE: GDRs / Weighted average of capital; FD: Dummy variable; if publish foreign convertible bond, then FD = 1; SD1: Spontaneous short-term debt / Total debt; SD2: External short-term debt / Total debt; CR: Current assets / Current liabilities; QR: (Current assets – inventory – advance payment) / Current liabilities; SIZE: Natural logarithm of employees; DR: Total debt / Total assets; AE: Advertisement expense / Net income; RD: Research & development expense / Net income.

	Whole sample		IT industry		non-IT industry	
Variable	R^2	VIF	R^2	VIF	R^2	VIF
Step 1						
ESTS	0.223	1.288	0.147	1.173	0.163	1.194
FATA	0.169	1.204	0.171	1.206	0.189	1.234
MCTA	0.090	1.099	0.061	1.065	0.119	1.135
FE	0.049	1.051	0.082	1.089	0.029	1.030
FD	0.103	1.114	0.169	1.203	0.022	1.022
SD1	0.292	1.413	0.414	1.708	0.224	1.288
SD2	0.250	1.333	0.304	1.437	0.240	1.316
CR	0.948	19.308	0.965	28.356	0.933	14.914
QR	0.949	19.541	0.964	27.772	0.933	14.890
DR	0.407	1.686	0.472	1.893	0.400	1.665
SIZE	0.268	1.366	0.344	1.526	0.254	1.340
AE	0.054	1.057	0.053	1.056	0.094	1.104
RD	0.253	1.339	0.394	1.650	0.106	1.119
Step 2						
ESTS	0.211	1.268	0.126	1.144	0.147	1.173
FATA	0.157	1.186	0.176	1.213	0.176	1.214
MCTA	0.090	1.099	0.073	1.079	0.118	1.133
FE	0.048	1.050	0.090	1.098	0.028	1.029
FD	0.102	1.114	0.169	1.204	0.022	1.022
SD1	0.288	1.405	0.407	1.687	0.221	1.284
SD2	0.246	1.325	0.328	1.488	0.240	1.316
QR	0.465	1.869	0.517	2.071	0.379	1.610
DR	0.376	1.603	0.449	1.813	0.370	1.587
SIZE	0.267	1.365	0.326	1.484	0.249	1.331
AE	0.042	1.043	0.052	1.055	0.069	1.075
RD	0.245	1.324	0.390	1.640	0.094	1.104

Appendix II : Results of the Fixed-effects Model for Whole Samples

Panel 1 shows the result of Equation (3) (Dependent variable is ROA in Equation (3)) and panel 2 shows the result of Equation (4) (Dependent variable is ROE in Equation (4)). ESTS: Export sales / Total sales; FATA: Foreign assets / Total assets; MCTA: Mainland China investment / Total assets; FE: GDRs / Weighted average of capital; FD: Dummy variable; if publish foreign convertible bond, then FD = 1; SD1: Spontaneous short-term debt / Total debt; SD2: External short-term debt / Total debt; QR: (Current assets – inventory – advance payment) / Current liabilities; SIZE: Natural logarithm of employees; DR: Total debt / Total assets; AE: Advertisement expense / Net income; RD: Research & development expense / Net income.

	Panel 1			Panel 2		
Variable	Estimated Coefficient	t-statistic	P-value	Estimated Coefficient	t-statistic	P-value
Constant	0.012	0.926	0.355	**0.062**	**1.904**	**0.058***
ESTS	**0.015**	**3.737**	**0.000*****	**0.027**	**2.721**	**0.007*****
FATA	**-0.070**	**-6.030**	**0.000*****	**-0.162**	**-5.549**	**0.000*****
MCTA	-0.031	-1.085	0.279	-0.095	-1.323	0.187
FE	0.003	0.488	0.626	-0.006	-0.350	0.727
FD	**0.017**	**1.739**	**0.083***	**0.057**	**2.281**	**0.023****
SD1	**0.029**	**1.862**	**0.064***	0.003	0.069	0.945
SD2	0.007	1.050	0.295	0.018	1.005	0.316
QR	**0.353**	**2.789**	**0.006*****	0.278	0.876	0.382
DR	**-0.069**	**-6.291**	**0.000*****	**-0.249**	**-9.112**	**0.000*****
SIZE	0.002	1.548	0.123	0.006	1.637	0.103
AE	0.007	0.422	0.673	0.035	0.795	0.427
RD	**-0.087**	**-2.607**	**0.010*****	**-0.199**	**-2.400**	**0.017****
F-test		P-value=0.000***		P-value=0.000***		
LM-test		P-value=0.021**		P-value=0.000***		
Hausman test		P-value=0.000***		P-value=0.000***		
R^2(Adj-R^2)		0.457 (0.432)		0.443(0.417)		

Note: *** represents significance at the 1% level; ** represents significance at the 5% level; and * represents significance at the 10% level.

Appendix III: Results of the Random-effects Model for the IT Industry.

Panel 1 shows the result of Equation (3) (Dependent variable is ROA in Equation (3)) and panel 2 shows the result of Equation (4) (Dependent variable is ROE in Equation (4)). ESTS: Export sales / Total sales; FATA: Foreign assets / Total assets; MCTA: Mainland China investment / Total assets; FE: GDRs / Weighted average of capital; FD: Dummy variable; if publish foreign convertible bond, then FD = 1; SD1: Spontaneous short-term debt / Total debt; SD2: External short-term debt / Total debt; QR: (Current assets – inventory – advance payment) / Current liabilities; SIZE: Natural logarithm of employees; DR: Total debt / Total assets; AE: Advertisement expense / Net income; RD: Research & development expense / Net income.

	Panel 1			Panel 2		
Variable	Estimated Coefficient	t-statistic	P-value	Estimated Coefficient	t-statistic	P-value
Constant	0.010	0.516	0.606	0.029	0.632	0.528
ESTS	**0.015**	**2.118**	**0.034****	**0.033**	**1.897**	**0.058***
FATA	**-0.064**	**-3.996**	**0.000*****	**-0.174**	**-4.554**	**0.000*****
MCTA	0.092	1.062	0.288	0.279	1.383	0.167
FE	0.000	-0.027	0.979	-0.001	-0.147	0.883
FD	0.000	-0.068	0.946	0.009	0.694	0.488
SD1	**0.041**	**1.981**	**0.048****	0.021	0.437	0.662
SD2	**0.021**	**2.236**	**0.025****	**0.048**	**2.198**	**0.028****
QR	**0.255**	**1.821**	**0.069***	0.285	0.858	0.391
DR	**-0.079**	**-4.714**	**0.000*****	**-0.215**	**-5.413**	**0.000*****
SIZE	0.003	1.290	0.197	0.006	1.346	0.178
AE	**-0.077**	**-2.690**	**0.007*****	**-0.150**	**-2.262**	**0.024****
RD	**-0.109**	**-3.304**	**0.001*****	**-0.213**	**-2.737**	**0.006*****
F-test		0.000***		0.000***		
LM-test		0.068*		0.000***		
Hausman test		0.018**		0.012**		
R^2(Adj-R^2)		0.254 (0.236)		0.256 (0.238)		

Note: *** represents significance at the 1% level; ** represents significance at the 5% level; * represents significance at the 10% level.

Appendix III: Results of the Random-effects Model for the Non-IT Industry

Panel 1 shows the result of Equation (3) (Dependent variable is ROA in Equation (3)) and panel 2 shows the result of Equation (4) (Dependent variable is ROE in Equation (4)). ESTS: Export sales / Total sales; FATA: Foreign assets / Total assets; MCTA: Mainland China investment / Total assets; FE: GDRs / Weighted average of capital; FD: Dummy variable; if publish foreign convertible bond, then FD = 1; SD1: Spontaneous short-term debt / Total debt; SD2: External short-term debt / Total debt; QR: (Current assets – inventory – advance payment) / Current liabilities; SIZE: Natural logarithm of employees; DR: Total debt / Total assets; AE: Advertisement expense / Net income; RD: Research & development expense / Net income.

	Panel 1			Panel 2		
Variable	**Estimated Coefficient**	**t-statistic**	**P-value**	**Estimated Coefficient**	**t-statistic**	**P-value**
Constant	0.008	0.639	0.523	**0.061**	**1.919**	**0.055***
ESTS	**0.009**	**1.862**	**0.063***	0.012	1.085	0.278
FATA	**-0.022**	**-2.283**	**0.022****	**-0.038**	**-1.651**	**0.099***
MCTA	-0.027	-1.059	0.290	**-0.132**	**-2.125**	**0.034****
FE	-0.008	-0.108	0.914	0.010	0.059	0.953
FD	0.004	0.445	0.656	0.017	0.706	0.480
SD1	**0.041**	**3.145**	**0.002*****	0.002	0.062	0.950
SD2	-0.007	-0.987	0.324	-0.016	-0.900	0.368
QR	0.204	1.771	0.077*	0.061	0.217	0.828
DR	**-0.055**	**-5.248**	**0.000*****	**-0.243**	**-9.437**	**0.000*****
SIZE	0.002	1.628	0.104	**0.007**	**1.977**	**0.048****
AE	-0.011	-1.180	0.238	-0.016	-0.697	0.486
RD	-0.089	-1.347	0.178	-0.048	-0.300	0.765
F-test		0.000***		0.000***		
LM-test		0.102		0.000***		
Hausman test		0.0220**		0.100		
R^2(Adj-R^2)		0.2209 (0.209)		0.218057(0.206641)		

Note: *** represents significance at the 1% level; ** represents significance at the 5% level; * represents significance at the 10% level.

Reflecting Applicability in Real Life:

1. In addition to financial flexibility, what kinds of flexibility can also help improve an MNE's operational performance?
2. What kinds of globalization strategies help most with improving an MNE's operational performance?
3. What are the best locations for your enterprise to invest to improve its financial flexibility and hence operational performance?

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Model

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A Model for Flexible Supply Chain through Flexible Manufacturing

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Abstract

This paper presents a model of manufacturing which attempts to enhance the flexibility in a supply chain. This model employs a staggered volume multiple assembly lines to fulfill the objectives of customization along with timely delivery. The measures of performance taken are the unit cost of production and the number of customers satisfied. In today's highly dynamic global economy, a supply chain may only survive by keeping its customer base growing or intact. The manufacturer is a crucial part of supply chain and hence the flexibility of the manufacturer has a major bearing on the overall supply chain agility.

Keywords: flexible manufacturing practices, genetic algorithm, supply chain flexibility

Introduction

In today's highly competitive world, a customer not only expects quality, reliability and competitive pricing but also customized products with timely delivery. Hence, it is desirable that an organization is as flexible as possible. Since the businesses everywhere are facing competition from all around the globe, hence, more value has to be provided to the customer to survive. In such a scenario, the profit on a single product is limited. Thus, for an organization to attain growth in an environment of intense competition and acute price cutting policies (to capture a market), it must either expand its customer base to ward off the effect of lowered profit per unit product sold. Or at least maintain the current customer base along with internal cost cutting measures. Only then an organization would be able to generate higher profits and hence, grow.

The producer's view of quality is defined as "conformance to specifications". The customer's view of quality is defined as "fitness of use", "customer's satisfaction" and ultimately "customer's delight". The customer's requirements keep changing from customer to customer as well as with time even for the same customer. Thus, rigid business system will generate products which will not be meeting the customer's requirements fully and thereby affecting the quality negatively. Whereas, flexibility in business systems will help in generating more options and adapting to the changing customer's requirements, thereby, enhancing the customers satisfaction and quality.

The manufacturer in the supply chain plays a vital role in the agility of the supply chain. If the manufacturer is unable to meet the deadlines, even the most efficient or innovative logistics network would be unavailing. Also, the concepts used today like lean manufacturing, JIT etc. are policies which entail keeping the inventory as low as possible. Just in Time technique urges the manufacturer to order raw materials as and when they are required and thereby keeping the inventory cost low. When an order is sent by the retailer to the manufacturer, the manufacturer should be flexible enough to produce the customized product within the given deadline. Thus, for a supply chain to be flexible, it is crucial that the manufacturer lead the way.

A flexible manufacturing technology (FMT) has come a long way in terms of the hard technology like automated guided vehicles (AGVs), computer numerically controlled (CNC) tools, automated storage and retrieval systems (ASRSs) etc. But the management of the FMT still remains a grey area. Various aspects of the FMT are given as product flexibility, process flexibility, operations flexibility, volume flexibility, machine and machining flexibility, routing flexibility, action flexibility and state flexibility, expansion flexibility, material handling flexibility, design and design change flexibility, labour flexibility, manufacturing flexibility and strategic flexibility as listed out by Upton (1994) and others. In this paper, though, we concentrate on product flexibility, routing flexibility, volume flexibility and strategic flexibility.

Literature Review

There is a lot of literature available with regards to the discussion of FMTs and its various aspects. For a start, quite

a few papers exist on the different definitions of flexibility itself. According to Upton (1994), flexibility in a generic sense can be defined as a quality to change or react with little penalty in time, effort, cost or performance. Another extension of the concept given by Young and Chan (1990) has been described as the ability to respond rapidly to internal and external changes. According to Bahrami (1992), flexibility is the ability to do things differently or do something else should the need arise.

The importance of flexibility in manufacturing has been well documented (Sethi and Sethi, 1990), (Hill and Chambers, 1991) and Sushil (1997) and its effectiveness in providing several benefits like reduction in set up time, manufacturing lead time, equipment idle time and inventory levels, improvement in productivity, and better control of the process have been adequately demonstrated. In fact manufacturing flexibility is high on the agenda of many manufacturing organizations according to Beach et al. (2000).

There are also many analytical models for flexible manufacturing systems. For example, Purdue came up with a closed loop queuing model for flexible manufacturing system. Draper labs took into consideration the overall production planning control problems of the FMSs. The model developed at MIT had the following salient features of flow control, routing control and sequence control.

According to Sharma (2001), manufacturing flexibility is introduced in an organization with a view to reduce the work in progress and reduce the time on the shop floor.

Gupta et al. (2001) present an approach to managing flexibility in an automobile sector. Some of the current business practices listed out by them are delayering (laying off the middle management level like supervisors so that there is faster interaction between the top level management and the bottom level workers), team based networking, alliances and partners.

Dangayach et al. (2001) put forward an interesting conceptual framework which broadly divides the manufacturing flexibility into two parts for the ease of measurement of flexibility. They are structural and infrastructural flexibility. The properties such as capacity, facility and technology are covered under structural flexibility and under infrastructural flexibility the properties like organization culture, quality policies and human resource policies are covered.

In today's hyper-competitive environment, a customer not only expects quality, reliability and competitive pricing but also customized products/services. Hence it is imperative that an organization be as flexible as possible.

The various literature available on supply chain flexibility focuses mostly on the various types of flexibility available to the supply chain players and how the industry's perceptions towards them vary. A counter-mechanism to tackle uncertainty in today's highly dynamic environment is flexibility. In this paper, we propose a model which improves the agility of a supply chain by concentrating on improving the flexibility of the manufacturer. The reason manufacturer is a crucial part of the supply chain is that often, the maximum capital of the supply chain is invested in it. With maximum investment, it also holds the maximum potential for improvement with the least effort. Also, the model affords many other advantages like timely delivery, late order satisfaction, minimum customer discontent etc. Here, we concentrate only on the internal flexibility of the supply chain namely volume flexibility, product flexibility, routing flexibility and strategic flexibility.

Table 1 shows the comparison between a rigid and a flexible supply chain in a volatile market according to the information collected from various journals.

Table 1: Behavior of Supply Chain

Attributes	Rigid Supply Chain	Flexible Supply Chain
1. Customer satisfaction	High	Very High
2. Unit cost of production	Relatively higher	Relatively lower
3. Initial investment	Relatively lower	Relatively higher
4. Time frame for recovery of investment	Relatively certain	Relatively uncertain
5. Potential for increasing the market share	Low	Relatively Higher
6. Time frame for making changes	Short time duration	Long time duration
7. Costs for future changes	Very high	Low
8. Opportunity for increasing market share	Low	Very high

Figure 1 shows a mix of partial and complete flexibility as discussed by Graves and Tomlin (2003). The framework taken into consideration is the simplest of a flexible supply chain networks. The distributor is shown by the directional lines in Figure 1. When a supply chain member can supply goods to all the other members of the supply chain at the next level, then it is considered to have completely flexible relationship. It is as depicted in the Figure 1 by the relationship between supplier and manufacturer. And when a supply chain member can only supply goods to a limited number of supply chain members in the next level, then it is supposed to be partially flexible relationship. It is depicted in Figure 1 as the relationship between manufacturer and the retailer. Also according to a conceptual framework advanced by Rao et al. (2002), the following configuration represents a supply chain with partial resource based flexibility and a complete product based flexibility.

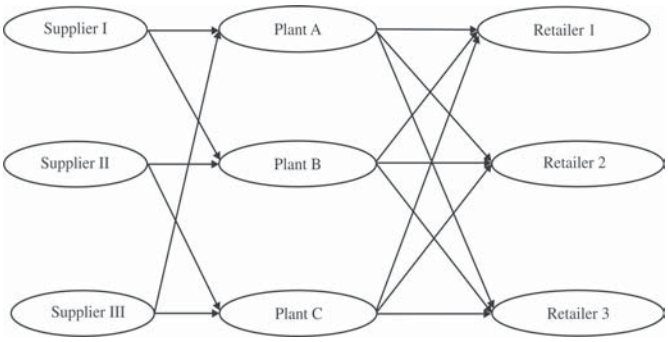

Figure 1: Supply Chain with Flexibility

The various flexibilities to be achieved are:

a) **Product Flexibility:** It is the ability to handle difficult, non-standard orders, to meet special customer specifications, and to produce products characterized by numerous features, options, sizes and colors as defined by Vickery et al. (1997). It requires effective collaboration of other players, including marketing, product design and development, and engineering. Product changeover involves many types of costs such as potential revenue loss due to changeover time and the capital required to affect the changeover. The aim of product flexibility is to reduce the lead time in change as well as reducing the capital required in changing the assembly line. By using the model below, a new product may be launched in the market with the least amount of lead time. For example, if a rival company's product is in high demand, then an organization can take the advantage of its flexibility to launch a similar product and it will find a ready market in the customers dissatisfied by the rival company. But this would require a considerable amount of flexibility.

The aim is to find a balance between the lead time (changeover time) of an assembly line and the unit cost that the supply chain is willing to bear.

Lesser lead time means more customers being satisfied but less lead time means higher unit cost of production.

Lesser unit cost would mean more standardization of the assembly line but that would lead to lesser flexibility and hence higher changeover time.

b) **Volume Flexibility:** The ability to effectively increase or decrease aggregate production in response to customer demand with the least effect on the unit cost of production so as to keep the profit at a healthy level. Volume flexibility may require close coordination between a manufacturer and its suppliers, especially in the face of increasing demand. Volume flexibility directly impacts the supply chain's performance by preventing out-of-stock conditions for products that are suddenly in high demand or by preventing high inventory levels (obsolete stock). For example, Toyota production system uses contract labor and set part supply (SPS) system. Even in this highly flexible system, they have to pay their workers a minimum stipulated amount. If they are manufacturing way below their production capacity, then they are paying the workers more money per unit produced. Having high volume flexibility means paying less for per each unit being manufactured over a wide range of production volume.

Now for having higher volume flexibility the unit cost must be higher.

c) **Routing Flexibility:** It is the capability of processing a part of an unfinished product through varying routes by using alternative machines, flexible material handling, and flexible transporting network. This flexibility reduces the negative impact of environmental uncertainty and unforeseen inefficiencies in the production process. Using the model being proposed here, the production of a particular product can be done at the nearest plant to the point of origin of demand. Had it been not so, the retailer would then have to source the products from a far off plant. Long distances usually increase transportation and order lead times (Stank, 1997) and decrease the reliability of demand forecasts (Ho, 1992). This in turn, increases the uncertainty with respect to production schedules, orders to suppliers, and the likelihood of meeting demand (Swenseth and Buffa, 1991). Hence using the model, we are making substantial savings on logistics cost as well as reducing the uncertainty.

The role of a manufacturer in the supply chains is crucial since maximum capital of the supply chain is invested in manufacturing function and holds maximum potential for improvement in the supply chain.

d) **Strategic Flexibility:** A network of flexible manufacturing plants gives a strategic edge to the supply chain. This way, the supply chain can always compensate for shortfall at one demand point with another plant by manufacturing on completely flexible line. This would not have been possible with a single line production system since the lead time would be very large as it is and there would be the additional burden of fulfilling the demand targets already been given. The company may also route the products through the desired plant nearest to the demand point so as to avoid the transportation cost. Although the manufacturing cost maybe high at completely flexible line, it is economically more viable than transporting a batch from a faraway plant to the demand point.

The Manufacturer's Flexibility Model

Considering a hypothetical case of an automobile manufacturer in a supply chain whose configuration is as shown in Figure 1. The configuration of the plant would be that each has three assembly lines. Each of them vary in certain characteristics. Each line varies in terms of their volume, flexibility and hence as a result that, their lead time

of manufacturing as well as the unit cost. The three lines maybe considered as sub-assembly lines too depending on the number of products to be manufactured and the level of flexibility to be achieved in those areas. A product can be manufactured on all three lines. And depending upon the requirement and the history of demand at various points, the manufacturing plants can be installed with the different assembly lines. The balance is to be found between lead time, unit cost, number of lines and the capacities (capacity represents the number of units manufactured in unit time) of each.

The explanation for a three line production system of each plant is as follows:

a) **Dedicated Assembly Line (DAL):** This line has the highest capacity of the three lines and has the least cost of unit production. It also takes the least time to produce a product. Since it is a dedicated line (to some degree, the degree of dedication to a particular product may vary according to the company policy), the level of flexibility is very low in it. The changeover cost and time for this line is the highest. Hence, this line is kept for manufacturing products which are in high demand.

b) **Intermediate Assembly Line (IAL):** This line has medium flexibility. It has lower capacity then the dedicated line but it has more flexibility. Consequently, the unit cost of production is higher in this line and also the average time taken to manufacture one product. Though the set up time, the changeover time and the changeover cost is lower compared to the dedicated line.

c) **Completely Flexible Line (CFL):** This line is flexible to a high degree. It has still lower capacity then the intermediate assembly line and yet larger unit cost of production. But the changeover time and the changeover cost is very low. This line is used to meet a sudden spike in demand or the demand for customized products in a short time span. Since this line is flexible, it can be used to even make up for a short fall in supply at another demand point.

When supply chain members can supply goods to all the other members of the supply chain at the next level, it is considered to have completely flexible relationship. Various flexibilities such as product, volume, routing and strategic will enhance quality of such relationships.

The following assumptions are made:

a) The automobile market is saturated or near saturation point, hence the companies are keen to protect their share of the market. Since they do not have a lot of potential customers, hence the organizations must lure the customers of the competition to expand its customer base. Hence, this fosters intense up one man-ship among the players and keeps every player on its toes to protect its market share.

b) The demand is uncertain due to various factors such as fuel prices hike, intense competition, increasingly less interval between new product launches, political factors etc. Although the growth rate is slow, but in a developed economy, the concept of two cars per home is growing since the people have the capital for it. Hence, if there is a new product launched, and then it may expect a huge demand depending on the quality of the product and how well it is accepted.

c) Although there are many more flexibility options which may be explored, but only three are considered since these three together have the maximum impact on the revenues of a supply chain.

d) The average time for production is the same for all assembly lines. It helps in simplifying the calculations for the performance measures.

The two performance measures taken to measure the efficacy of the proposed model are as follows:

a) **Unit Cost:** Only by keeping the unit cost in check can an organization make profits. It is a factor which is directly affected by the ups and downs in a volatile market. With the rise and fall of demand, an organization is hard put to meet the demand at the same unit price even though the production cost varies. Hence, it is important that the unit cost be controlled. Hence, it is considered to be one of the performance measures.

b) **The Number of Customers Satisfied:** One of the objectives is to maximize the number of customers who are satisfied. The reason we do not take the measure of minimizing the number of customers dissatisfied is that we cannot put a ceiling on the incoming demand since it is immeasurable.

There are two ways of improving customer service level. First is by decreasing the lead time and the second by keeping sufficient inventory. Decreasing the lead time is a more desirable option compared to holding inventory. Due to uncertainty in demand, it might be that the demand for a particular product might fall since a better product was introduced by a rival. Now the supply chain is stuck with a redundant stock. Whereas having a flexible line with short lead time gives the company the option to change the product being manufactured as and when the demand varies.

Flexibility and the Operating Capability of a Supply Chain

As shown in the Figure 2, as the flexibility increases, the capability of the supply chain to serve more number of customers also increases and hence, the feasible production range increases dramatically. With the increase in flexibility, the supply chain can satisfy more number of customers in an uncertain environment due to enhanced responsiveness.

This way, the potential revenues increase and the supply chain can grasp the opportunity to increase its customer base. At any given moment, the market has a product for which the demand is very high. The supply chain player can introduce a similar product using the CFL to capture those customers who are either dissatisfied with the product in demand or else they have not been serviced.

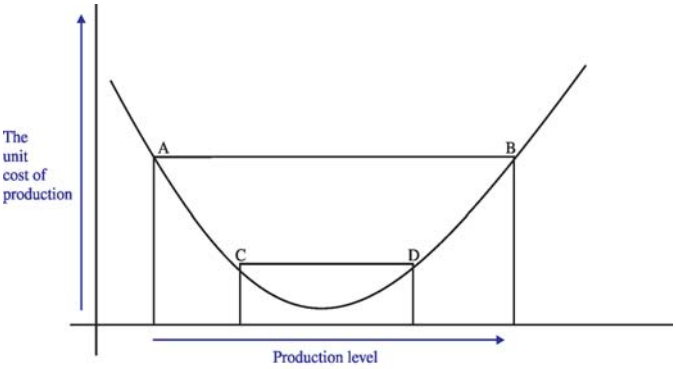

Figure 2: the relationship between production level and unit cost

Figure 2: The Relationship between Production Level and Unit Cost

Explanation for Figure 2:

- **AB:** It represents the area of operations where a flexible supply chain can make profits. Since the supply chain is flexible in terms of penalties levied and other such factors, hence the supply chain can make profits in a wider range of production level. This trait is essential to survive in the modern market.
- **CD:** The area under CD represents the area of operation for an inflexible or rigid supply chain. Since it has low flexibility, hence the area of operation of the production level decreases.

Flexibility can be assessed on unit cost and number of customers satisfied. Customer service level can be enhanced by decreasing lead time and/or by keeping sufficient inventory.

The balance to be achieved is between:

a) The sum of set up cost for the multiple assembly lines v/s single assembly line

b) Increased unit production cost and maintenance cost

c) The sum of opportunity cost. Opportunity cost is an unforeseen expenditure which has to be incurred for example due to machine breakdown or a rush to satisfy a sudden spike in demand.

d) Revenue earned due to satisfying demand early, holding or increasing the market share

e) Logistics flexibility.

The various variables that have to be taken into account for designing a model are:

a) The capacity of each line to be installed. The capacity would depend on how uncertain the market forces are.

b) The number of lines to be made depending upon the level of flexibility required at a certain production level.

c) The different ways a line is made to achieve flexibility.

An Illustrative Example

In the following section, we show how a particular manufacturer with multiple assembly line flexible configuration system would behave at different levels of demand. It depicts the behavior of the supply chain in a dynamic market scenario with uncertain and highly variable demand. As given in the Figure 1, we take a scenario of three suppliers, three manufacturers, three retailers and the distributor who is responsible for the logistics. The number of products being manufactured are assumed to be three namely product I, product II and product III.

Suppose the three lines of variable capacity are 500 units for CFL, 1000 units for IAL and 2500 units for the DAL. Now the behavior of a hypothetical supply chain organization with the demand is as follows:

a) When the demand is lower then 500 units: Then the manufacturer uses the CFL to satisfy the demand since it has lesser lead time then the others.

b) When the demand is between 500 and 1000 units: The manufacturer starts off with production on CFL to compensate for the long lead time of changing product at IAL. This way the manufacturer loses the minimum amount of customers. But the manufacturer has to take into account the time frame for satisfying the demand and whether the demand will continue or not. If it so happens that the demand is going to continue in the next season too then, the manufacturer might consider shifting the production to the DAL.

c) When the demand is between 1000 and 2500 units: The manufacturer starts off with production at CFL and then correspondingly shift it too IAL and then shift to DAL. This way, the manufacturer can absorb the suddenness of demand without incurring any extra cost and is able to retain maximum number of customers. Since the long lead time for the DAL and IAL are absorbed by the CFL. Plus any customization that may be required could be done at CFL to save more flexibility in the DAL.

d) When the demand is between 2500 and 3500 units: The manufacturer keeps shifting the production similar to the above case. Only here, it continues the production in both the IAL and DAL due to the high demand.

e) When the demand is between 3500 and 4000 units: The production goes on in all the three lines so as to satisfy the demand.

f) When the demand is above 4000 units: The retailer may request other plants to satisfy the extra demand. This can

be done readily using the CFL of the other plants.

g) **A change of product in demand:** This sudden change in demand can readily be absorbed by the manufacturer using CFL as long as it is small. If the sudden change is quite large, even then the retailer can ask the other plants to supply the products in a short time. This shows that the supply chain becomes more flexible with a flexible manufacturing configuration. Had a rigid manufacturing model been used, then the lead time of delivery from other plants would have been very large, which would have resulted in loss of potential revenue.

Either a plant is over utilized or it is under utilized. Both are adverse to the organizations profits. Over utilization diminishes the life of the plant no matter how zealously it is maintained. It also requires the organization to shell out more capital in terms of extra working hours allowance and higher maintenance costs.

The demand varies because the needs of the customers keep changing. Also, the competition keeps introducing new products at regular intervals in the market. Because of this, the demand might be created for the product due to its quality or its novelty value.

Analysis of the Model

The model on excel is based on the past demand in the market. It analyzes the past demand to set the volume and flexibility limits for the assembly lines. The simulation is done keeping the past demand in mind as a forecasting model has not been used here. The model on excel clearly shows that for a highly unstable demand environment, the three assembly line model not only leads to lesser production cost but also leads to higher customer reach. This production model absorbs the uncertainty of the market and hence provides the retailer with the flexibility to supply the customers satisfactorily.

As the flexibility increases, the capability of the supply chain to serve more number of customers also increases and hence, the flexible production range increases dramatically.

In a stable demand environment, though the production cost is higher, the three line production system still reaches higher number of customers. Hence the higher cost in a stabler environment is offset by the reaching larger number of customers.

a) The behavior as shown in Figure 3 is an indicator of uncertainty in demand. In this scenario, the three line production system not only achieves cost effectiveness but also satisfies more number of customers. It is shown by Figure 4. We see that series 1 is often higher then series 2 i.e. the total number of customers satisfied over a period is higher in case of multiple line production system. Series 1 represents the multi line production system and series 2 represents the single line production system.

b) The behavior as shown in the Figure 4 indicates stability in demand. In this scenario, the model though shows greater reach in terms of customer satisfaction, the production cost is higher. This was due to the higher flexibility provided with a single line which increases its lead time and hence the delay in its response to the future demands.

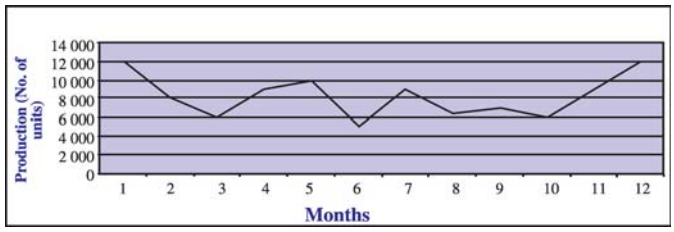

Figure 3: Dynamic Demand

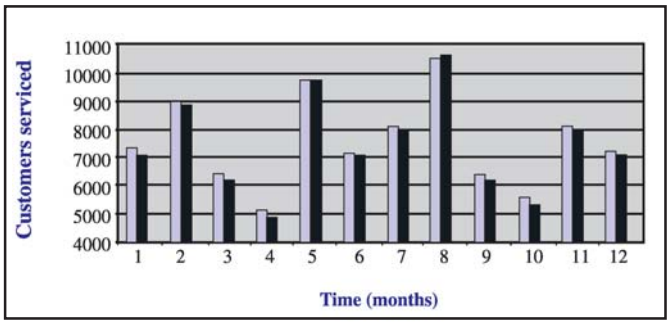

Figure 4: Customers Satisfied

Hence, the rudimentary mathematical techniques used here indicate that a multi-line production system is superior to a single line production system in many respects.

As shown in Figure 6, the number of customers being satisfied is still higher in case of multiple line production system then a single line production system. Although the total cost of production is higher for multiple line production system in case of stable demand environment, it can be compensated by the higher number of customers being satisfied. Series 1 represents the multi line production system and series 2 represents the single line production system.

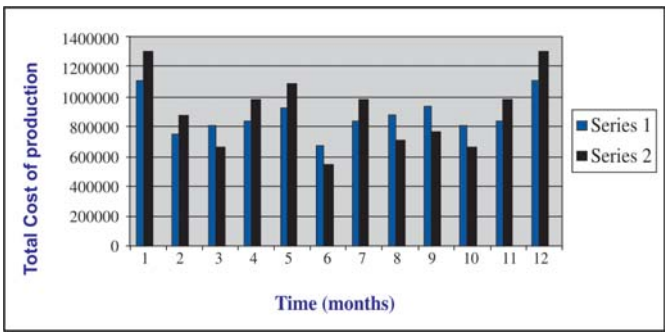

Figure 5: The Total Cost of Production for each Month

A more robust mathematical model taking into account many more factors would only lead to sharpen the contrast between the 3 line model and a single line model.

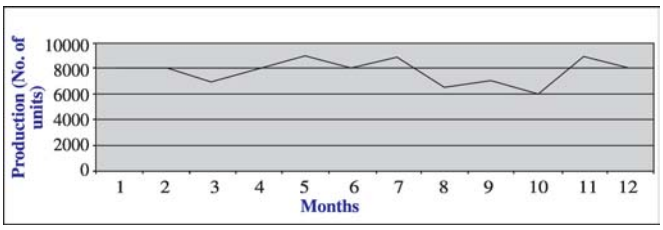

Figure 6: Stable Demand

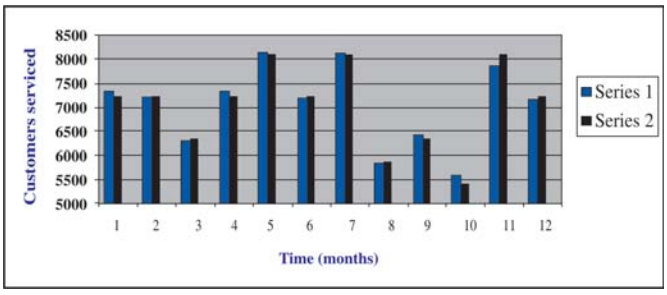

Figure 7: Customers Satisfied

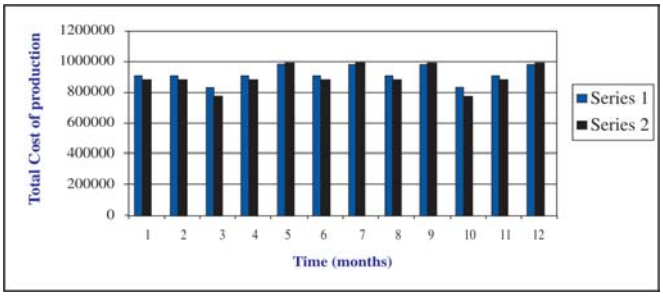

Figure 8: Total Cost of Production for each Month

Assumptions

The various assumptions taken in the excel model are:

a) The demand is for a single product only. The quick changeover ability of the 3 model system is not taken into account here.

b) The initial investment i.e. the set up cost is not considered in this model.

c) No forecasting model is used here. The use of forecasting would only increase the uncertainty and hence make the 3 model system more relevant.

Concluding Remarks

Although the manufacturing model provides a lot of flexibility, it also raises a lot of pertinent issues as follows:

a) The flexibility in the manufacturing plant would have to be matched by equally efficient service by the supplier which calls for a robust coordination between the various members. This avenue can be explored on how a supplier can efficiently send raw materials to satisfy the requirements of the different assembly lines.

b) While analyzing the effects of this model, not all the factors were taken into account like the change in unit time of production, the customers absorbed when the in a high demand situation, the production starts from the CFL while the other lines are being prepared etc. Forming a model by taking all these factors into consideration would only lead to a more stark contrast between a single assembly line system and a multiple line assembly system.

c) Instead of having more then one complete assembly lines, the option of having multiple sub-assembly lines in a single whole assembly line could also be explored. This would also necessitate the design department to be flexible. But having flexibility in design department would mean delay in launching of a new product in the market. Hence, a balance has to be looked for between the flexibility in design department as well as in the assembly lines.

Hence, we see that in a volatile market, the above mentioned manufacturing model lends the supply chain an unprecedented amount of flexibility which enables it to maximize the number of customers satisfied and also to minimize the unit cost while providing service to the customers. By providing flexibility locally, we have achieved global supply chain flexibility.

References

Kumar, V., Fantazy K.A and Kumar, U. (2005), "Implementation and management framework for supply chain flexibility", *Journal of Enterprise Information Management*, Vol. 19, No. 3, pp. 303-319

Duclos, L.K, Vokurka R.J and Lummus R.R (2003), "A conceptual model of supply chain flexibility", *Industrial Management and Data Systems*, 103/6, pp. 446-456

Prater, E., Biehl, M. and Smith, M.A (2001), "International supply chain agility tradeoff between flexibility and uncertainty", *International Journal of Operations & Production Management*, Vol. 21, No. 5/6, pp. 823-839

Chang, S.C., Chen, R.H, Lin, R.J, Tien S.W. and Sheu C. (2005), "Supplier involvement and manufacturing flexibility", Article in press (Elsevier)

Oke, A. (2003), "Drivers of volume flexibility requirements in manufacturing plants", *International Journal of Operations & Production Management*, Vol. 23, No. 12, pp. 1497-1513

Sanchez, A.M. and Perez, M.P (2005), "Supply chain flexibility and performance", *International Journal of Operations & Production Management*, Vol. 25, No. 7, pp. 681-700

Yusuf, Y.Y, Adeleye, E.O. and Sivayoganathan, K. (2003), "Volume flexibility: the agile manufacturing conundrum", *Management Decisions*, 41/7, pp. 613-624

Garavelli, A.C. (2003), "Flexibility configuration for the supply chain management", *International Journal of Production Economics*, Vol. 85, pp. 141-153

Sushil and Sharma, O.P (2002), "Issues in managing manufacturing flexibility", *Global Journal of Flexible Systems Management*, Vol. 3, No. 2 & 3, pp. 11-29

Huang, H.H (2002), "Integrated production model in agile manufacturing systems", *International Journal of Manufacturing Technology*, Vol. 20, pp. 515-525

Graves, S.C and Tomlin, B.T (2003), "Process flexibility in supply chains", Management Science, Vol. 49, No. 7, pp. 907-919

Sharma, O.P (2001), "Incorporating flexibility in manufacturing and operations: A case study in the Indian context", *Global Journal of Flexible Systems Management*, Vol. 2, No. 1, pp. 29-42

Gupta, A.B and Singh, T.P (2001), "Flexibility in an automobile manufacturing enterprise", *Global Journal of Flexible Systems*

Management, Vol. 2, No. 1, pp. 43-50

Dangayach, G.S. and Deshmukh, S.G (2001), "Manufacturing strategic perspective on flexibility: A case study of select Indian companies", *Global Journal of Flexible Systems Management*, Vol. 2, No. 2, pp. 21-30

Kumar, P. (2002), "A comparative analysis of flexibility practices in two world class companies- General Electric and Cisco", *Global Journal of Flexible Systems Management*, Vol. 3, No. 4, pp. 11-23

Rao, K.S and Wadhwa, S. (2002), "Understanding flexibility in supply chains: a conceptual framework and models", *Global Journal of Flexible Systems Management*, Vol. 3, No. 4, pp. 1-12

Questions

1. How manufacturing flexibility can be linked to supply chain flexibility?
2. What are the important performance measures /dimensions of flexibility?
3. What are the behavioral implications of manufacturing flexibility?

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Simulation Model

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Flexible Supply Chains: A Context for Decision Knowledge Sharing and Decision Delays

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Abstract

Building supply chains as flexible system represents one of the most exciting opportunities to create value. This requires integrated decision making amongst autonomous chain partners with effective decision knowledge sharing between them. For any decision process, one of the main inputs required is the available knowledge. Hence, it is important to have the actual real time knowledge for the decision process. Knowledge sharing has immense potential to offer, expedient opportunities to create and retain greater value for supply chains. In this context, knowledge management (KM) can be used as an effective approach to achieve knowledge sharing and decision synchronization in supply chains. To explore this in greater extent, we propose a decision knowledge sharing (DKS) framework based on decision and knowledge sharing in dynamic flexible supply chain environment. By exploiting DKS and flexibility in supply chain structures, better operational performance can be achieved. Considerable research efforts have been devoted to development of decision knowledge sharing framework in flexible supply chains (FSCs) environment, especially at operation levels, wherein decisions and knowledge delays have implicitly been assumed to be significant. Thus, there is need to model significant knowledge sharing delays in the decision process at the critical decision stages. In this paper, we focus on the knowledge, knowledge sharing, and decisions to study the impact of the decision flexibility, DKS and delays on the performance of the flexible supply chains. It is important because of relationship between control decisions and availability of knowledge in any DKS based FSCs. There is further a need to evolve a judicious use of decision flexibility at selected chain stages. Thus, a careful analysis of the chain with a focus on integrated decision is useful to ensure success. This paper presents this endeavor and highlights the key insights.

Keywords: decision flexibility, decision knowledge sharing, flexible supply chains, knowledge management

Introduction

The evolving supply chains (SCs) environment requires a judicious combination of flexibility, knowledge sharing, and decision making. As a result there is need to provide judicious selection of supply chain flexibility levels and stages. Thus, most real world supply chains having varying levels and types of flexibility, employ decision knowledge with dynamic changing ability of the system, so as to harness this flexibility when required. The dynamic SCs environment involves the following activities, related to the decision initiation, processing and implementation: (1) selection of dynamic parameters; (2) selection of major performance measures like cost, time etc.; (3) collection of actionable information (i.e. knowledge); (4) sharing of knowledge with other partners; (5) recognition of changes in the state of the system and determination of their impact; (6) evaluation of alternative opportunities; (7) judicious flexibility types; (8) selection of most suitable decision; (9) implementation of decision by providing necessary IT support. One of the important problems faced by the supply chain practitioners is the lack of proper visibility of decision knowledge sharing in dynamically changing SCs environment. This is due to the delays in knowledge and decision sharing and improper combination of flexibility and dynamic environment. This means the knowledge intensive activities depending on the level of flexibility and integration in a given SCs, they may also entail significant decision and knowledge sharing delays. The extent of these delays and their impact depends on the decisions system employed. Typically a knowledge sharing delay is associated with the available knowledge, due to the decisions involved in assessing the exact demand picture. A seemingly good decision, at a certain stage based on dynamic knowledge sharing often ends up, as not only detrimental to the total chain costs but also to the total cost of the stage itself. This indicates that the decision integration across the chain is a critical factor for ensuring success of the knowledge enriched chain. Thus, decision focused flexible supply chain models can help demonstrate the value of the available knowledge to the chain members. Based on the dynamic knowledge of the order, from the adjacent partner or other partners about the end customer's demand,

transformed demand, lead time, cost etc, decisions at each stage are made. This paper presents a three stage and four level Decision Knowledge Sharing (DKS) focused Flexible Supply Chains (FSCs) simulation model and highlights its key results along with its implications on the industry. The evolving Flexible Supply Chains (FSC_s) environment requires a judicious combination of flexibility and knowledge based integration. A great deal of research has been done in the area of SC_s dynamics. A widely used approach to study SC_s dynamics have been the system dynamics methodology (Knrsch and Timm, 1999). The interest here has been focused on examining the SCs response over time, to changes in its external environment. This has led to the development of SCs in dynamic environment, to reduce total cost, lead time, inventory, backorders etc by selection of best suppliers (e.g. for customer-selection of best retailer, for retailer-selection of best wholesaler etc). This problem is relatively new since many SCs are integrated together and complexity is created to manage decisions at each individual node. In real industrial practice, the SC partners mostly take the decision for own benefits rather then considering other SC members or benefit of entire SCs. We demonstrate this type of dynamic SC wherein explicitly assumed that the SC partners are free to take his decisions, which perhaps reduced the total cost of the entire SCs. When complexity increases (i.e. integration among many SCs), decision knowledge sharing (i.e. transform decision knowledge with dynamic switching) is more important rather than traditional information sharing. In the process of FSCs, the nodes are basically choosing immediate suppliers based on the given data and set of rules. The nodes dynamically select the best immediate suppliers to improve performance measure (i.e. in our case, total cost). To cope with the uncertainty in SC_s, we suggest a different level and stages of flexibility. As a further step in this direction, we developed a model of the DKS based flexible supply chain system and carried out simulation studies to understand the impact of flexibility and DKS on the performance of these supply chains system. Some of these studies are presented in this paper.

A seemingly good decision, at a certain stage based on dynamic knowledge sharing often ends up, as not only detrimental to the total chain costs but also to the total cost of the stage itself.

The paper is organized as follows. In section two background and motivation is presented. Section three describes the FSCs perspective. The role of information, knowledge and decisions is discussed in section four. Section five discusses the DKS framework followed by DKS delays in section six. Section seven presents the detail study of decision flexibility and DKS followed by results and discussion in section eight. Section nine discusses the key industrial and research implications. Section ten presents the conclusions.

Background and Motivation

In this paper we are motivated to study the supply chains from a decision focused perspective where each decision maker in the chain has a defined level of flexibility and DKS levels. This flexibility allows him to individually decide what to order from its immediate supplier. The decision is based on the available knowledge. The motivation for studying this chain has resulted from our background research on the judicious use of flexibility in supply chains. Wadhwa and Rao (2003) suggest the knowledge management (KM) in enterprise synchronization. They also discuss the decision information synchronization (DIS) for supply chains. They emphasis the information availability needs to be fully synchronized with the decision making. At an enterprise level the role of DIS is more challenging to synchronize entity in the flow process. Wadhwa and Rao (2003) have shown how improved decision knowledge can have significant impact on supply chain performance. In the light of the above, there is a need to study the performance of decision knowledge sharing in flexible supply chains environment. Inspired with these researches, our primary motivation in this paper was to emphasize the importance of explicitly modeling of DKS and decision and knowledge sharing delays in flexible supply chains when the SC environment is dynamic and flexible. Decision delays can manifest themselves in different modes and in each mode their decision knowledge implications are different. Literature indicates several efforts by researchers and practitioners to enrich this domain. However different authors addressed the issue from different perspective and used different methodology. In supply chain, activities are knowledge intensive and depending on the level of sharing and integration in a given flexible system, this may entail significant decision and knowledge related delays. The time leg between the starting of collection of information and making it available for decision process is referred as information delays and time lag between the time of invoking the decisions and its implementation is referred as decision delays (Wadhwa and Bhagwat, 1998). Also knowledge is a key for any company and needs to be disclosed very judiciously. That's why practitioners mostly assume penalty cost associated with knowledge sharing. Thus before embarking upon IT investment one requires a closer understanding of the value of information, knowledge and its role in supply chain dynamics (Browne et al. 2000). Most of the previous studies assume ideal information and decision synchronization conditions in manufacturing environment (Browne et al., 1996, Browne et al., 1998), and, therefore they do not explicitly address the dynamic switching between suppliers, flexibility, knowledge and DKS issues in supply chains. In the case of DKS based FSCs, while there are many studies, on information distortion and information sharing related issues, which indirectly reflects the transformed information or knowledge (i.e. decision knowledge sharing). The studies directly addressing the DKS are very few and rare. Keeping the above scenario in view, we highlight some of the important studies relevant to our

proposed framework. There is a need to enrich the studies on performance of supply chains under DKS delays conditions. Wadhwa and Rao (2000) defined flexibility as the ability to deal with changes by judiciously providing and exploiting controllable options dynamically. Golden and Powell (2000) defines flexibility as the capacity to adopt across four dimensions: temporal, range, intention and focus. Sushil (2000) defines flexibility as the exercise of free will or freedom of choice on the continuum to synthesis the dynamic interplay of thesis and antithesis in an interactive and innovative manner, capturing the ambiguity in systems and expanding the continuum with minimum time and efforts. Thus the concept of flexibility encompasses several notions. Wadhwa and Rao (2003) show some of the key notions of flexibility found in the literature and summarized in figure 1 which motivates us to extend this work, in similar directions with KM and DKS enrichment in FSCs.

Improved decision knowledge can have significant impact on supply chain performance.

It is expedient to view the research and practicing efforts in flexibility, in relation to change. Some change affects the performance; the enterprise must be able to provide an adaptive response. The growing realization in the industry and academic community of the importance of decision information synchronization can be gauged by the views expressed by various authors. However, most authors focused on reducing the information process times using the latest advances in information technology and structured communication methodologies. These authors do not explicitly focus on decision systems. Some recent authors realized that information alone may not improve the performance, and started discussing the decision automation. However, in our view, both information (i.e. in our case knowledge) as well as decision systems is important, but their synchronization with flexibility is more important. We identify this as an important research gap, and focus our research efforts in this direction. Our research efforts are motivated by the above identified research gaps. The next section focuses on this important issue.

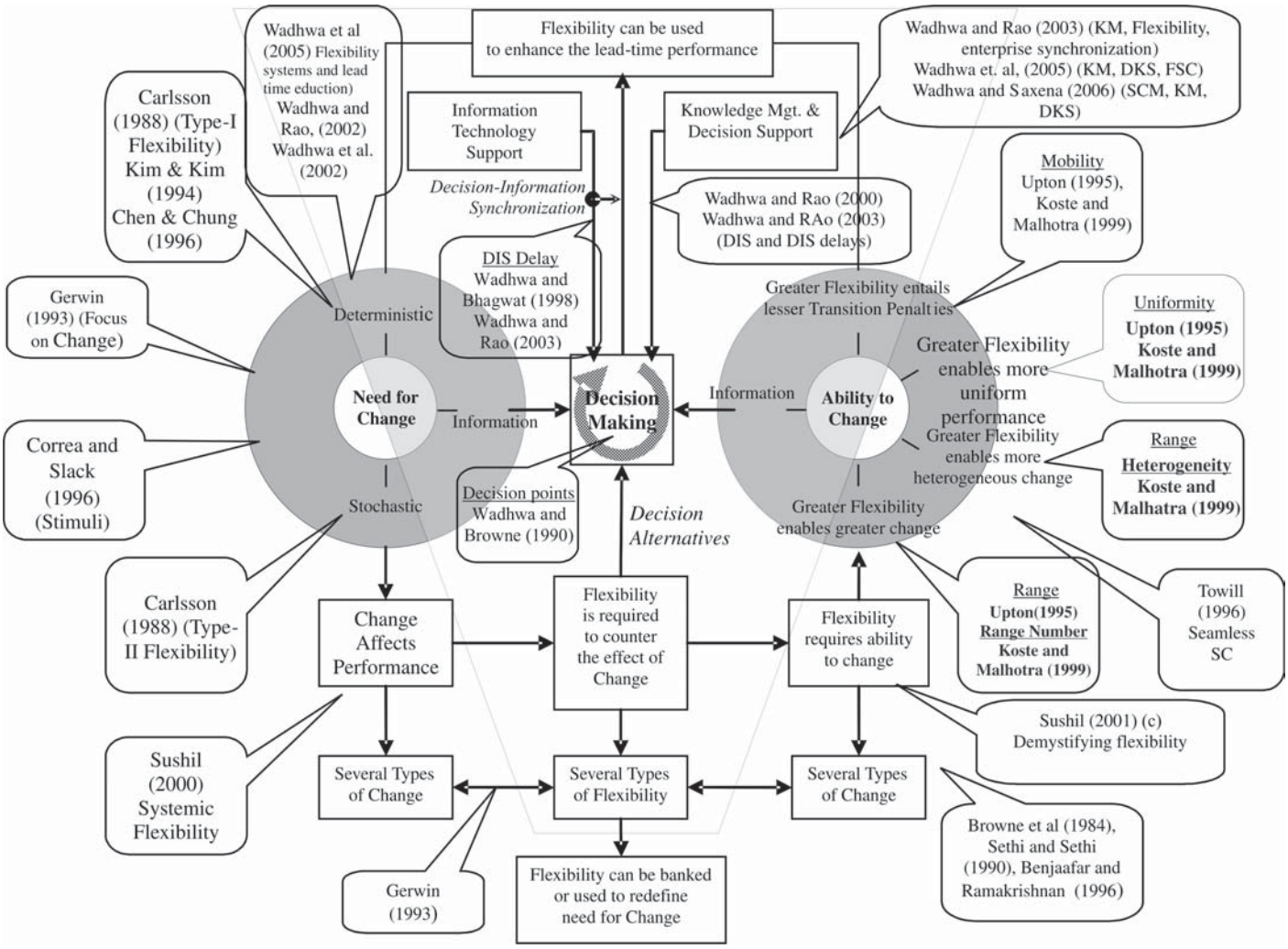

Figure 1: Some of the Key Notions of Flexibility in Literature and Our Background Research (Wadhwa and Rao, 2003)

Flexible Supply Chains: An Evolutionary Perspective

Flexibility is an important factor in manufacturing and supply chains. Browne et al. (1984) have identified various types of flexible manufacturing systems. The study draws several significant conclusions about how the system should be controlled. Sethi and Sethi (1990) provide extensive survey on flexibility in manufacturing. Wadhwa and Bhagwat (1998) discuss the issue of decision information synchronization in the context of various entities flows within the semi-computerized flexible manufacturing systems. These studies are indicating the need to focus on the value of recent information in flexible environment. In the literature, there are some studies addressed to evaluate the effect of flexibility configurations on SCs planning performance, such as lost sales etc (e.g., Albino et al., 2002). In this paper, like other simulation studies they focused on the flexibility of a single-stage production system (e.g., Garavelli, 2003), SC_s lead time and work-in process. Vickery et al. (1999) propose the following dimensions of SCs flexibility: product, volume, launch, access, target market, while Viswanadham and Raghavan (1997) consider: volume, mix, routing, delivery time, new product flexibility. Eventually, knowledge is considered the primary base in which the innovative capabilities of an enterprise are embedded. Managing a supply chain involves the flow of both tangible and intangible resources including materials, information, and capital across the entire supply chain (Bourland et al., 1996). Over and above, our focus is on flexible supply chains that encompass the SC partners worked in global and dynamic environment using varying flexibility types, levels and stages. In this paper 3-stage, four level full flexible supply chains have been modeled based on decision knowledge shared focused framework. The different levels from bottom up are customers, retailers, wholesalers, distributors, and manufacturers. The end product demand at the retailer level is independent, irregular and uncertain. Each level maintains certain inventory level to meet the unexpected demands from down stream members. The FSCs were modeled for incorporating no and full decision knowledge sharing between the nodes. Replenishment order is based on the type of knowledge sharing and sharing delay. No decision knowledge sharing refers to the situation where no interaction between individual supply chain members and each individual member has his own replenishment policies. Full decision knowledge sharing refers the case where decision knowledge is shared among all the supply chain members. The inventory positions equal the inventory on hand plus outstanding orders minus backorders. The transit time between any two levels is selected on the basis of least cost (e.g. air mode, sea mode, road mode and rail mode). Stock outs, if any are backordered. A penalty cost is incurred for each backorder occurrence. The inventory level can be viewed and accordingly order placed to upstream level only at the end of the day. The order placed by downstream member shall reach the upstream member immediately. A small variation at the front end of the supply chain can result in larger variations at the back end due to a phenomenon known as the bullwhip effect (Lee et al., 1997). As the ability to share knowledge across nodes in SCs, models are more versatile and useful if created on this platform (Cachon and Fisher, 2000). Motivated by these developments, we believe that real time simulation systems should be made more "friendlier" by using traditional and KM framework in SCM context. This paper attempts to use a supply chain, as a case to study, how to apply a java-based object oriented approach to real time simulation. SCs simulation involves the simulation of the flow of materials, information and knowledge through multiple stages of manufacturing, transportation, and distribution and they are used to take decision on the basis of the knowledge and information flow (Knirsch and Timm, 1999). It includes the simulation of the replenishments of incoming inventory and operation at each manufacturing stage, and shipments of the products from one stage to the next. A supply chain, often involves multiple companies across enterprise boundaries. Each of these companies may, already have its own simulation program to perform 'what-if' kind of analysis for its daily operation (Simchi-Levi et al., 1998, Tayur et al, 1998). In addition, to overcome this situation we associated some decision sharing cost in our simulation model. Figure 2 explore the framework of dynamic supply chains. The selection is based on the static and dynamic parameters throughout the supply chains. Dynamic supply chain configuration is beneficial when there are changes in cost of the products/services, resource availability, lead time, transport distances and customer demands.

Improved decision knowledge can have significant impact on supply chain performance.

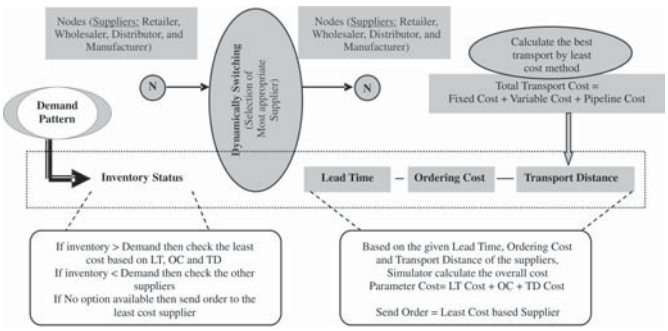

Figure 2: Framework for Dynamic Selection in Supply Chains

The associated properties are found being constant throughout the supply chains in all experiments. Inventory is the first check which decides, whether the supplier has sufficient quantity as per the order or not. The other parameters decide the selection based on least cost. The heuristics select the cost that allows least cost for a product to be released, taking into account the current demand and inventory of the player (i.e. SCs node). The heuristics then find the lowest expected cost at a given time, $E(TC)$, expressed as the sum of lead time based cost $(LT_c)_s$,

ordering cost $(OC_c)_s$ and transport distance cost $(TD_c)_s$ of the supplier μ_s and the product in process N, with queue NQ and path p of a given SCs configuration: Min. = ++.

We suggest the flexibility based framework for SCs using a simulation for demo cases (i.e. based on no flexibility, partial flexibility, and full flexibility configuration). We proposed decision flexibility for linear, 2-stage and 3-stage FSCs. The decision flexibility is further categorized into supply chain routing flexibility (SCRF) and supply chain resource type flexibility (SCRTF). Figure 3 shows the different level, stages and decision flexibility configuration involved in FSCs.

Both information (i.e. in our case knowledge) as well as decision systems are important, but their synchronization with flexibility is more important.

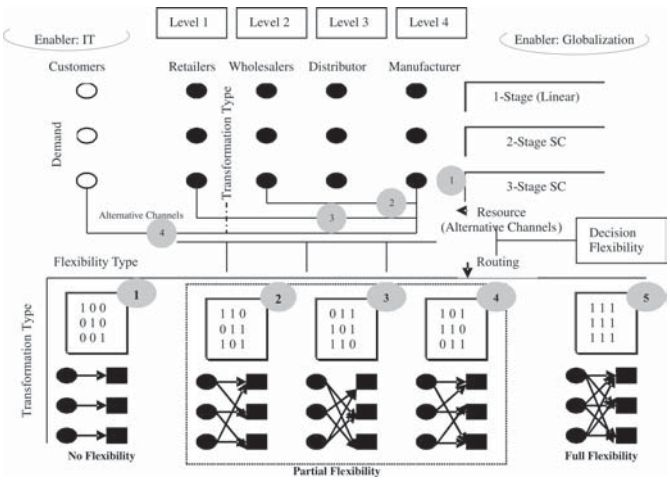

Figure 3: Flexible Supply Chains and Its Configuration

In order to gain some insights into the interrelationships between flexibility, DKS and DKS Delays, we have developed number of demonstration models of supply chains with flexibility stages, and carried out simulation studies. For the purpose of the above studies, we have developed a hierarchical simulation model of flexible supply chain system as shown in figure 4. At the highest level, the model comprises of a flexible supply chain system connected to the customers and suppliers. The flexible supply chain system accepts order from the customers, source the required material from the suppliers and fulfill the customers order in the best possible way. The flexible supply chain system comprises of a number of supply chains interconnected in parallel through an order management system. The order management system accepts the order for the entire supply chain system and depending upon the level of flexibility and the supplier selection criteria, allocates the order to different supply chains in a dynamic manner.

The DKS based FSCs simulator offers experimentation options with many controllable and uncontrollable variables. Thus knowledge can be generated, used and advanced. It allows adequate flexibility with respect to SCs nodes. Discrete event simulation models were developed for a typical decision knowledge sharing (e.g. no and full DKS) focused flexible supply chains (e.g. SCRTF and SCRF) scenario. The various models have been developed for simulation. Logistics models deal primarily with material flows at the various levels. It is at these levels where the transfer of materials is accomplished using some sort of transportation such as trucks, rail, boat, or plane. The logistics model includes order planning, transportation planning, and inventory planning, among others. Material flows in the supply chains are handled by the transportation systems, which in turn are governed by some time-cost tradeoffs. Four main types of transportation modes are considered as 1) Road Transport 2) Rail Transport, 3) Air Transport and 4) Sea Transport with following parameters:

- Speed / Transportation time per unit distance (S) S1 < S4 < S2 < S3 … (1)

This relation holds as Road transport takes highest amount of time and Air transport is the swiftest. Hence road transport has the highest pipeline cost.

- Transportation capacity (K) K1 < K3 < K4 < K2 … (2)

A truck for example has a capacity to carry a maximum of 100 units of a product. This parameter depends on physical constraints of the carrier.

- Transportation fixed cost (Cf) Cf3 = Cf2 < Cf1 < Cf4 ... (3)

This is the fixed cost that the transport agency will charge for each transport project depending on the distance of transport.

- Transportation variable cost (Cv) Cv1 < Cv4 < Cv2 <

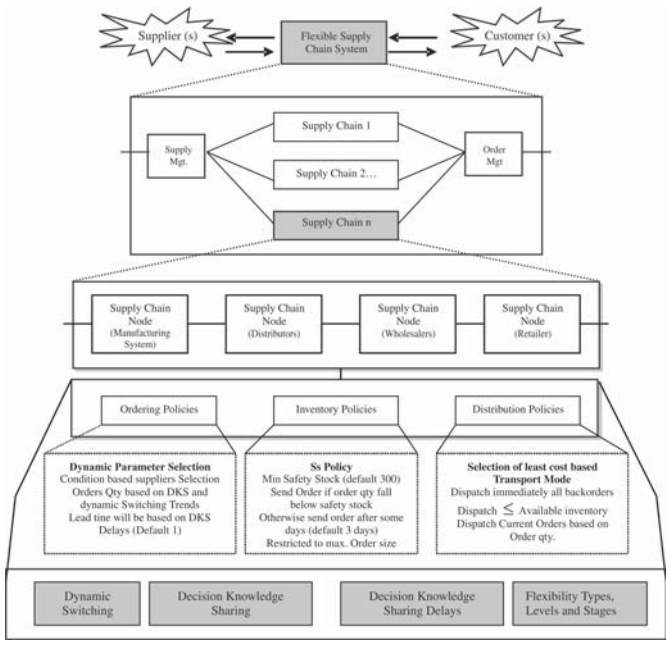

Figure 4: A Hierarchical DKS Enriched FSCs Simulation Model

Cv3 … (4)

This is the cost that varies with the number of items to be delivered. The transport agency will also take into account the distance of transport.

- Total Transport Cost TC = Cf + Cv + Cp …(5)

Cp is the pipeline cost that the sender bears. The total cost can be calculated once we have the distance of the destination and the number of items to be delivered.

Inventory holding cost (I) is viewed as: if 'N' is the number of items in the inventory and 'IPD' be the cost of keeping 1 item for a day, I = N * IPD … (6)

Backlog cost (B) is seen as if 'M' is the number of items in backlog and 'BPD' is the cost of backlog of 1 item for a day, B = M * BPD … (7)

Transportation cost (T) is the sum of all the transportation cost for the day.

T = © TC_i for all i on that day … (8)

Total Cost (CT) at j_{th} day CTj = CTj-1 + (I + B + T) j … (9)

Shortage Order (So) = Backorder – Inventory-Order ion Transit … (10)

Dispatch = Backorder (if Inventory >= Backorder) else Dispatch = Inventory … (11)

Production = Order size (If order size <= Capacity) else Production … (12)

The total cost of the system is the sum of cost of all nodes and cost of each node is

Total Cost = Transport cost + Order in transit cost (Pipe line cost) + Backorder cost + Inventory Cost … (13)

The DKS framework incorporated for the retailer, wholesaler, distributor, and manufacturer were similar. The decision makers at each of these stages have the flexibility to decide the inventory levels and reorder quantities. The overall decision logic deals with stocking, ordering, and shortages. The decision maker exercises his flexibility to determine the level and type of DKS in a given scenario. Decision process models specify various management decisions that are made throughout the chain. Examples include: Location selection (Which supplier is best to produce and distribute?), Inventory planning (Where and how much inventory should be stored?), Load planning (How is the workload handled by each supplier?), Distribution planning (When and how much volume of end products or component parts should be transported and by what mode?). In our opinion all these problems entail decision flexibility. The simulation logic is given in figure 5 to explore the features of the model. The model associates the basic component (i.e. Inventory, backorder, order in transit, etc) into the supply chains. The order policy is based on the forecasting which takes the average of initial demands. The model can deal with different SC_s configurations. The figure 5 also explains the detail of each static and dynamic factor based on the changing environment.

Real time simulation systems should be made more "friendlier" by using traditional and KM framework in SCM context.

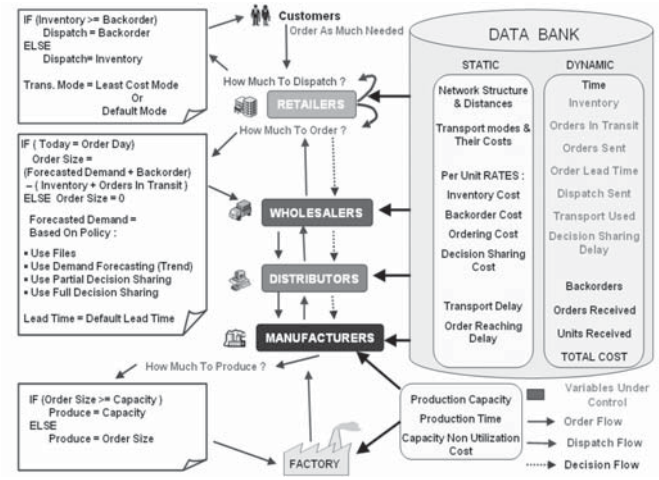

Figure 5: Simulation logic to Flexibility and DKS based Supply Chains

The role of simulators is considered useful, For example; Wadhwa and Browne (1989) indicate the decision flexibility can be properly exploited through decision points where the control rules must be implemented at the operation level. Our SCM simulation model encompasses all the essential features regarding information, decision and knowledge sharing with other parameter which improvise the performance of supply chains. The success of SC_s depends on whether the decision knowledge sharing is effective or not. To maximize competitive advantage, concept of SCs is emerging for encouraging the market place knowledge to move through the supply chains as effectively as possible with Knowledge Management (KM). KM provides new opportunities to create and retain greater value from SC_s based on core business competencies. This offers immense opportunities that can best be exploited by judicious decision making along the supply chain. One way of looking at knowledge is that it allows for making predictions, casual associations, or predictive decisions about what to do, unlike the information that simply gives us the fact. In a similar direction, Wadhwa et al. (2005) presents the potential of applying green supply chains that may incorporate environmental attributes through KM. They developed KM focused supply chains simulators in flexible environment that may encourage knowledge sharing and cost of environment impact. FSC_s are composed of many flows guided by autonomous entities or nodes. It is proposed that such chains can significantly benefit from effective decision knowledge sharing strategies guided by KM initiatives across the entire chain. In the light of the above, there is a need to study the performance of decision knowledge

sharing in flexible supply chains environment. Thus, we developed the concept of Decision Knowledge Sharing (DKS) which facilitate the FSC_s, modeling. Considerable research efforts have been devoted to the development of decision knowledge sharing and FSC framework. Wherein, decision and knowledge sharing delays have implicitly been assumed to be significant. For the purpose of exploiting Decision flexibility, DKS, and DKS delays concepts, simulation based demo models are developed.

The Role of Information, Knowledge and Decisions in FSCs

It is important to understand the distinction between data, information, knowledge and decisions. Data is the existence of statements of facts (or simple plain truths). Information is the interpolation of relevant data in view of specific objective. Wisdom of the interpreter uses the information to gain knowledge. So, actionable information is knowledge. Knowledge is used by the common sense and intelligence of the user to make a decision in view of several goals, objective, considerations, constraints, circumstances and futuristic visions. The key to success of managers lies in his ability to draw the line between information and interference i.e. between relevant and non relevant information. Our focus is on the decisional knowledge and flexibility of each decision making member of the chain. The traditional supply chain does not offer the possibility of reviewing the end customer demand picture at various decisional stages. In practice each decisional stage has generally the possibility of accessing the end customer demand picture from its preceding stage during a mutually acceptable decision sharing period. We are therefore motivated to study such a decision knowledge shared focused supply chain to achieve seamless performance by wide integration and collaboration. The practical difficulties to get benefits from information sharing in present environment are shown in figure 6. We have considered flexible supply chains in which we elaborate the flexible decision stages and their implications in information and decision knowledge sharing.

The DKS based FSCs simulator offers experimentation options with many controllable and uncontrollable variables. Thus knowledge can be generated, used and advanced.

Decision Knowledge Sharing encompasses three basic elements i.e. information, knowledge and decisions. Information is the term most rarely used because it is used in the background of the process. The extracted useful information which called as knowledge is used for knowledge sharing purposes. Decision invokes when extracted knowledge is received at the other end. Decision making involves the predetermined rules and extracted knowledge considering the benefits of the current supply chain players. Eventually the aim is to reduce the individual player and supply chain cost. Previous research says that supply chain players integrate with each other by information sharing. But in real industry practice the

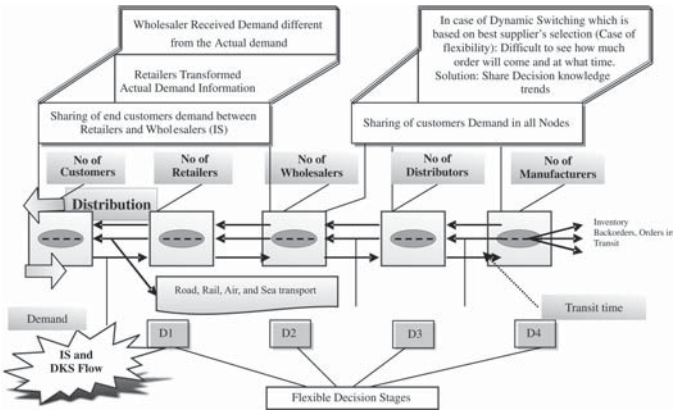

Figure 6: Flexible supply Chains: Moving towards Information Sharing to Knowledge Sharing

relations are dynamically changed according to the individual member's requirement. In other words, it is a combination of multiple supply chain integration with each other to get the individual benefits. We suggest that, in dynamically changing supply chain environment, knowledge sharing is more important then information sharing. The knowledge is extracted from the information based on the dynamic parameters. In step wise fashion, partner who receives the order from customer or immediate partner shares the detail information to the successor partner i.e. end customer demand, lead time, order time etc. Now this successor partner has to take the sourcing and distribution decisions. Normally, partner delivers the order to the immediate customer who creates the demand, so the distribution is almost decided. But sourcing is normally a difficult task. In dynamic supply chain there may be number of available partners where orders can be placed. To decide this, industry may select few important parameters, which vary from supplier to supplier. Based on the dynamic condition and current user requirements, the order is placed to the most feasible supplier. This creates uncertainty in demand. Even if organization share the information, it is difficult to assess the actual demand because organization may change this demands for his individual benefits. Here we suggest the decision knowledge sharing, where decision may be based on transformed actionable information (called knowledge). In knowledge sharing, partners shares the decisions and transformed demand with each other. This gives a clear picture of dynamic switching and to chances of getting the orders from the immediate customers (SC Partners). By using this transformed information or knowledge, user can schedule his planning and make better decision making. We present one such paradigm shift through DKS modeling and extending this is to incorporating DKS Delays. We expedient, this is useful for effective supply chains planning and functional process improvement, which will further reduce the overall cost.

Decision Knowledge Sharing Framework

Decision knowledge is crucial to the performance of FSC_s because it provides the platform for decisions in which, knowledge enablers actively participate to make decisions. Initially supply partners can clarify various issues like what type of knowledge is required and up to what extent. Information technology consists of the tools used to gain awareness of this information and to analyze the information to make the best decisions for the FSC_s. Walsh and Michael (1999) have discussed similar information and knowledge flow aspects. However, DKS framework emphasizes greater focus on knowledge sharing. For instance, knowledge transfer is very important in supply chains simply because it enables, integration of knowledge that is spread across each of the nodes, to facilitate smooth flow of entities leading to improved SCM synchronization. This also helps choose the best available option when involved in making upstream as well as downstream decisions. Figure 7 shows a conceptual framework for decision knowledge sharing between two different nodes and highlights the importance of DKS (with decision flexibility) in enterprise wide nodes. The concept of DKS is suggested as combination of KM-Flexibility-Dynamics switching approach to manage supply chains effectively. This helps to overcome the limitation of information sharing and shows better cost based performance. One important test for the success of DKS approach is that it must give result in improvements towards enterprise synchronization. This is possible by increasing flexibility and dynamics of supply chains. In short we can explore DKS is: Collaborative Modified Information Sharing + Trends of Dynamic Switching. We evaluate the trends of expected demands and dynamic switching of nodes and decide the policy of supplier node based on this pattern.

The DKS model allows various forms of flexibility and is motivated by Wadhwa and Rao (2000) and Wadhwa et al. (2005) that suggest manufacturing and supply chain flexibility to be seen as an ability to deal with change by judiciously providing and exploiting controllable options dynamically. For instance in DKS model the structural flexibility is reflected by a choice of a node to form a given SC_s configuration. Das and Malik (2003) modeled SC_s flexibility of order quantities and lead times. Further an SC node can also participate in several supply chains. The decision knowledge is embedded in various knowledge processes to enhance SC_s effectiveness. In other words knowledge is the key to the success of a supply chain as it affects decisions. The KM takes the entire chain into account to minimize the cost of individual SC partner and subsequently leading to reduce the cost of entire supply chain. At each node, the process begins by collecting knowledge about the nodes in the next stage upstream. We use some of the concepts of proactive knowledge management proposed by Wadhwa and Rao (2002) to evolve

One way of looking at knowledge is that it allows for making predictions, casual associations, or predictive decisions about what to do, unlike the information that simply gives us the fact.

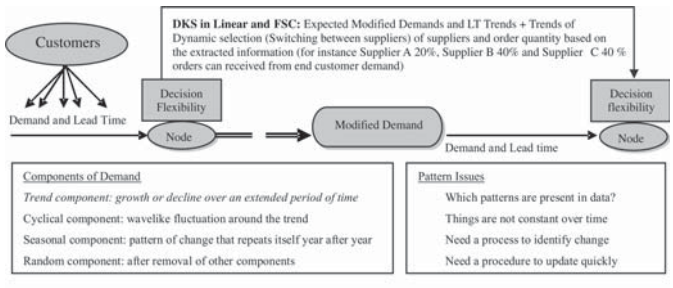

Figure 7: Conceptual Framework for Decision Knowledge Sharing (DKS) between Two Nodes

a novel framework supported by decision toolset to evolve KM guided SCM efforts in Industry. Furthermore, since suppliers are distributed across the globe, communicating information and transporting material can be costly and time consuming. Therefore, the proposed architecture must support communication protocols to allow worldwide knowledge transfer. The DKS simulator offers experimentation options with many controllable and uncontrollable variables. Thus, knowledge can be generated, used and advanced. It allows adequate flexibility with respect to SC_s nodes.

Decision Knowledge Sharing Delays Focused FSCs

In the context of supply chain management, information flow and decision-making have been the focus of research for several years. Literature indicates several efforts by researchers and practitioners to enrich this domain. However, different authors addressed the issue from different perspectives and used different terminology. Wadhwa et al. (2005) presents the results of a conceptual study and simulation experimentation aimed at understanding the underlying mechanisms of knowledge shared supply chains. Here, it is important to highlight that many systems offer decision options without actually referring to them as a form of flexibility. For instance, Chan et al. (2004) deal with the order-distribution decision in a demand-driven collaborative supply chain, without referring to this as flexibility. From the literature review it appears that the important developments in this domain have occurred in three phases; the first phase with a focus on reducing information distortion, the second phase with a focus on enhancing the levels of information integration, and the third phase with a focus on supply chain decision knowledge synchronization. The third phase is still in development phase. Several authors have articulated this need in an implicit manner. For instance, in an excellent paper on time compression in supply chains, Towill (1996) discusses about information and decision systems as important constituents of a supply chain. He observes that the operation of supply chains is complicated because of the quality of information and with the time delay associated with the many transmission lags (both for material flow and

information flow). Similarly, the word "transmission lags" indicates the fact that it takes finite amount of time for information and knowledge to flow from the point of its origination to the point of its utilization (decision points). Similarly, the author emphasizes the fact that decisions are made in the light of available information, which indicates the importance of making available the latest information at all, the decision points. A decision point essentially comprises of two key elements, namely an knowledge flow process (K) and a decision flow process (D). A decision is made at time t_n by invoking the decision flow process D_n. The decision flow process arrives at a decision by making use of knowledge available to it at that point of time. However, the knowledge is generated by the knowledge flow process K_n which is independent of the decision flow process. Hence, the knowledge available to the decision flow process may not correspond to the point of decision-making. In addition, both the knowledge flow process as well as the decision flow process takes finite amount of time to complete their respective processes. This gives raise of delays, which we call as Decision Knowledge Sharing Delays (DKS Delay). Based on this perception a generic view of the decision point has been developed. Figure 8 presents the generic view of a typical decision point in a supply chain.

Actionable information is knowledge. Knowledge is used by the common sense and intelligence of the user to make a decision in view of several goals, objective, considerations, constraints, circumstances and futuristic visions.

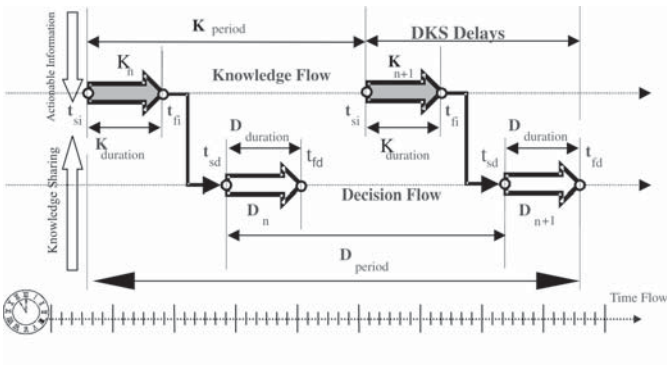

Figure 8: A Generic View of a Decision and Knowledge Flow (DKS Delays)

The generic view of the decision point is based on a perception that the information flow and decision flow are independent and concurrent, each with its own flow process duration and flow process periodicity, and there may also be a phase difference between these two flows. In the generic view shown in Figure 8, K_n and K_{n+1} represent the nth and $n+1^{th}$ information epochs and, D_n and D_{n+1} represent the nth and $n+1^{th}$ decision epochs. $K_{duration}$ and $D_{duration}$ represent the information and decision flow process durations respectively. K_{period} and D_{period} represent the information and decision flow process periodicity respectively. The DKS Delay at a decision point comprise of the following basic constructs: Knowledge flow process duration ($K_{duration}$): This is the time taken by an knowledge flow process to complete its process. It is measured as the time elapsed between the start of the knowledge flow process (t_{si}) and the finish of the knowledge flow process (t_{fi}). The magnitude of the knowledge flow process duration depends up on the level of Information Automation. (b) Decision flow process duration ($D_{duration}$): This is the time taken by a decision flow process to complete its process. It is measured as the time elapsed between the start of the decision flow process (t_{sd}) and the finish of the Decision flow process (t_{fd}). The magnitude of the decision flow process duration depends up on the level of decision Automation. (c) Period of knowledge flow process Cycle (K_{period}) (d) Period of decision flow process cycle (D_{period}). Using the three types of flows viz., information flow, decision flow, and knowledge flow, described above, several DKS Delays scenarios can be modeled. The conceptual framework for DKS has been synthesized by relating the knowledge and decision flow processes in terms of their flow process durations and periods, in the context of a generic decision point. A decision is made by invoking the decision flow process, which in turn makes use of the knowledge generated by a knowledge flow process. These two processes may flow independent of each other in a cyclic manner, with their own durations and cycle periods. The magnitude of these durations and cycle periods depends on the level of knowledge and decision automation available in the system. In spite of large scale IT based automation, in our view, most of the real life manufacturing and supply chains operate in semi-computerized environments. This gives raise to various modes of DKS Delays. In such an environment, DKS Delays are important barriers for the success of IT based strategies. Hence, our focus is on understanding of these delays and the various modes in which they may manifest in a supply chains environment. The development of proposed conceptual framework is a step in this direction. Thus, several possibilities exist for the magnitude of durations and periods, and their combinations will result in various modes of DKS delays.

Study of Decision Flexibility, DKS and DKS Delays in FSCs

The objective of the studies is to gain some insights into two important aspects of the supply chain systems, viz., (a) the possible influence of different types of supply chain flexibility (with or without DKS) on the performance of the supply chain system and (b) how this influence may be modified by various modes of supply chain DKS delays. Accordingly, we present some interesting results obtained from a series of studies carried out in this direction. The series of studies include three sets of studies viz., studies on the influence of supply chain resource type flexibility (SCRTF), supply chain routing flexibility (SCRF) and DKS (with or without delay) on the supply chain cost

performance. Resource type flexibility refers to the ability of alternative resource types to perform a given type of process. This type of flexibility refers to situations where a given resource type may be able to provide more than one type of processes (figure 9). In a supply chain context the resource types may be supply chain nodes representing raw material suppliers, manufacturers, warehouses, transport agencies, distributors, wholesalers, retailers etc., and processes provided by them may be the raw material supply, manufacturing, storage, transportation, distribution, wholesale and retailing respectively. Hence providing resource type flexibility in supply chain systems require modelling situations where, for example, a manufacturer may also perform the process of distribution, wholesaling, retailing etc., i.e., existence of alternative channels for knowledge and product flow. The emerging e-commerce practices are examples for this type of flexibility. Accordingly, this type of flexibility has been modelled by providing alternative channels for knowledge and product flow in supply chains. Under the conditions of no flexibility, the knowledge and product flow though the regular channels of end customer to retailer to wholesaler to distributor to manufacturer, whereas under the conditions of flexibility the wholesaler, retailer, or even the end customer may be able to directly order and obtain materials from manufacturer. The level SCRTFL=1 indicates the condition of no flexibility. The level SCRTFL=2 refers to a condition where one alternative process type can be performed by a given resource type, that is one level of flexibility. Under this condition, there will be an alternative channel for the flow of knowledge and product between the wholesaler and the manufacturer, and the process of distribution will be performed by both the distributor as well as the manufacturer. When SCRTFL=3, there will be an alternative channel for the flow of information and materials between the retailer and the manufacturer, and the process of wholesaling is being performed by both the wholesaler as well as the manufacturer. When SCRTFL=4, there will be an alternative channel for the flow of information and materials between the end-customer and the manufacturer, and the process of retailing is being performed by both the retailer as well as the manufacturer. The number of levels of supply chain resource type flexibility that can be modeled is limited by the number of resource types and the number of process types. During this study, we have assumed four resource types performing four process types. Therefore, we could model up to four levels of supply chain resource type flexibility as discussed above. For the purpose of this study, two specific assumptions are made. The first one is regarding the supply chain flexibility and the second one is regarding the supply chain DKS delays. The supply chain system is assumed to possess only the supply chain resource type flexibility and all other types of flexibility is assumed to be insignificant. Similarly, the DKS flows of the supply chain system are assumed to be real-time i.e. one day.

One important test for the success of DKS approach is that it must give result in improvements towards enterprise synchronization.

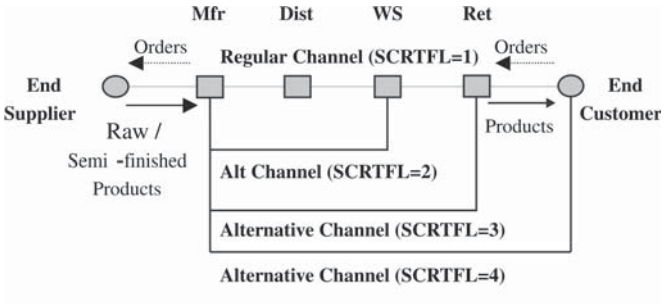

Figure 9: Supply Chain Resource Type Flexibility (Decision Flexibility)

Routing type flexibility refers to the availability of alternative resources of the same resource type, i.e., having more than one resource of the same type. This type of flexibility refers to situations where more than one type of resource of a given type exists. Accordingly, this type of flexibility has been modeled by providing multiple resources of the same type available in the supply chain as shown in figure 10.

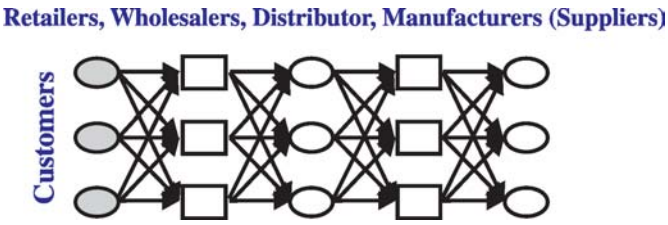

Figure 10: Supply Chain Routing Flexibility (Decision Flexibility)

For the purpose of these studies, the supply chain routing flexibility (SCRF) is modeled through the existence of alternative suppliers (retailers, wholesalers, distributors and manufacturers) capable of handling a given product. Under the conditions of no flexibility (i.e. SCRF=1) product is handled by only one type of supplier, where as under the conditions of flexibility (i.e. SCRF=5) product is handled by more than one type of suppliers. Under the condition of partial flexibility (i.e. SCRF-2, 3, and 4), product is handled by limited number of suppliers. The effect of this flexibility on the supply chain performance has been studied.

Results and Discussion

Results of the studies address three research questions. The first question is how does the decision flexibility with or without DKS influence the cost performance of a supply chain system that encompasses it? The second question is how does the DKS delay modify the influence of flexibility and DKS on the performance of supply chain system? The third question is how does the flexibility stages with or without DKS influence the performance of the supply chain

system?

The results of the simulation study on the above questions are shown in figure 11 and figure 12.

The results for supply chain resource type flexibility indicate that; (a) the supply chain costs drastically decreases with the increasing levels of supply chain resource type flexibility but the combination of DKS and flexibility reduced the cost monotonously (b) this influence is not uniform at all the levels of the flexibility (c) SCRTF= 2 is highly influence the SC performance and then effects constantly (d) SCRTF=4 and DKS further greatly effect the performance due to the reduce distortion of demand and (e) Initially, in the SCRTF=1, the performance of with out DKS is far below then with DKS but as flexibility increases the performances of flexibility comparatively increases then DKS. The results indicate that the influence of supply chain resource type flexibility on the supply chain cost is comparatively strong and very significant. However, the benefit due to this type of flexibility could be realised only when the bottleneck is in the main channel. In supply chain routing flexibility, results indicate that, (a) the benefit of cost reduction decreases with increasing levels of DKS and flexibility based combination supply chain routing flexibility (i.e. from partial to full flexibility), (b)major cost reduction is achieved when partial flexibility configuration is used and then further little cost reduction is achieved in full flexibility configuration, (c) partial flexibility options gives almost same percentage of cost reduction in all configuration, (d) the first level of supply chain routing flexibility (SCRF=2) provides the greatest benefit followed by lower and lower benefits at subsequent levels (e) DKS provides significant impact in all flexibility cases to reduce SC cost drastically (f) In DKS case, greater impact is achieved in SCRF=2 case (g) Partial flexibility (SCRF=2,3,4) is more significant when we used DKS, instead of without DKS case (h) SCRF=2 shows very close results to full flexibility (SCRF=5), which motivate us to judicious use of partial flexibility and DKA levels (i) impact of full flexibility and DKS is less compared to without DKS. The results shown in figure 12 indicate that the effect of DKS delays in SCRTF and SCRF types of decision flexibility. In supply chain resource type flexibility with DKS Delays, results indicate that, (a) DKS Delay (DKS delay=1 to5) significantly influence the performance SCRTF=1 (b) the effect of DKS Delay is far less in SCRTF=4 (i.e. negligible), (c) the effects of DKS delays in continuous decreasing

A decision point essentially comprises of two key elements, namely a knowledge flow process (K) and a decision flow process (D).

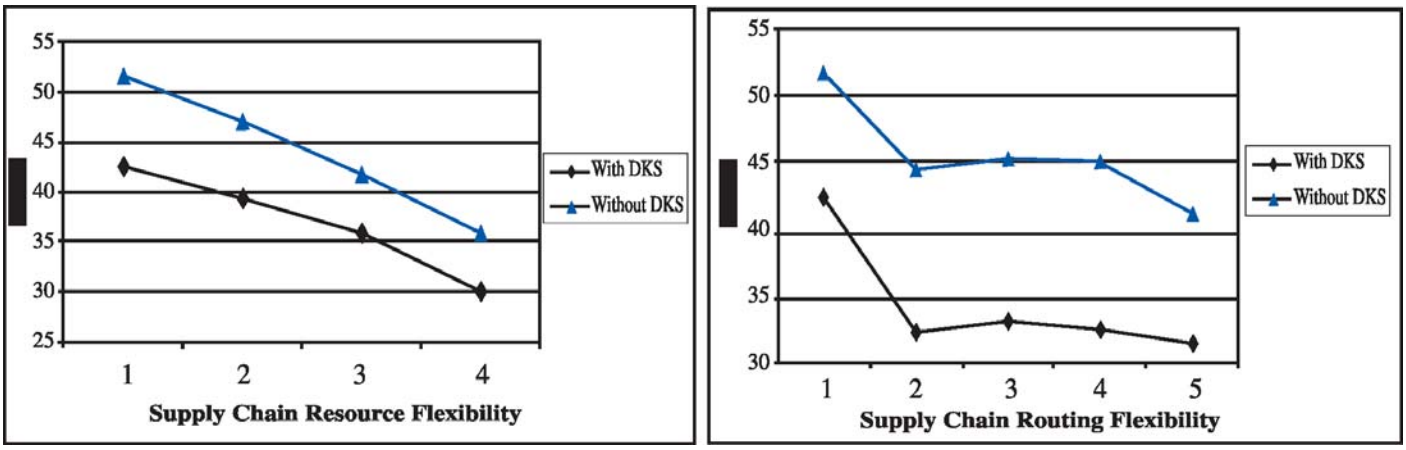

Figure 11: SCRTF and SCRF Influence on with and without DKS based Flexible Supply Chains

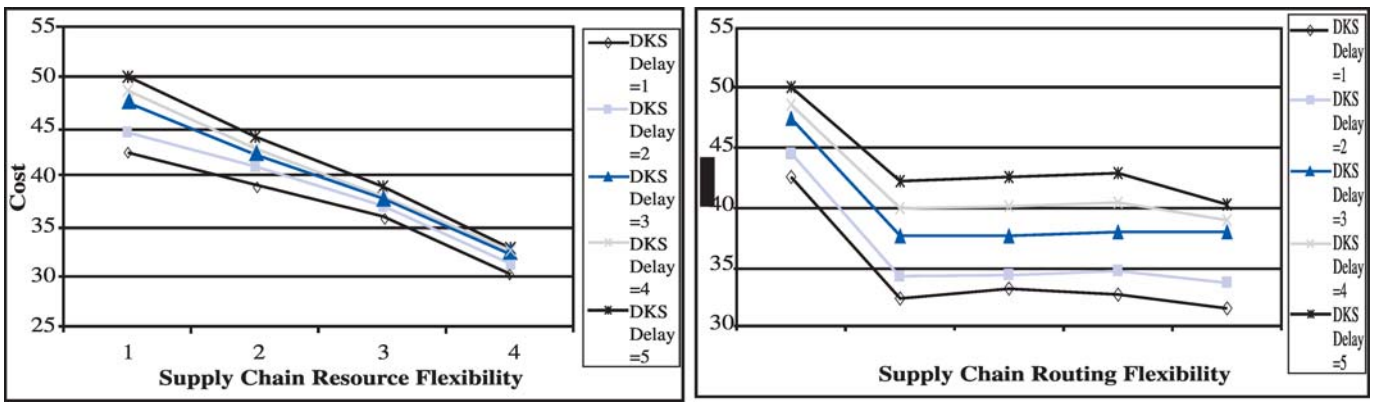

Figure 12: SCRTF and SCRF Influence on Flexible Supply Chains with DKS Delay

manner from SCRTF=1 to 4, (d) From DKS delay=1 to 2, its influence on SCRTF is more and then reduce constantly, (e) it is observed that the performance of SC is more influence by SCRTF levels rather then DKS delays. As the magnitude of DKS delays increases, the cost at all the levels of flexibility increases. However, this increase in cost due to DKS Delays being much lower as compared to the decrease in the cost due to flexibility. In supply chain routing flexibility with DKS Delays, results indicate that, (a) SCRF=2 (Partial Flexibility) highly influence the SC performance with DKS delays, (b) The effects of DKS delays is observed more then the effects of flexibility (c) DKS delay =2 significantly influence the performance of SC, (d) the increase in DKS delays is less influenced (i.e. deteriorate) the SC performance (i.e. from DKS delay=3 to 5 SC cost constantly increased. The results indicate, that the effect of DKS delay on the supply chain cost is very strong and equally significant as compared to the effect of supply chain routing flexibility. The interaction between the partial SCRF and DKS delays appear to be very strong and significant as compared to full flexible SCRF. In a broader canvass, results show the wider benefits of DKS with flexibility and emphasis on judicious selection of flexibility levels, DKS levels, and DKS delays. It is further observed that flexibility continuous to be beneficial at all the levels of DKS delays studied. The results also show the wider influence of DKS and flexibility over performance of individual performance of supply chain players (i.e. performance of retailer, wholesaler, distributor and manufacturer). Figure 13 support our view in this direction.

Several possibilities exist for the magnitude of durations and periods, and their combinations will result in various modes of DKS delays.

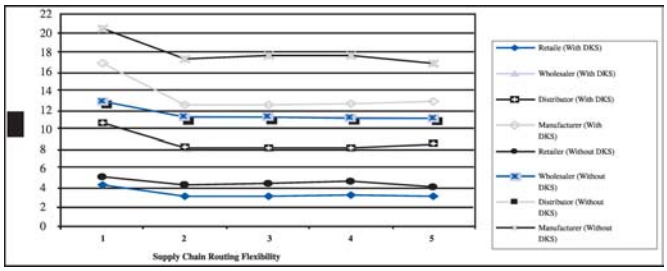

Figure 13: Effects of DKS and SCRF on Individual Supply Chain Partners Performance

The result of flexibility levels and DKS performance is also studied. The total system cost in DKS mode is reduced by 23.75%. The manufacturer's total cost is also improved drastically (i.e. 27.25%, for manufacturer 3, 21.73% for manufacturer 2and 16.17% for manufacturer1).The performance of distributors is improved by 16.59%, 14.93%, and 17.54% for distributors 1, 2 and 3 respectively. The performance improvement for wholesalers 1, 2 and 3 is 20.49%, 14.09% and 17.20%. The performance of retailers is improved by 27.60%, 21.75%and 28.15% respectively. As we move from no flexibility to two-stage flexibility and then 3 stage flexibility, we find drastic performance improvement in results. The 10.22% improvement is observed when we increased the flexibility from 0 to 1(no flexibility to two stage flexibility. The further increase in flexibility (i.e. three-stage flexibility) is observed to be 10.22%. The total improvement in the system in this level is 20.04%. In the similar manner, DKS application in above discussed case further improved the performance. The results observed in all three cases show significant impacts of flexibility and DKS (i.e. in Three stage flexibility-Full DKS case is shown 24.45%, improvement then three stage flexibility–No DKS case). Table 1 shows the simulation results of performance improvement obtained with respect to cost output.

Table 1: Full and No DKS Configurations in Linear, Two stage and Three stage FSC_s

No DKS	Total Cumulative FSC Cost (0,00,000)	Results/Improvement
Linear FSC	51.598	————-
Two Stage FSC	46.321	LSC=10.22 %
Three Stage FSC	41.253	LSC =20.04% and 2 Stage FSC= 10.94%:
Full DKS- FSC	Total FSC Cost (0,00,000)	Results/Improvement
Linear FSC	42.493	LSC, No DKS =17.64%; 2 Stage FSC, No DKS = 8.26%; 3 Stage FSC, No DKS = No Improvement
Two Stage FSC	35.847	LSC, No DKS =28.86%; 2 Stage FSC, No DKS = 22.61%; 3 Stage FSC, No DKS = 13.10%; LSC, with DKS =15.64%
Three Stage FSC	31.451	LSC, No DKS =39.04%; 2 Stage FSC, No DKS= 32.10%; 3 Stage FSC, No DKS= 23.76%; LSC, with DKS =25.98%; 2 Stage FSC, with DKS= 13.97%

These results suggest that the SCs can get more benefits, if the supply chains flexibility increases at the supply chain stage, specially providing more options to each supplier. This is also useful to reduce the bullwhip effect by better integration and dynamic selection. This is also suitable to fulfill customer demands quickly and effectively. The best feasible is that partial DKS can serve our purpose at lowest cost compared to full DKS based mode. Finally, the use of DKS and flexibility at each stage has different impacts on the chain performance.

Industrial and Research Implications

This paper establishes the motivation and need for flexibility modeling and the impact of decision and knowledge delays on the performance of flexible supply chains. The modeling of DKS based flexible supply chains are more complex then simple supply chain as they involve explicit consideration

of the logical relationships resulting from decision and knowledge flows in FSCs. The performances clearly deteriorate with the increase in knowledge sharing and the decision making delays. It is suggested that the while evaluating the alternative decision and knowledge system in a FSCs, it is useful to explicitly model the logical implications of the decision and knowledge flows in the form of modes and delays. The concept of decision and knowledge delays captures the notion of the level of decision knowledge sharing and flexibility. The motivation for this study is to study the combined impacts of changing flexibility, decision knowledge under a full scope of decision and knowledge delays in supply chains. From the IT perspective, the cost of IT to reduce the delays needs to be evaluated in comparison to the costs of knowledge sharing in SCs. If IT options happen to be costly, an attempt should be made to improve the supply chains that may help to counteract the delays. Our studies have provided a number of observations, that indicate the need to study the synergistic issue of flexibility, DKS and delays in the context of a given supply chain environment. In many industries, the full information sharing is a complex issue and as alternative DKS can overcome this problem in SCs, with effective use of flexibility and dynamic ability. Judicious use of flexibility and DKS in SCs relates to development of guidelines that may help management to start with lower cost alternatives that offer acceptable performance.

In a supply chain context the resource types may be supply chain nodes representing raw material suppliers, manufacturers, warehouses, transport agencies, distributors, wholesalers, retailers etc., and processes provided by them may be the raw material supply, manufacturing, storage, transportation, distribution, wholesale and retailing respectively.

From an industry perspective, the studies presented in this paper indicate the importance of supply chain flexibility for business enterprises. The studies demonstrate that the several industry practices could be conceptualized and modeled at various types of supply chain flexibility and DKS. In a similar manner, we have conceptualized the emerging e-business practices as a type of supply chain flexibility called the supply chain resource type flexibility. The results can benefit industries implementing e-business practices. Such practices are widely supported in literature. For example while reviewing the nature of the changes anticipated in the future business models as a result of changes in ICT, Ritchie and Brindley (2000) observes that the small and medium enterprises may utilize the Web to promote and sell its product directly to potential customers at home and overseas. This could effectively exclude intermediaries such as sales and promotion agencies supporting the sales to SMEs to the marketplace. There are numerous organization who now sell and supply directly via the www. One great advantage is that the relationship between customer and supplier can be both direct and very fast. This allows an organization to design and build tailored products and get them to customers very quickly. The technology allows the suppliers organizations to move away from market centric culture to one focused on individual customers and their specific needs. We have also studied flexible supply chains involving multiple suppliers and procurement practices involving competitive biddings (i.e. SCRF). We have conceptualized these practices as a type of supply chains flexibility called the supply chain routing flexibility. This type of flexibility represents realistic practices in industry and literature supports such practices. For example, Chandra and Kumar (2000) view, a supply chain network, as a complex web of systems, sub systems, operations, activities and their relationship to one another, belonging to its various numbers, namely supplier, manufacturer, distributor, retailer and consumers. Similarly, Wadhwa et al. (2005) presents results of flexibility enable lead time reduction in flexible system. The use of such practices will result in some kind of SCRF and the studies presented in this paper demonstrated the beneficial influences of such practices on the cost performance of supply chain systems.

Conclusions

As a whole, supply chain flexibility appears to be having a beneficial influence on the supply chain cost performance. This paper shows the need for explicitly modeling alternative levels of DKS and DKS delays while studying alternative levels of decision flexibility in the supply chain. Different combination of supply chain flexibility types and supply chain DKS delay modes will lead to different situations. In addition, keeping in view the fact that the extent of benefit in each case appears to be significantly large in its magnitude, and the results are encouraging. Also, since the partial flexibility gives the greatest benefit of cost reduction, it offers industrial motivation towards initial investment in flexibility. Since in practice most of the supply chains operate with finite amount of supply chain DKS delay, they will have implications on supply chain cost. However, since different types and levels of flexibility and DKS give different levels of cost reduction, there is a need to arrive at judicious types and levels of supply chain flexibility (i.e. Decision Flexibility) and DKS. Perhaps, this is useful to reduce the cost of SC (including SC partners) significantly. This paper demonstrates the DKS modeling of supply chains with a focus on decision flexibility and DKS delays offer an enormous potential. Further research is also possible through considering flexibility (i.e. partial and full) and DKS (i.e. partial and full) in terms of time, cost and scope dimensions in the same framework. Such a consideration will make the analysis of flexibility and DKS more accurate and will have less abstraction. Consequently, it will have more applicability. Our Research is continuing in this direction.

References

Albino, V., Garavelli, A.C., and Giannoecaro, I., Process and logistic flexibility for the SCM, Pro. of the seventh inter. *Symposium on Logisti*, Melbourne, Australia, 2002, 14-17, July.

Bourland, K., Powell, S., and Pyke, D, Exploiting timely demand information to reduce inventories, *European Journal of Operational Research*, 1996, Vol. 92, No. 2, pp.239–253.

Browne, J., Doumeingts, G., *Modelling techniques for business process re-engineering and benchmarking*. Chapman & Hall Publishers, UK, 1998. pp. 392-398.

Browne, J., Dubois, D., Rathmill, K., Sethi, S.P. and Stecke, K.E, Classification of flexible manufacturing systems, *The FMS Magazine*, 1984, April, pp. 114-117.

Browne, J., Goggin, K. and Raey, E., Modelling End-of-Life Product Recovery Chains - A Case Study, *Production Planning and Control*, 2000, Vol. 11, No. 2, pp. 187 - 196.

Browne, J., Harhen, J. and Shivnan, J., *Production Management Systems: An Integrated Perspective*, Second Edition. Harlow: Addison-Wesley, 1996.

Cachon, G.P., and Fisher, M., Supply chain inventory management and the value of shared information, *Management Science*, 2000, Vol. 46, No. 8, pp. 1032–1048.

Chan, F.T.S., Chung, S.H. and Wadhwa, S, A heuristic methodology for order distribution in a demand driven collaborative supply chain, *International Journal of Production research*, 2004, Vol.42, pp. 1–19.

Chandra, C., and Kumar, S., Supply Chain Management in theory and practice: a passing fad or a fundamental change, *Industrial mgt. and Data System*, 2000, Vol. 100, No. 34, pp. 379-394.

Das, S., K., and Malek, L. A., Modeling the flexibility of order quantity and lead times in supply chains, *Int. J. Production Economics*, 2003, Vol. 85, pp. 171-181.

Garavelli, A.C., Flexibility configuration for the supply chain management, *Int. J. Production Economics*, 2003, Vol. 85, pp. 141-153.

Golden, W., and Powell, P., Towards a definition of flexibility: in search of the Holy Grail? *OMEGA-The Inter. Jour. of management Science*, 2000, Vol. 28, PP. 373-384.

Knirsch, P., and Timm, I.J., *Adaptive multi agent systems applied on temporal logistic networks*, Proceedings *of the 4th Int. Symposium on Logistics, ISM-99*, Florence, Italy, 1999, pp. 213–218.

Lee, H.L., Padmanabhan, V., and Whang, S., The bullwhip effect in supply chains, *Sloan Management Review*, 1997, Vol. 38, No. 3, pp. 93–102.

Ritche, B. and, Briendley, C., Disintermediation, disintegration and risk in SME global supply chain, *Management Decision*, 2000, Vol. 38, No. 8, pp. 575-583.

Sethi, A.K., and Sethi, S.P., Flexibility in Manufacturing: A survey, *International Journal of Flexible Manufacturing Systems*, 1990, Vol. 2, No. 4, pp. 289-382.

Simchi-Levi, D., Kaminsky, P., and Simchi-Levi, E., Designing and Managing the Supply Chain, Irwin/McGraw-Hill, New York, 1998.

Sushil, Concept of Systemic Flexibility, *Global Journal of Flexible Systems Management*, 2000, Vol. 1, pp. 77-80.

Sushil, 2001, Demythfying flexibility, *Management decision* Vol. 39, No.10, pp. 860-865.

Tayur, S., Magazine, M., and Ganeshan, R. (Eds.), *Quantitative Models for Supply Chain Management*, Kluwer Academic Publishers, Boston, MA, 1999.

Towill, D.R., The seamless supply chain. *Int. Journal of the technology management*, Vol. 13, No. 1, pp. 37-56, 1997.

Vickery, S., Calantone, R., and Droge, C, Supply chain flexibility: An empirical study, *The Journal of Supply Chain Management*, 1999, (August), Vol. 35 pp. 16–24.

Viswanadham, N., and Raghavan, N.R., Flexibility in manufacturing enterprises, *Sadhana,1997*, Vol 22, No 2, pp. 135-163.

Wadhwa S., Saxena A., and Kumar A., A KM Motivated Web based Supply Chain Simulator: Facilitating e-learning for SMEs, Accepted, 2006, *Int. Jo. Of Business Performance Management*.

Wadhwa S., Saxena A., and Kumar A., Green Supply chain management: A KM focused e-governance view for SMEs, *Productivity*, 2005, Vol. 45, No. 3, pp. 361-373.

Wadhwa, S, and Rao, K.S, Flexibility and Agility for enterprise synchronization: Knowledge and Innovation Management towards Flexagility, *SIC Journal*, 2003, Vol. 12, No. 2, pp. 111-128.

Wadhwa, S, and Rao, K.S., Enterprise Modeling of Supply Chains involving Multiple Entity Flows: Role of Flexibility in Enhancing Lead Time Performance, *SIC Journal*, 2003, Vol. 12, No. 1, pp. 329-342.

Wadhwa, S. and Bhagwat R., Judicious increase in flexibility and decision automation in semi-computerized flexible manufacturing (SCFM) system, *SIC*, 1998, Vol. 7, No 4, pp. 329 -342.

Wadhwa, S., and Brown, J., Modeling FMS with decision Petri Nets", International Journal of *Flexible Manufacturing Systems*, 1989, Vol. 1, pp.253-280.

Wadhwa, S., and Rao, K. S., Flexibility: An Emerging Meta-Competence for Managing High Technology, *Inte. Journal of Technology Management*, 2000, Vol. 19, No. 7/8, pp. 820-845.

Wadhwa, S., and Rao, K.S., Proactive knowledge management: Developing a novel view on flexibility in systems, *Studies in Informatics and Con*, 2002, Vol. 11, No. 2, pp. 16-32.

Wadhwa, S., Rao, K. S., and Chan, F. T .S, Flexibility Enabled Lead Time Reduction in Flexible Systems, *International Journal of Production Research*, 2005, Vol.43, No.15, pp.3131-3162.

Wadhwa S. and Saxena A, Supply Chain Flexibility and Knowledge Management: A Decision Knowledge Sharing Focus. *Studies in Informatics and Control*, March 2006, Vol. 15, No. 1.

Walsh, W.E., and Michael, P.W., Modeling supply chain formation in multi-agent systems, *IJCAI-99 Workshop on Agent Mediated Electronic Commerce*, 1999.

Reflecting Applicability in Real Life

1. How does the decision flexibility with or without DKS influence the cost performance of a supply chain system that encompasses it?
2. How does the DKS delay modify the influence of flexibility and DKS on the performance of supply chain system?
3. How does the flexibility stages with or without DKS influence the performance of the supply chain system?

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Empirical Study

Predicting Turnover Intentions: Incorporating the Role of Organization and Work-Group Level Variables

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Abstract

Managing turnover of IT/software professionals is a major task confronting the software organizations. This study explores the flexible impact of organizational and work-group level social psychological factors, satisfaction, commitment, leader-member exchange, justice and voice on their turnover intentions. Using a sample of 295 software professionals, the relationships were tested and the results indicate that at the organization level, satisfaction predicts turnover intention through commitment. Within the workgroup, the two dimensions of Leader-member exchange (LMX) predict the outcomes of satisfaction and commitment differentially and leader-member exchanges lead to justice through voice. Justice predicts the employee outcomes of satisfaction and commitment, which in turn determine turnover intention. Results are discussed in terms of their implications for theory and practice.

Keywords: commitment, leader-member exchange, procedural and distributive justice, satisfaction, turnover intentions, voice

Introduction

Growth of the IT industry in India is putting demands not only on hiring IT professionals but also on retaining them, as the turnover in the industry is very high, ranging between 20 and 40 percent in some organizations (Atlas, 2005). In this paper we focus on the construct of intention to quit/ turnover intention to understand the turnover behavior of software professionals. Researchers have shown that turnover intentions are significantly related to actual turnover (Cotton & Tuttle, 1986; Gerhart, 1990; Hom & Griffeth, 1995; Steel and Ovale, 1984) and are a reliable predictor of actual turnover. Research has also shown that post-exit interviews often do not provide insights into real reasons for turnover whereas pre-turnover studies provide clearer insights into decision processes (Steers and Mowday, 1981; Steel and Ovale, 1984). Hence, turnover intentions or intention to quit is taken as the focal construct to understand the turnover of software professionals.

This study makes several contributions, both to theory as well as practice. First, this is the only study, in our knowledge, that systematically assesses the social psychological causes of turnover intentions of software professionals in India. Second, the antecedents are conceptualized as occurring flexibly at the work-group or the organization levels. In our study, issues of leader-member exchange (LMX), voice mechanisms and justice perceptions are identified as work-group issues, whereas global job satisfaction and commitment are treated as organization level issues. Third, the role of a leader is incorporated as leader-member exchange in our study which is assessed as a two-dimensional construct whereas most of the previous studies, except a few (cf. Liden & Maslyn, 1998), have treated it as a one-dimensional construct. Fourth, the process paths, that link the group level antecedents with that of the organization, are identified and tested. Finally, structural models comparing direct paths with more constrained paths are compared to provide an insight into the actual operation of the two sets of variables in predicting turnover intentions.

In the following sub-sections, we first discuss the literature on organization level predictors—satisfaction, commitment and their interrelationship— of intent to leave. Second section incorporates the role of LMX, justice and voice in predicting subordinate outcomes. Based on the discussion the hypothesized model is presented.

Theoretical Framework and Development of Hypotheses

Organization Level Variables and Turnover Intentions

Researchers have defined and measured satisfaction both as a global construct and as a concept with multiple dimensions or "facets" (Price, 1997). Facet satisfaction refers to satisfaction with specific aspects of the workplace like pay, supervisor etc., global satisfaction on the other hand

refers to general satisfaction with the organization as a whole. This study adopts the global approach over the facet approach; conceptualizing job satisfaction as the degree of positive emotions an employee has toward the work as a whole (Kalleberg, 1977; Locke, 1976; Smith, Kendall, & Hulin, 1969). Commitment is an attitude of company loyalty exhibited by the employees. According to Mowday, Porter & Steers (1982) commitment is defined as the 'relative strength of an individual's identification with and involvement in a particular organization' (p. 226). A consistent negative correlation has been reported between turnover intentions and commitment (Meyer & Allen, 1997). Many studies have explored the relationship among commitment, satisfaction and turnover intentions. Though there are some that have reported job satisfaction to be a direct predictor of turnover intention (e.g., Cotton & Tuttle, 1986; Hom & Griffeth, 1991, Tett & Meyer, 1993), there is a large body of research that indicates that the relationship between job satisfaction and turnover intentions is mediated by commitment (Brown & Peterson, 1993; DeConink & Stilwell, 2004; Mathieu & Zajac, 1990; Price & Mueller, 1986; Williams & Hazer, 1986). Since satisfaction is predominantly affective in nature, it may be less useful in predicting specific behavioral intentions (Fishbein and Azjen 1975), more accurate predictor of specific turnover behaviors and intentions comes from attitudes pertaining to such behaviors, which are more closely reflected in commitment (Fishbein and Azjen, 1975). Hence, we hypothesize as follows

Commitment is defined as the 'relative strength of an individual's identification with and involvement in a particular organization'. A consistent negative correlation has been reported between turnover intentions and commitment.

H1: Satisfaction will predict turnover intentions through commitment.

Workgroup Variables: LMX Dimensions and Employee Outcomes

The LMX or VDL theory of leadership (Dansereau, Graen & Haga, 1975) proposes that the nature of exchanges and the quality of interaction of a leader varies across different subordinates in the work group. Along with many other subordinate outcomes, LMX has shown significant negative associations with turnover (Graen, Liden & Hoel, 1982) and turnover intention (Vecchio & Gobdel, 1984; Tekleab, Takeuchi & Taylor, 2005). Most of the studies linking subordinate outcomes to LMX have treated LMX as a one-dimensional construct. The development of LMX is rooted in role development and social exchange theories, which support a multi-dimensional conceptualization of LMX. According to the role theory (Katz & Kahn, 1978; Jacobs, 1971) roles are multidimensional and are likely to have different combinations of task focus and social interaction. Further, the nature of interaction in different quality dyads is maintained through social exchanges. These exchanges too are conceptualized as multidimensional involving material (like pay, resources and benefits) and non-material rewards (like advice, workflow and friendship). Since both roles and exchanges are multidimensional, Dienesch and Liden (1986) and Liden and Maslyn (1998) propose that LMX too needs to be studied as a multidimensional construct. Dienesch & Liden (1986) suggested that LMX may be based on three "currencies of exchange: task behaviors (perceived contribution), loyalty to each other (loyalty) and simply liking for each other (Affect). Thus, perceived contribution deals with on the job dimension of interaction, loyalty with social support and affect with affective feelings of liking which go beyond the work situation. This conceptualization has subsequently been used by researchers to develop psychometrically tested scales of LMX (e.g., Bhal & Ansari, 1996; Liden & Maslyn, 1998). Bhal & Ansari (1996) study resulted in a two-dimensional scale consisting of perceived contribution and affect dimensions. A high 'contribution' dominated exchange is likely to involve intensive interaction on task related activities, whereas an affect dominated exchange is likely to involve more off- the-job, affective and personal interactions. Using these two dimensions is in line with the earlier conceptualizations that have treated leader behavior as task or job related, with focus on task or social interaction (Bales, 1958). The two dimensions are likely to predict, different outcomes differentially. Since satisfaction is predominantly an affective response to the organization, it is possible that the affective relationship of the subordinates with their leaders get transferred to the organization. Commitment on the other hand has both affective and behavioral components and is manifested in terms of more contribution to the organization and the contribution in the work group helps not only the work group but also the organization as a whole (Liden & Maslyn, 1998). Hence our next hypothesis is as follows:

H2: Perceived contribution will be a better predictor of commitment whereas affect will be a better predictor of satisfaction, in the turnover model.

Incorporating LMX, Justice and Voice in the Model

Most of the previous research has studied the impact of LMX on intent to leave and other subordinate outcomes independently. Of late (cf. Masterson, Lewis, Goldman & Taylor, 2000; Scandura, 1999; Tekelab, Takeuchi & Taylor, 2005), there have been seminal efforts at integrating LMX with justice usually basing the two in social exchange theory. The notion of justice was initially studied in terms of three components—distributive, procedural (Cropanzano & Folger, 1991), and interactional (Bies & Moag, 1986;Tyler & Bies, 1990). Distributive justice is concerned with the perceived fairness of the outcomes and has been understood predominantly through equity in social exchange (Adams, 1963), wherein people compare their contributions and rewards with comparison others. Distributive justice would provide significant understanding of a differentiated work

group and tends to relate strongly to reactions to the organization or to one's supervisor (Folger & Konovsky, 1989; Konovsky, Folger & Cropanzano, 1987; Sweeney & McFarlin, 1993). The relationship between procedural and interactional justice has been debated. Earlier, work treated procedural justice as related to formal aspects of the decision-making processes, whereas interactional justice is related to interpersonal treatment (Baron, 1993; Bies & Moag, 1986) and sharing of information (Bies, 1989; Bobocel & Farrell, 1996; Bobocel, McCline & Folger, 1997). Though there have been some researchers who emphasize the similarity of procedural and interactional justice (Cropanzano & Greenberg, 1997), a strong case is being made for the distinction between the two by some like Bies (2001) and Bobocel & Holmvall (2001), due to the fact that the two justices have different correlates. Whereas procedural justice is more related to the formal organization systems and the company as a whole, interactional is related to one's immediate leader (Cobb, Vest & Hills, 1997).

Leaders have multidimensional relations with their subordinates. Perceived contribution assesses on- the-job task related interactions and Affect explains off-the- job personal interactions.

Interactional justice is shown to be related to both interpersonal relationships and the supervisor. It is also a better correlate of LMX than procedural justice (Cropanzano, Prehar & Chen, 2002), and hence,needs to be explored further in relation to LMX. Earlier efforts at integrating justice with LMX have significantly advanced understanding of how LMX operates in a work group. Most of the previous research on LMX and justice has treated LMX as the outcome of justice perceptions or as a mediator of justice—outcome relationship (Manogran, Stauffer & Conlon, 1994; Tekelab, Takeuchi & Taylor, 2005; Masterson, Lewis, Goldman & Taylor, 2000). However, it is noteworthy that Tekelab, Takeuchi & Taylor, (2005) have used a longitudinal data where justice perceptions at an early point in time (t1) lead to LMX, which at a later time (t2) results in employee outcomes. There is a possibility that the relationship between LMX and justice is time-dependent, wherein in the initial stages of role development, justice perceptions lead to LMX. At this stage, justice perceptions are at the dyadic level centering on exchanges between a leader and a member. The role development process, through which LMX gets stabilized, emphasizes that it is during the initial stages of role development that active exchanges between a leader and a member take place and subordinates are likely to develop justice perceptions based on their inducements and contributions. But, once the role is stabilized there are no active exchanges (Graen, 1976; Graen & Cashman, 1975; Graen & Scandura, 1987). We propose that once a relationship is stabilized in a work group, it is the justice perceptions that mediate the relationship between LMX and subordinate outcomes. Which implies that if "… justice is experienced by members, the effect of in/group or out/group memberships become nonsignificant " (Scandura, 1999; p. 35).

Hypothesis 3: Interactional justice will mediate the relationship of LMX with subordinate outcomes of satisfaction, commitment and intent to leave

In the LMX conceptualization, low and high quality of exchanges vary in terms of decision latitude given to the subordinate (Dansereau, et. al, 1975), the leader's communication (Baker & Ganster, 1985), and the level of trust in and empowerment of the subordinates (Gomez & Rosen, 2001). Earlier conceptualizations of LMX assessed it in terms of negotiating latitude which is the amount of 'say' or voice that different members have in decision making processes of the leader (e.g., Graen & Cashman, 1975; Graen, Cashman, Ginsburgh & Schiemann, 1977; Graen & Schiemann, 1978). Whereas perceived contribution on the job might relate to communication and voice in work related factors, affect is likely to lead to increased frequency of affective and off-the job voice. Consequently, the nature and amount of voice that different members have in the decision-making processes of the leader vary across subordinates as a function of both the contribution as well as the affect dimensions of LMX. Interactional justice, too, occurs when the leaders provide justifications and explanations to the subordinates (Bies, 1989; Bobocel & Farrell, 1996; Bobocel, McCline & Folger, 1997) and the subordinates have a voice in the decisions that concern them. It is possible that those who have a high LMX have a higher voice which in turn leads to higher interactional justice for the subordinates and vice versa. Our, next hypothesis, hence, is

H4: LMX leads to voice which leads to interactional justice in the turnover model.

Based on the preceding discussion and the proposed hypotheses, the hypothesized model for understanding turnover intentions is given in Figure 1.

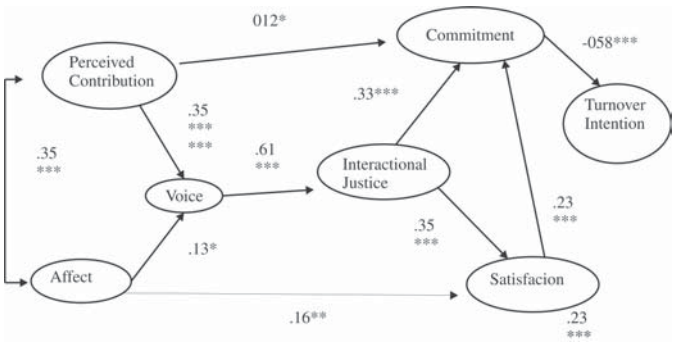

Figure 1: Hypothesized Model (with Standardized Estimates)

Methodology

Data was collected on a structured questionnaire by the second author personally from professionals working in software organizations. Over 40 software organizations and 700 professionals working in these organizations were given the questionnaire. These organizations were situated in the

southern, western and northern regions of India and employed more than 100 software professionals and recruited them from engineering and business schools. The professionals were contacted using the alumni network of a premier engineering/management school in India. To maintain the confidentiality of their responses, they were asked to return the form in a sealed envelope that were provided to them along with the questionnaire. Only those questionnaires that were returned within three weeks of their distribution were considered usable for the study. A total of 338 questionnaires were returned (within the stipulated time), after deleting the questionnaires that were incomplete, the sample size was reduced to 295. Of these 250 were males and 45, were females. In this sample too about 92% were in the range of 20 to 31 years. Mean tenure in the organization was 2.38 years (sd of 2.70). Care was taken to include only those respondents who had worked with the leader for over 6 months, to make sure that the subordinates were in a position to assess the quality of interaction (LMX) with their supervisors. Since software organizations are project based and have to complete the projects in stipulated time, the role relationships in these organizations get defined in lesser time. After discussing with many project leaders and team members, it was decided that six months could be taken as reasonable time during which the relationships become relatively more stable. Data was collected on a structured questionnaire consisting of scales on LMX, voice, interactional justice, satisfaction, commitment and intent to leave besides some demographic details like their age, gender and tenure with the organization. Respondents were asked not to give any form of identification to ensure the anonymity of their responses.

Measures

Organizational Commitment was assessed using the nine items of affective commitment out of 15 items in the original scale of Mowday, Steers and Porter (1979). The respondents were asked to rate their agreement with each statement, which was rated on a five-point scale (1 = Strongly Disagree; 5 = Strongly Agree).

Perceived fairness of outcomes is not enough to understand people's reactions at work, individuals also assess fairness of processes. It is possible for people to be satisfied with lesser rewards if they perceive the processes to be just.

Satisfaction was assessed using six items scale used by Price (2001). The respondents were asked to rate the extent to which they agreed or disagreed (1 = Strongly Disagree; 5 = Strongly Agree) with the statements that were related to global satisfaction with their job.

Interactional justice was measured through a nine-item scale by Niehoff and Moorman (1993), which assessed the degree to which employees felt their needs were considered, and adequate explanations were made for job decisions. The respondents were asked to rate the items on a five-point scale (1 = very true, 5 = not at all true) as to how true were the items to them.

LMX was assessed using a 10-item scale by Bhal & Ansari (1996). They developed a two-dimensional scale of LMX, based on the conceptualization given by Dienesch and Liden (1986). The two dimensions were perceived contribution and affect. The scale consisted of 10 items with 5 items each of perceived contribution and affect. The respondents were asked to rate the statements on a five-point scale (1 = Not at all true; 5 = Very True) as to how true were the statements to their relationship with their supervisor.

Voice was assessed using the three items used by Dulebohn & Ferris (1999). The response was assessed on a five-point scale (1 = Strongly disagree, 2 = Disagree, 3 = Neutral, 2 = Agree, 1 = Strongly Agree).

Intent to leave or turnover intention was assessed using one-item. The respondents were given the following question 'Which of the following statements most clearly reflects your feeling about your future with this employer/ organization?' The response varied at five levels: 1 = definitely will leave; 2 = Probably will leave; 3 = Uncertain; 4 = Probably will not leave and 5 = Definitely will not leave. This item was reverse scored, such that a high score on it meant high intention to leave.

Final score for each dimension was taken by taking the mean of the items comprising that dimension. Since intent to leave was assessed through one item, the score on that item constituted the final scale.

Analysis and Results

The analysis was conducted using Amos 5.0 software. The model in Figure 1 was evaluated using the process recommended by Anderson and Gerbing (1988). In Stage 1 of the process, the fit of a confirmatory factor analytic (CFA) model to the observed data was evaluated to determine if the items loaded on their respective scales. In this stage, a single-factor model was compared to the hypothesized model. After confirming the factor structures, we formed composite variables for each construct from their respective items and used those composites as single indicators of their respective factors, in Stage 2. Four measures were used to assess the fit of structural models: the goodness of fit index (GFI), the adjusted goodness of fit index (AGFI) (Joreskog and Sorbom, 1984), comparative fit index (CFI) given by Bentler (1990) and root mean square error of approximation (RMSEA) (Browne & Cudeck, 1993).

For confirmatory factor analysis in stage 1, as mentioned above, first a single –factor model was estimated. This model provided poor fit to the data (c^2 = 3772.553, df = 667, p = .000, GFI = .513, AGFI = .459, CFI = .412, RMSEA = .126). Next, the hypothesized six-factor model, the six factors of LMX—contribution, LMX—affect, satisfaction, commitment, interactional justice, and voice, was tested. Given the number

of variables, the results of the CFA provided a reasonable model fit (c^2 = 1441.508, df = 628, p = .000, GFI = .784, AGFI = .758, CFI = .842, RMSEA = .066). All the items were significant predictors of their respective latent variables.

The reliability of the scales was assessed through Cronbach's coefficient alpha. The reliability coefficients, means, sds and inter-correlations of the exogenous and endogenous variables are contained in Table 1. Table 1 shows that reliabilities of all the variables are fairly high and acceptable for research purposes. They ranged from .75 to .91.

Table 1: Means, Standard Deviations, Cronbach's Coefficients Alpha and Inter-correlations of Study Variables

		Mean SD	1.	2.	3.	4.	5.	6.
1.	*Commitment*	3.42 *.55*	(.75)					
2.	*Satisfaction*	2.96 *.87*	.372 ***	(.87)				
3.	*LMX—PC*	3.55 *.73*	.292 ***	.191 **	(.91)			
4.	*LMX—Af*	2.80 *.82*	.136 *	.240 ***	.353 ***	(.89)		
5.	*I J*	3.48 *.58*	.457 ***	.383 ***	.394 ***	.244 ***	(.80)	
6.	*Voice*	3.63 *.91*	.352 ***	.297 ***	.396 ***	.250 ***	.610 ***	(.87)
7.	*IL*	2.62 *1.02*	-.581 ***	-.307 ***	-.111	-.117 *	-.323 ***	-.282 ***

Note: N=295. Cronbach alpha is in parentheses along diagonal. Standard deviations are indicated in itals below the means. * = p<.05, ** = p< .01, *** = p<.001.PS=Pay satisfaction, S/A= Structure/ Administration, LMX(PC) = Perceived Contribution Dimension of LMX, LMX (Af) = Affect dimension of LMX. DJ = Distributive Justice, IJ = Interactional Justice, IL= Intent to Leave (Turnover Intention)

Zero-order correlations were all in the expected directions. All the variables of the study showed a negative correlation with intent to leave and all of them (except with LMX-PC) were significant. Commitment showed a stronger correlation with turnover intention (r = -.581, p< .000) as compared to satisfaction (r = -.307, p< .001). Commitment showed a stronger correlation with perceived contribution (r = .292, p< .000) than with affect (r = .136, p< .05). However, satisfaction showed a stronger correlation with affect (r = .240, p< .000) as compared to perceived contribution (r = .191, p< .01). These correlations provide a preliminary confirmation of the proposed relationships. However, perceived contribution does not have a significant relationship with intent to leave, which will be discussed subsequently.

Voice, having a say, in the decision making process is important for development of justice perceptions.

In stage 2, three models were tested to evaluate hypothesis 1. First, the relationship among satisfaction, commitment and turnover intention was established using three models, a) satisfaction —— commitment —— turnover intentions, b) commitment —— satisfaction —— turnover intentions and c) both satisfaction and commitment lead to turnover intentions independently. Results showed the best fit indices for model a) (c^2= 4.271, df = 1, p= .039, GFI= .990, AGFI = .943, CFI = .980, RMSEA = .150) compared to both model b), that showed the poorest fit indices (c^2= 96.135, df = 1, p= .000, GFI= .843, AGFI = .059, CFI = .426, RMSEA = .569), and model c), which too showed poor fit indices (c^2= 43.694, df = 1, p= .000, GFI= .916, AGFI = .494, CFI = .743, RMSEA = .381). Thus, our first hypothesis that satisfaction leads to turnover intentions through commitment finds full support from the data.

Next, we tested the hypothesized model as given in Figure 1 by comparing it with an alternate model (Figure 2) where LMX is shown to mediate the relationship of interactional justice with subordinate outcomes. This alternate model tested the path of voice interactional justice LMX (PC & Af).

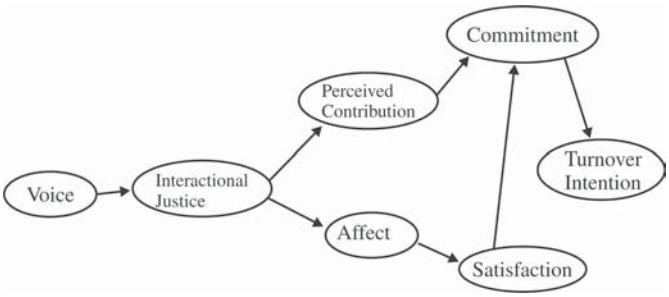

Figure 2: Alternate Model

The alternate model showed a chi-square of 96.799 with 13 df. It showed poorer model fit indices (GFI = .921, AGFI = .831, CFI = .834, RMSEA = .178) as compared to the hypothesized model, which showed a chi square of 29.097 with 11 degrees of freedom. And good model fit indices (GFI = .973, AGFI = .931, CFI = .964, RMSEA = .075) The hypothesized model shows much-improved fit indices (Dc^2 = 67.792, D df = 2, p< .000). The fit indices support the hypothesized model and a comparison of the alternate model with the hypothesized model supports the assertion that justice mediates the relationship of LMX with subordinate outcomes of satisfaction and commitment. The hypothesized model was also tested against a more constrained model where two of the direct relationships (between perceived contribution and commitment and between affect and satisfaction) were dropped from the model. This model showed a chi square of 42.016 with 13 degrees of freedom. The fit indices for this model were (GFI = .962, AGFI = .918, CFI = .943, RMSEA = .087). The overall fit indices of the hypothesized model are superior to this more constrained model (Dc^2 = 12.919, D df = 2, p< .001).

The resulting path estimates (standardized) in the hypothesized model (which was also the best fitting model) are given in Figure 1. All the paths in the model are significant though the strength of the direct paths between perceived contribution and commitment ($p < .05$) and between affect and satisfaction ($p < .01$) is relatively weaker. This could also be taken as an indicator in support of the mediation of LMX and outcomes relationship by voice and interactional justice. Our model finds full support from the data.

The variance explained in each of the endogenous variables, in the hypothesized model, was as follows: voice, 17.1%; interactional justice 37.2%; satisfaction 16.1%; commitment 25.4% and turnover intention 33.3%.

Discussion

Research on determinants of turnover and turnover intentions has focused on institutional, sociological and social psychological factors (Price, 2001). This paper explores some organization and group level, social psychological predictors of turnover intentions. It replicates and extends research in different but related areas.

First, and most obviously, it contributes to the understanding of intent to leave. The causal link between satisfaction, commitment and intent to leave or actual turnover has been much researched. Fewer studies support a direct link between satisfaction and turnover (Currivan, 1999) whereas a wealth of empirical evidence supports the causal precedence of satisfaction over commitment (e.g. DeConink & Stilwell, 2004; Johnston, Parsuraman, Futerell & Black, 1990). In this context, the study replicates the assertion that satisfaction precedes commitment in the prediction of intent to leave. Next, the study incorporates the role of leader-member exchange and justice in predicting intent to leave. Importance of the immediate leader in determining employee outcomes has been established in previous studies, this study incorporates the role of leader-member exchange in determining intent to leave. Further, the study also identifies some process paths through which LMX predicts intent to leave. One result, in this regard requires a little deliberation. Perceived Contribution dimension of LMX does not significantly relate to intent to leave (Table 2). A path is considered significant, in its strongest form, only when the predictor too relates to the outcome (Baron & Kenny, 1986). However, we suggest that mediation may also exist when the predictor is not related directly to the outcome but through the mediator(s). Such mediation was claimed by Wright (1989), who asserted that goal-setting mediated the effects of incentives on performance, despite a non-significant relationship between incentives and performance. Moreover, in this study, the process path includes a few intervening variables and all the paths in the model are significant. Finally, the overall model showed good fit indices. This suggests that it may be premature to reject the hypothesized model.

Understanding the psychological processes would significantly help in understanding the causes of turnover intentions and remedies for overcoming them.

Second, the study provides insights for leader member exchange theory. It does so in three ways. First of all, the study extends the understanding of LMX by conceptualizing it as a two-dimensional construct—one focusing on job related interactions and the other on affective interactions and exchanges. Confirmatory factor analysis provides very good fit indices for a two factor model and the two dimensions differentially predict the employee outcomes which is an evidence of construct and predictive validity of the two-dimensional conceptualization, providing support for multi-dimensional nature of LMX (Liden & Maslyn, 1998). Next, the study supports the causal precedence of LMX over justice in predicting subordinate outcomes, much in line with the assertion of Scandura (1999). The fact that LMX leads to a differentiated workgroup in terms of both rewards and assignments of the subordinates under a leader makes the issue of justice relevant. The results indicate that the nature of leader-member relationship predicts employee outcomes in this kind of a work-group through perceived justice. Finally, the study, for the first time, incorporates LMX and justice perceptions through voice mechanisms. Past researches have shown that in many cases, employees are either reticent in using formal voice mechanisms (even when the organizations provide for them) (Krone, 1992; Lewin, 1987) or they prefer to use informal mechanisms (Kolb & Putman, 1992). The nature of LMX determines whether there will be an opportunity for the employees to express their concerns and, in turn, this participation prompts employees perceptions of interpersonal fairness. Essentially, it is through voice procedures that a leader is likely to be perceived as fair or otherwise.

The work group and organization level factors flexibly and jointly predict the intent to leave of the software professionals.

Limitations and Future Research

The implications of the study must be considered in light of its limitations. First, all the data for this study was collected from a single source, raising concerns of common method bias. Also, since the data was cross-sectional, direction of causality is assumed, not tested. Thus, inclusion of longitudinal studies and others ratings of behavior and attitudes could provide support for current findings. Longitudinal studies are also likely to provide insight into how dyadic relationships in a software project team grow over a period of time. All the data collected through self-reports is likely to be influenced by social desirability response bias. Although this bias cannot be ruled out but some researches have shown that social desirability may not be a source of bias in measuring organizational perceptions

(Moorman & Podsakoff, 1992; Spector, 1987).

The operationalization of intent to leave could be another limitation of the study. One-item was used to assess it. Though this item, along with others, has been used as a measure of continuance commitment by Mowday, Steers and Porter (1979), assessing intent to leave through a larger scale would strengthen the study results.

Practical Considerations

In addition to making conceptual contributions, this study also has important practical implications. First of all, just having satisfied employees is not likely to affect the software professionals' intent to leave. Efforts have to be made to ensure that the emotional state of satisfaction actually gets translated into commitment to the organization and its goals, in order to influence the turnover intentions of the professionals. Next, there are significant implications for perceived justice of interactions with the leader. As mentioned earlier, jobs in software consulting organizations are not well defined and change from project to project. Relying on formal contracts for getting subordinates to collaborate on unstructured tasks may not be feasible, and the leaders are likely to use informal social exchanges with subordinates to get collaboration on these unstructured tasks. This is likely to lead to a work-group—differentiated into in and out-groups. The results indicate, that because of perceived justice, subordinates with different qualities of interaction with the leader have different job related attitudes and behaviors. In this situation, it is the responsibility of the leader to be seen as just and fair to the entire workgroup. The results have implications for LMX enhancement interventions. In general enhancing work related interaction through guiding, sharing and communicating (Bauer & Green, 1996) can result in higher-level employee outcomes. The focus of leadership intervention, in the light of this study, needs to be on equitable treatment as it may not be possible to give equal treatment. The nature of leader-member relations provides an explanation for why this is likely to happen. An important mechanism that leaders can use for enhancing justice perceptions of the subordinates is to build some systems through which the subordinates and the leaders get a platform to share their views and perceptions. Use of communication and voice mechanisms, by the leader, is likely to lead to better perceptions of justice, which in turn is likely to influence the employees' turnover intentions and other job related attitudes and behaviors.

The results indicate that the turnover intentions of the software professionals simultaneously get influenced by phenomenon at two levels—work group and the organization. In managing the software professionals organizations have to design the systems that operate flexibly at the organization and the group levels. Flexibility in the design of the systems by incorporating the issues relevant at the two levels is likely to improve the retention of the employees.

References

Adams, J. S. (1963). Toward an understanding of inequity. *Journal of Abnormal Social Psychology, 67,* 422-436.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin,* 103, 411-423.

Atlas, T. (2005). Bangalore's big dreams. *US News and World Report, 138,* 50-52.

Baker, D.D. & Ganster, D.C. (1985). Leader communication style: A test of average versus vertical dyad linkage models. *Group & Organization Studies, 10,* 242-249.

Bales, R.F. (1958). Task roles and social roles in problem solving groups. In E.E. Maccoby, T.M. Newcomb & E.L. Hartley (Eds), *Readings in Social Psychology* (pp. 437—447). New York: Holt & Company.

Baron, R. A. (1993). Criticism (informal negative feedback) as a source of perceived unfairness in organizations: Effects, mechanisms, and countermeasures. In R. Cropanzano (Ed.), *Justice in the Workplace: Approaching Fairness in Human Resource Management* (pp. 155-170). Hillsdale, NJ: Lawrence Erlbaum.

Baron, R. M., & Kenny, D. A. (1986), The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations", *Journal of Personality and Social Psychology, 51,* 1173-1182.

Bauer, T.N. & Green, S.G. (1996). Development of leader-member exchange: A longitudinal test. *Academy of Management Journal, 39,* 1538—1567.

Bentler, P.M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin, 107,* 238–246

Bentler, P.M. & Bonnett, D.G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin, 88,* 588–606.

Bhal, K.T., & Ansari, M.A. (1996). Measuring quality of interaction between leaders and members. *Journal of Applied Social Psychology, 26,* 945—972.

Bies, R. J. (1989). Managing conflict before it happens: The role of accounts. In M. A. Rahim (Ed.), *Managing Conflict: An Interdisciplinary Approach* (pp. 83-91). New York: Praeger.

Bies, R. J. (2001). Interactional (in)justice: The sacred and the profane. In J. Greenberg & R. Cropanzano (Eds.), *Advances in Organizational Justice* (pp. 89-118). Stanford, CA: Stanford University Press.

Bies, R. J., & Moag, J. S. (1986). Interactional justice: Communication criteria for fairness. In B. Sheppard (Ed.), *Research on Negotiation in Organizations* (Vol. 1, pp. 43-55). Greenwich, CT: JAI.

Bobocel, D. R., & Farrell, A. C. (1996). Sex-based promotion decisions and interactional fairness: Investigating the influence of managerial accounts. *Journal of Applied Psychology, 81,* 22-35.

Bobocel, D. R., & Holmvall, C. (2001). Are interactional justice and procedural justice different? Framing the debate. In S. Gilliland, D. Steiner, & D. Skarlicki (Eds.), *Research in Social Issues in Management: Theoretical and Cultural Perspectives on Organizational Justice* (pp. 85-110). Greenwich, CT: Information Age.

Bobocel, D. R., McCline, R. L., & Folger, R. (1997). Letting them down gently: Conceptual advances in explaining controversial organizational policies. In C. L. Cooper & D. M. Rousseau (Eds.), *Trends in Organizational Behavior* (Vol. 4, pp, 73-88). Chichester, England: Wiley.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. A. Long (Eds.), *Testing Structural Equation Models.* Newbury Park, CA: Sage.

Brown S.P. & Peterson, R.A. (1993). Antecedents and consequences of salesperson job satisfaction: meta-analysis and assessment of causal effects. *Journal of Marketing Research, 30,* 63–77.

Cobb, A. T., Vest, M., & Hills, F. (1997). Who delivers justice? Source perceptions of procedural fairness. *Journal of Applied Social Psychology, 27,* 1021-1040.

Cotton, J. & Tuttle, J. (1986). Employee turnover: A meta-analysis and review with implications for research. *Academy of Management Review, 11,* 55—70.

Cropanzano, R., & Folger, R. (1991). Procedural justice and worker motivation. In R. M. Steers & L. W. Porter (Eds.), *Motivation and Work Behavior*. New York: McGraw-Hill.

Cropanzano, R., & Greenberg, J. (1997). Progress in organizational justice: Tunneling through the maze. In C. L. Cooper & I. T. Robertson (Eds.), *International Review of Industrial and Organizational Psychology* (pp. 317-372). New York: John Wiley.

Cropanzano, R. S., Prehar, C.A., & Chen, P.Y. (2002). Using social exchange theory to distinguish procedural from interactional justice. *Group & Organization Management, 27,* 324-351.

Currivan, D.B. (1999). The causal order of job satisfaction and organizational commitment in models of employee turnover. *Human Resource Management Review, 9,* 495—524.

Dansereau, F., (Jr)., Graen, G., & Haga, W. J. (1975). A vertical dyad linkage approach to leadership within formal organizations: A longitudinal investigation of the role making process. *Organizational Behavior and Human Performance, 13,* 46-78.

DeConinck, J.B. & Stilwell C.D. (2004). Incorporating organizational justice, role states, pay satisfaction in a model of turnover intentions. *Journal of Business Research, 57,* 225—231.

Dienesch, R.D., & Liden, R.C. (1986). Leader-member exchange model of leadership: A critique and further development. *Academy of Management Review, 11,* 618-634.

Dulebohn, J.H. & Ferris, G.R. (1999). The role of influence tactics in perceptions of performance evaluations' fairness. *Academy of Management Journal, 42,* 288-303.

Fishbein, M. & Ajzen, I. (1975). *Belief, Attitude, Intention and Behavior*. Reading, MA: Addison-Wesley Publishing Company.

Folger, R. (1977). Distributive and procedural justice: Combined effect of 'voice' and peer opinions on responses to inequity. *Journal of Personality and Social Psychology, 35,* 108—119.

Folger, R., & Konovsky, M.A. (1989). Effects of procedural and distributive justice on reactions to pay decisions. *Academy of Management Journal, 32,* 115-130.

Gomez, C. & Rosen, B. (2001). The leader-member exchange as a link between managerial trust and employee empowerment. *Group & Organization Management, 26,* 53-69.

Graen, G. (1986). Role making processes within complex organizations. In M.D. Dunnette (Ed), *Handbook of industrial and organizational psychology* (pp1201-1245). Chicago: IL: Rand McNally.

Graen, G. B., Cashman, J., Ginsburgh, S., & Schiemann, W. (1977). Effects of linking-pin quality upon the quality of working life of lower participants: A longitudinal investigation of the managerial understructure. *Administrative Science Quarterly,* ***2,*** 491–504.

Graen, G., Liden, R., & Hoel, W (1982). Role of leadership in the employee withdrawal process. *Journal of Applied Psychology, 67,* 868—872.

Graen, G., & Scandura, T.A. (1987). Toward a psychology of dyadic organizing. *Research in Organizational Behavior, 9,* 175—208.

Graen G. B., & Schiemann, W. (1978). Leader-member agreement: A vertical dyad linkage approach. *Journal of Applied Psychology, 63,* 206-212.

Hom, P.W. & Griffeth, R.W. (1991). Structural equations modeling test of a turnover theory: Cross-sectional and longitudinal analyses. *Journal of Applied Psychology,* ***76,*** 350–366

Hom P.W. & Griffeth R.W. (1995). *Employee turnover*. Cincinnati: South Western.

Jacobs, T.O. (1971). *Leadership and Exchange in Formal Organizations*. Alexandria, VA: HumRRO

Jöreskog, K.G. & Sörbom, D. (1984). *LISREL-VI User's Guide* (3rd ed.). Mooresville, IN: Scientific Software.

Katz, D., & Kahn, R.L. (1978). *The Social Psychology of Organizations* (2nd ed.). New York: Wiley.

Kolb, D.M. & Putman, L.L. (1992). The multiple faces of conflict in organizations. *Journal of Organizational Behavior, 13,* 311-324.

Konovsky, M. A., Folger, R., & Cropanzano, R. (1987). Relative effects of procedural and distributive justice on employee attitudes. *Representative Research in Social Psychology, 17,* 15-24.

Krone, K.J. (1992). A comparison of organizational, structural and relationship effects on subordinates' upward influence choices. *Communication Quarterly, 40,* 1-15.

Lewin, D (1987). Dispute resolution in the nonunion firm: A theoretical and empirical analysis. *Journal of Conflict Resolution, 31,* 465-502.

Liden, R.C. & Maslyn, J.M. (1998). Multidimensionality of leader-member exchange: An empirical assessment through scale development. *Journal of Management, 24,* 43-73.

Locke, E.A. (1976). The nature and causes of job satisfaction. In Dunnett, M.D. (ed.) *Handbook of Industrial and Organizational Psychology* (pp. 1293-1349). Chicago: Rand McNally.

Manogran, P., Stauffer, J., & Conlon, E.J. (1994). Leader-member exchange as a key mediating variable between employees' perception of fairness and employee citizenship behavior. National Academy of Management meeting proceedings. Dallas, TX.

Masterson, S.S., Lewis, K., Goldman, B.M., & Taylor, M.S. (2000). Integrating justice and social exchange: The differing effects of fair procedures and treatment on work relationships. *Academy of Management Journal, 43,* 738—748.

Mathieu, J.E. & Zajac, D.M. (1990). A review and meta-analysis of the antecedents, correlates, and consequences of organizational commitment. *Psychological Bulletin,* ***108,*** pp. 171–194

McFarlin, D.B. & Sweeney, P.D. (1992). Distributive and procedural justice as predictors of satisfaction with personal and organizational factors. *Academy of Management Journal, 35,* 626-637.

Meyer, P. & Allen, N.J. (1997). *Commitment in the workplace: Theory, research, and application.* Thousand Oaks, CA: Sage Publications

Moorman, R.H. & Podsakoff, P.M. (1992), "A meta-analytic review and empirical test of the potential confounding effects of social desirability response sets in organizational behavior research", *Journal of Occupational and Organizational Psychology, 65,* 131-149.

Mowday, R.T., Porter, L.W. & Steers, R. (1982). *Organizational Linkages: The Psychology of Commitment, Absenteeism, and Turnover.* San Diego, CA: Academic Press.

Mowday, R. Steers, R.M. & Porter, L.W. (1979), The measurement of organizational commitment, *Journal of Vocational Behavior, Vol. 14,* pp. 224-247.

NASSCOM (2003). *NASSCOM Hewitt Total Rewards Study*. New Delhi: NASSCOM

NASSCOM (2005). *NASSCOM Strategic Report*. New Delhi: NASSCOM

Niehoff, B.P. & Moorman, R.H. (1993). Justice as a mediator of the relationship between methods of monitoring and organizational internship behaviors. *Academy of Management Journal, 36,* 527-556.

Price, J. L. (1997). *Handbook of Organizational Measurement*. Bradford, UK: MCB University Press.

Price, J.L. (2001). Reflections on the determinants of voluntary turnover. *International Journal of Manpower, 22,* 600-624.

Scandura, T. A (1999). Rethinking leader-member exchange: An organizational justice perspective. *Leadership Quarterly, 10*, 25, 25—41.

Smith, P. C., Kendall, L. M., & Hulin, C. L. (1969). *The Measurement of Satisfaction in Work and Retirement.* Chicago: Rand McNally

Spector, P.E. (1987), "Method variance as an artifact in self reported affect and perceptions at work: Myth or significant problem", *Journal of Applied Psychology, 72,* 438—443.

Steel, R. and Ovalle, N. (1984) 'A Review and Meta-Analysis of Research on the Relationship between Behavioral Intentions and Employee Turnover', *Journal of Applied Psychology, 69*, 673–86.

Steers, R. and Mowday, R. (1981) 'Employee Turnover and Post Decision Accommodation Processes'. In Cummings, L. and Staw, B. (eds) *Research in Organizational Behavior, Vol. 3.* Greenwich, CT: JAI Press.

Sweeney, P.D., & MacFarlin, D.B. (1993). Workers' evaluations of the ends and means: An examination of four models of distributive and procedural justice. *Organizational Behavior and Human Decision Processes, 55,* 23-40.

Tekleab, A.G., Takeuchi, R., & Taylor, M.S. (2005). Extending the chain of relationships among organizational justice, social exchange, and employee reactions: The role of contract violation. *Academy of Management Journal, 48,* 146-157.

Tett, R.P. & Meyer, J.P. (1993). Job satisfaction, organizational commitment, turnover intention, and turnover: path analyses based on meta-analytic findings. *Personnel Psychology. 46***,** 259–293.

Tyler, T. R., & Bies, R. J. (1990). Beyond formal procedures: The interpersonal context of procedural justice. In J. S. Carroll (Ed.), *Applied Social Psychology and Organizational Settings* (pp. 77-98). Hillsdale, NJ: Lawrence Erlbaum.

Vecchio, R. P., & Gobdel, B. C. (1984). The vertical dyad linkage model of leadership: Problems and prospects. *Organizational Behavior and Human Performance, 34*, 5-20.

Wakabayashi, M., Graen, G. & Graen, M. & Graen, M. (1988). Japanese management progress: Mobility into middle management. *Journal of Applied Psychology, 73,* 217-227.

Williams, L.J. & Hazer, J.T. (1986). Antecedents and consequences of satisfaction and commitment in turnover models: A reanalysis using latent variable structural equation methods. *Journal of Applied Psychology, 71***,** 219–231.

Wright, P. (1989). Test of the mediating role of goals in the incentive-performance relationship. *Journal of Applied Psychology, 74,* 699-705.

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Incorporating Flexibility in Information Technology Strategies to Answer Contemporary Marketing Issues

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Abstract

Since the creation of world wide web at CERN the internet has infiltrated every inch of our planet, but its use remains largely rudimentary compared with the potential it has offered. This article contains investigation that focuses strategic marketing issues driven by information technology, internet in particular, and globalization. Marketing successfully requires not only insight into how a product or service can be successfully marketed but also flexibility into the marketing of a product or service. Innovation, creativity and flexibility are needed in any type of marketing efforts. Trying several types of information technology strategies in marketing is usually the best method of eliminating marketing methods that fail, and determining which marketing methods are successful.

Keywords: competitive advantage, flexibility, internet, internal scanning, strategic marketing

Introduction

Information system strategies provide business units competitive advantage

The impact of performance measures of strategic marketing management must be communicated to those who are responsible for formulating and implementing strategic plans. Strategic information systems perform this function. The system allows all information to be recorded automatically. It helps develop strategy to market new product and the flexibility to respond to major changes and unexpected events (Richards,1996). Information system strategies provide business units competitive advantage. Multinational corporations are finding that the use of sophisticated WWW communication allows their employees to practice *follow-the-sun management*, in which project team members living in one country can pass their work to members in another country in which the work day is just beginning (Greco, 1998). Ultimately, Information Technology is challenged to make these initiatives operational, and to provide comprehensive information snapshots for better decision-making—as close to real time as possible. Also, technology professionals must integrate otherwise disparate legacy information, creating dynamic data-sharing and workflows among multiple units, departments, employees, vendors, and other stakeholders. Forward-looking companies have long aimed to perfect their critical business functions. By examining their best practices in terms of their information technology decisions, specific guidelines emerge as it relates to technology and infrastructure.

Impact of Internet on Strategic Marketing Management

Technology can provide the means for very low-cost information distribution, remote accessing and information processing and universally accessible and globally distributed electronic commerce and sales.

The low cost, global nature of the technology, opportunity to reach millions, interactive nature of the electronic commerce via the Internet are some of the potential benefits to strategic marketing management. The benefits (Turban, Lee, King and Chaung, Shaw, 2000) are:

- Expansion of marketplace to national and international markets
- Decrease the cost of creating, processing, distributing, storing and retrieving information
- Internet search engine enables people to create highly specializes business venture
- Allows just-in-time manufacturing and less overhead expenses by facilitating pull-type supply chain management

- Customization of product and services to better suit customer needs
- Initiate reengineering processes
- Provide easy access to information on customers, suppliers and competitors
- Increases flexibility and compresses cycle and delivery time

Information technologies include computers and automated information management but also other related technologies such as scanning, software and databases. Communications technologies refer to telephone-based transmission of digital messages. In the early days, digital transmission was primarily proprietary with information moving back and forth along secure and dedicated networks from remote terminals to centralized mainframes. These networks belonged to large organizations such as governments, the military and global corporations; they are now being superseded in public consciousness and in reality by networks based on personal computers and the Internet.

The Internet started as a network facilitating communication within small scientific communities, particularly those engaged in defense related research. Funded by the U. S. Defense research budget, the initial Internet consisted of restricted electronic links within a small community of American scientists. Over several years these connections spread to link scientists from several disciplines and communities throughout the United States. From there, the network extended even further into the non-scientific community and grew in a decade ago to link thousands of computers.

Research at CERN in Geneva developed a means for the transmission of graphical images over the Internet. HTML (Hyper Text Markup Language) became the basis for the World Wide Web, which created a virtual revolution in the way in which information is managed and communicated electronically. This means for distributing information gave flexibility to the companies to customize information on the real time to many who previously had been isolated from information technology such as those living in rural and remote areas.

Technology can provide the means for very low-cost information distribution, remote accessing and information processing and universally accessible and globally distributed electronic commerce and sales.

Internet and Social Responsibility

Technology provides a new and powerful set of tools to enable participation rather than to create a "virtual world." The Internet can be a "marketing" tool for small rural businesses, where local entrepreneurs develop Web sites and increase their markets.

Internet provides fast way to communicate a company's mistakes and any unethical or illegal actions to interested people throughout the world. Every data packet contains the users' electronic identification. Internet activists have launched WEB site to monitor working of corporations (Berkeley,2000). Differential access to Information and Communication Technologies (ICT) is likely to become one of the major part of social and economic life in rural and metropolitan areas. As ever larger elements of the productive economy become integrated and infused with ICT, any limitation on access to the technology or to the training required to effectively use ICT will become a new basis for social and economic inequality, the "information rich" and the "information poor". ICT is the new means of production, as were the tools of the early craft workers or the machines of the industrial age of production. Those without access to these tools whether through limited physical access, funds or training will find individual and community advancement restricted.

ICTs also give local communities and enterprises an historic opportunity to participate remotely but directly in the global economy as suppliers of specialty items in the world market and participants in production networks as information processors and suppliers. Local enterprises can work with and leverage the entire network of interdependent information processing nodes and inter-communicating hubs to become globalized. The network at least for the moment is open to everyone. Smoothly integrated communications networks, wideband information delivery channels, the capacity for remote and secure management and administrative controls all allow enterprises and individuals to rapidly expand local into national and national into global enterprises.

Internet on Market Scanning

The Internet has changed the way the strategist in market scanning. It provides the quickest

New models of commercial interaction are developing as businesses and consumers participate in the electronic marketplace and reap the benefits.

means to obtain data on almost any subject. A recent study (Miller (1998) of 77 companies reveals that 73% of the firms ranked the Internet as being used to a great extent. Other mentioned sources of information were competitors' offerings and products (66%), industry expert (62%), personal industry contacts (60%), online databases (56%), market research (55%), and the sales force (54%). Today there are softwares available like e-signal® which provides real – time fast, reliable, world market information and decision support tools delivered to active traders and professionals, directly to the networked PC or laptop. It allows traders to scan their database of stocks and find any stock that is performing to technical analysis criteria that they have set. The following information is available upon scanning the market.

- Customers and markets
  - The changing needs of customers
  - Their changing relationship to company
  - Their degree of solvability
- Suppliers
  - The supply of new products
  - The changing relationship of suppliers to the company
  - The suppliers' ability to provide essential products at the lowest possible cost
- Labor market
  - Changes in the supply of new skills
  - The relationship between labor and management
  - Manpower costs
- Dissatisfaction of the customers

Identifying factors associated with market scanning should have important implications for policy makers, managers of small businesses and researchers. By identifying which aspects of market scanning are critical to business growth, policy makers may be able to provide the companies with sales leads, exhibit their products in new geographic territories, and help advertise their products. Also, it may be possible to identify forms of market information companies want from research agencies and to develop methods in which the same agencies can assist in promoting these companies to potential buyers. Additionally, firms with reliable information sources continually exploit opportunities by tailoring service and products to well defined market niches, retrieve and react to market information more quickly, pursue orders, and typically are more flexible in meeting specific market demands. Yet, many companies, especially smaller ones usually possess fewer resources for instituting elaborate market-scanning mechanisms, thus possibly making them vulnerable to environmental shifts. Examining market-scanning activities of firms should enhance understanding of the complexities they face in dealing with market demands.

Internet on Corporate Competitive Advantage

In the Internet-enabled paradigm, information management may be based simultaneously on widespread access to an expanded range of information resources, and on the capability to implement and sustain far-reaching yet coherent information strategies that bestow competitive advantage.

Establishing one set of values throughout its global operation an MNC can get advantage over its rivals (Guyon,1996). Parcy Bernevik, Swedish Chairman of Asea Brown Boveri AG introduced his concept of a company with no geographic base which draws its expertise from around the globe. The Company adopts local cultures while executing global marketing strategies. It gets competitive advantage to cut costs, improve efficiency and integrate local businesses with the world view. Many in the "real world" are attempting to use information technology to create a world where they can participate. Technology provides a new and powerful set of tools to enable participation rather than to create a "virtual world." The Internet can be a "marketing" tool for small rural businesses, where local entrepreneurs develop Web sites and increase their markets. These successes will likely be repeated and extended as the Web expands. In rural areas the Net can also be used as a "tool" for product or marketing information or for collaborative business activities (production, marketing). ICT supports the formation of online networks for distributed economic development and production. Technology allows for continuous

communication; work sharing; remote administration and management; and, seamless presentation and marketing of multiple centres as a single entity to the world.

Coordinating production, optimizing the selective advantages within the network and using the larger scale capacities of the network to undertake more elaborate activities are being explored. This could be a major opportunity for local economies that previously had been limited by their access to specialized skills and their small and dispersed populations. "Flexible networks" gain advantage from geographic or cultural social distinctiveness and from being a component of a larger network of producers, even when the linkages are largely "virtual." New types of networked organizations may be created. They could be structured as hubs and multiple self-sufficient nodes (Gurstein,1998). Collaborative specialization, information dispersal and multiple or distributed ownership, decentralized and horizontal support structures, and a high degree of local self-sufficiency (and thus structural redundancy/survivability) characterizes these new organizations. These structures allow for a speed of adaptation, highly efficient (low friction) horizontal rather than vertical information flow, and the economies of mutual rather than functional support. Client needs can be responded to more immediately, both geographically and culturally, creating powerful and globally competitive marketing opportunities.

This in turn would map onto the strengths and competitive advantages of existing local enterprise efforts. Highly adaptive responses to external economic conditions would help the local economy to evolve towards information intensity, increasing complexity and functional elaboration while integrating clients directly into dispersed supplier chains. The resulting disintermediation between user and supplier is precisely what many are predicting as being the organizational model of the marketplace of the immediate future.

The Growth of Global Internet Commerce

Internet may be the next major phase in the evolution of the competitive intelligence function.

According to a report (Enter the Eco System 2000) the electronic commerce is poised to grow rapidly throughout the world to a total over USD 7 trillion in the Internet sales by 2006. Asia-Pacific region will grow to USD 1.6 trillion Internet sales. In a liberalized economy under the WTO umbrella the trading partners will invest in crucial technology infrastructure such as phone lines, computers, Internet hosts, CAIDA- type network and cell phones. Economic climate is improving in a border-less economy. As the Internet empowers citizens and democratizes societies, it is also changing classic business and economic paradigms. New models of commercial interaction are developing as businesses and consumers participate in the electronic marketplace and reap the resultant benefits. Entrepreneurs are able to start new businesses more

WORLD INTERNET USAGE AND POPULATION STATISTICS

World Regions	Population (2006 Est.)	Popul-ation % of World	Internet Usage Latest Data	% Population (Penetration)	Usage % of World	Usage Growth 2000-2005
Africa	915,210,928	14.1 %	23,649,000	2.6 %	2.3 %	423.9 %
Asia	3,667,774,066	56.4 %	364,270,713	9.9 %	35.6 %	218.7 %
Europe	807,289,020	12.4 %	291,600,898	36.1 %	28.5 %	177.5 %
Middle East	190,084,161	2.9 %	18,203,500	9.6 %	1.8 %	454.2 %
North America	331,473,276	5.1 %	227,303,680	68.6 %	22.2 %	110.3 %
Latin America/ Caribbean	553,908,632	8.5 %	79,962,809	14.4 %	7.8 %	342.5 %
Oceania/ Australia	33,956,977	0.5 %	17,872,707	52.6 %	1.7 %	134.6 %
WORLD TOTAL	6,499,697,060	100.0 %	1,022,863,307	15.7 %	100.0 %	183.4 %

NOTES: (1) Internet Usage and World Population Statistics were updated for March 31, 2006. (2) Demographic (Population) numbers are based on data contained in the world-gazetteer website. (3) Internet usage information comes from data published by Nielsen//NetRatings, by the International Telecommunications Union, by local NICs, and other reliable sources.Source: www.internetworldstats.com.

Figure 1

easily, with smaller up-front investment requirements, by accessing the Internet's worldwide network of customers.

Internet technology is having a profound effect on the global trade in services. World trade involving computer software, entertainment products (motion pictures, videos, games, sound recordings), information services (databases, online newspapers), technical information, product licenses, financial services, and professional services (businesses and technical consulting, accounting, architectural design, legal advice, travel services, etc.). An increasing share of these transactions occurs online. The Internet has also revolutionized retail and direct marketing. Consumers are now able to shop in their homes for a wide variety of products from manufacturers and retailers all over the world.

To ensure the growth of global electronic commerce over the Internet, standards will be needed to assure reliability, interoperability, ease of use and scalability in areas such as:

- electronic payments;
- security (confidentiality, authentication, data integrity, access control, non-repudiation);
- security services infrastructure (*e.g.*, public key certificate authorities);
- electronic copyright management systems;
- video and data-conferencing;
- high-speed network technologies (*e.g.*, Asynchronous Transfer Mode, Synchronous Digital Hierarchy); and
- digital object and data interchange.

A flexible network can involve similar firms which band together to share the costs of developing a new product or market, or dissimilar but complementary firms which collectively approach the capability of a vertically integrated large firm.

Internet on Strategic Internal Scanning

The market-oriented Internet has made significant expansion into intranets and extranets contribute to increased performance through supply chain management (Poirer, 1999). Industry leaders are integrating modern information systems into their corporate value chains to harmonize efforts to achieve competitive advantage. With actual-point-of-sale information, products are replenished to meet the current demand and minimize stock-outs while maintaining low inventories. All organizations need to monitor at some level what goes on in their environments and recognize their strengths and weaknesses in relation to it. The importance of environmental information depends on the degree to which the success of the organization itself depends on its environment. In the business literature, this dependency of the organization on its environment is referred to as perceived environmental uncertainty (PEU). Gordon and Narayanan (Gordon, Lawrence and Narayanan, 1984) identified factors that determine PEU. These factors include the nature of the society, economic stability, legal stability, political constraints, the nature of the industry, the customer base and the nature of the organization. While PEU varies from industry to industry, the level of recognition of the importance of the environment also varies from company to company, as does the reaction of companies to their environment. Internet resources and services are quickly becoming strategic information tools for a growing number of commercial, government, and non-profit organizations. Organizations connected to the Internet can break out from the traditional model of managing information as a form of exercising control over the integrity of and access to information. In the Internet-enabled paradigm, information management may be based simultaneously on widespread access to an expanded range of information resources, and on the capability to implement and sustain far-reaching yet coherent information strategies that bestow competitive advantage.

Networking is linked to improved productivity and competitiveness, and the Internet and e-commerce technologies are being used to coordinate global operations in a variety of industries.

Internet on Business Strategy

Business to Business (B2B) web portals have been designed to make electronic connection between buyers with suppliers to strengthen collective purchasing activities. B2 B operation is a recent example of the use of corporate strategies to obtain competitive advantage." If our information was 100% right", asserts Dick Hunter, head of Dell's Computer's supply chain management, "the only inventory that would exist would be in transit" (Enter the Eco-System, 2000). Internet may be the next major phase in the evolution of the competitive intelligence function. A higher form of competitive intelligence is evolved when businesses and organizations integrate the resources and services on the Internet into their organizational learning processes.

The organization's knowledge network expands as more people in the organization tap into external knowledge, and as connections are made with relevant expertise and advice outside the organization. Businesses develop deeper insight about their customers, competitors, and technologies; broaden their intellectual horizons; and generally become more swift-footed in responding to market needs and external opportunities. Businesses new to the net are initially enticed by the access to open information sources and the access to potential markets, but access to information and access to markets are only the opening gambits, the longer term value of the Internet could be the facilitation of a new information and learning culture that enables organizations to adapt themselves as nimbly as the external environment transmutes.

Networking on Corporate Strategy

Growth of Internet allows corporations to rethink what business they should be in. Any company considering entering international markets must consider the impact of the Internet. Simply creating a Web site is likely to result in inquiries from people in foreign countries where the company has no experience (Gimeno and Woo, 1999). Creating a Flexible Manufacturing Network seems to be a promising possibility of the future.

A flexible network is a group of two or more firms which have banded together to carry out some new business activity that the members of the network could not pursue independently. The network can involve similar firms which band together to share the costs of developing a new product or market, or dissimilar but complementary firms which collectively approach the capability of a vertically integrated large firm. Typically the nature of the cooperation within the network is carefully defined so as to preserve each firm's independence and original lines of business.

The duration of the collaboration may be very short and limited to a particular project for a single customer. A new network may then be assembled with the best configuration to meet the needs of the next customer. A flexible production network is not just a joint venture among several firms. nature of the collaboration tends to be deeper in a true network, and one form of collaborative endeavor tends to lead to others. Shared input procurement to get large scale cost breaks may lead to joint bids or a common work force training program.

Small firms, who want to improve their competitiveness, develop new products, penetrate new markets, adopt new technology and upgrade work force skills while retaining the unique lifestyle of a small business should be interested in the network approach. Significant progress on these fronts can be achieved more easily in a well functioning network than in isolation. A significant new opportunity presented by ICT may be through the formation of flexible networks online, using electronic links to manage and coordinate distributed development and processing of information intensive products.

The capacity of technology to facilitate and accelerate continuous communication, work sharing and remote administration and management, seamless presentation and marketing of multiple centres as a single source to the world (the basis of "flexible networks") is only beginning to be explored. In addition new types of networked enterprises would emerge that would take advantage of product differentiation and the flexibility of distributed and more adaptable systems. In this way it might be possible to achieve economies of "disaggregation" rather than economies of scale.

Internet on Functional Strategy

Tracking potential online customers is the rationale for electronic customer relationship management (e-CRM) software (Medford, 2001). Every time a corporate executive clicks on a banner or views a product on the Internet, Web site operators add this information to the person's digital trail. The user does not have to purchase anything because a decision not to buy is almost as important as a decision to buy. The data is used to answer questions such as, "Why did the customer visit our site but not buy our product? Is our checkout process too long? Did the customer come from an affiliate site? Should we have offered this person a discount of special offer? The answer to these questions can strongly influence an MNC's marketing strategy (Brady, 2000). The position of Internet strategy among functional strategies is special in that it must support both the superior business strategy and the rest of the functional strategies with all of whom it should be interrelated so that the Internet can contribute to the achievement of

partial strategic goals of the related functional strategies as much as possible.

Internet Provides Infrastructure for Companies to Become Global

In today's economic life globalization is becoming a permanent and irreversible part. A key reason is the use of information system technology to connect operations around the world. The Internet via e-mail and Web sites in multiple languages provides instantaneous communication. Enterprise resource planning (Garten, 1998) (ERP) Systems software can manage any corporation's internal and international operations in a single powerful server network. ERP is able to unite customers and suppliers so that they can transact business with each other online with global sourcing and pricing strategy. Enterprise resource planning (ERP) is an exercise that focuses on optimizing the way things are done internally. It attempts to integrate all departments and functions across a company onto a single computer system that can serve all those different departments' particular needs. The best way to demonstrate the value of ERP is by improving the way the company takes a customer order and processes it into an invoice and revenue.

The process of economic globalization is perhaps most vivid with the integration of information technology and Internet. Networking is linked to improved productivity and competitiveness, and the Internet and e-commerce technologies are being used to coordinate global operations in a variety of industries. The rapid adoption of Internet-based electronic commerce is expected to have major impacts on the way companies do business worldwide. These include changes in the internal organization of firms, helping to link all of the firm's activities and allowing for better communication, sharing of information, and coordination of activities within the firm. The expected impacts also include changes in the external organization of economic activities. As companies apply IT internally, they have also developed electronic linkages with suppliers, customers and business partners to pursue similar improvements in performance in the entire value chain. The Internet and electronic commerce are bringing countries together to create a global networked economy.

Conclusion

This article develops an understanding of the adopting various information technology strategies to achieving business success. It firmly establishes the impact of Internet on strategic research on marketing management. It integrates most of the strategic marketing management concepts, research and theories on the Internet. There is growing consensus in the industry to create adaptive, agile Information Technology architecture. The world of business is characterized by rapid change, unexpected shifts, and relentless competition. In this environment, companies need the ability to adapt quickly to change, and to use change as an advantage. Flexibility means success.

References

Berkeley. J., (2000) Web Attack, *Harvard Business Review,* 20.

Brady. D., (2000) Customer Service, *Business Week,* 119-128.

Enter the Eco-System. (2000) *The Economist E-Management Survey*, 30.

Garten. J.E., (1998) Why the Global Economy is Here to Stay, *Business Week,* 21

Gimeno. J. and Woo. C.Y., (1999) Multimarket Contact, Economics of Scope, and Firm Performance, *Academy of Management Journal,* 239-259.

Gordon, Lawrence A. and Narayanan, V.K. (1984) Management Accounting Systems, Perceived Environmental Uncertainty and Organization Structure: An Empirical Investigation. Accounting Organizations and Society, 9(1), 33-47.

Greco. J., (1998) Good Day Sunshine, *Journal of Business Strategy,* 4-5.

Guyon. J., (1996) ABB Fuses Units with One Set of Values, *Wall Street journal,* A15.

Hypergrowth for E-Commerce. (2000) Forrester Research Report, *The Futurist,* 15.

Medford. C., (2001) Know Who I am, *PC Magazine,* 136-148.

Michael Gurstein (1998) Flexible Networking, Information and Communications, Technology and Local Economic Development, Australian Community Networking Association (ACNA).

Miller. S.H., (1998) Developing a Successful CI Program: Preliminary Study Results, *Competitive Intelligence Magazine,* 9.

Poirer. C.C., (1999) *Advanced Supply Chain Management,* Berrett-Koehler Publishers, San Francisco, 2.

Richards. B., (1996) The Business Plan, *Wall Street Journal,* 10

Shaw. M.J., (2000) Electronic Commerce: State of the Art, in M J Shaw et al Ed. *Handbook of Electronic Commerce,* Springer, Berlin, 3-24.

Turban. E. J. Lee, King. D. and Chung. H.M., (2000) *Electric Commerce: A Management Perspective,* Prentice Hall, NJ.

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Strategic Flexibility: Study of Selected Telecom Companies in India

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Abstract

The Telecom sector is one of the integrated parts of economy of any country and the Government regulatory and policy initiatives have also been directed towards establishing a world class infrastructure in India also. It provides an ideal environment for the investment but it also has a very complex structure. The challenges imposed on the Indian telecom market are increasing day by day because of the new technologies and knowledge. India's 21.59 million-line telephone network is one of the largest in the world and the 3rd largest among emerging economies (after China and Republic of Korea). Given the low telephone penetration rate - 2.2 per 100 people of population, which is much below the global average, India offers vast scope for growth. There is great need of Indian Telecom companies to be flexible. This paper basically deals with the different kind of flexibilities and types of flexibilities exist in any company. Here, basic research is done for two Indian companies that are Bharti Tele-Ventures Limited (BTVL) and Bharat Sanchar Nigam Limited (BSNL) and this shows how any company do well in market if it is flexible.

Keywords: integrated flexibility, regulatory flexibility, strategic flexibility

There is an emergent need to increase the tele-density in India by incorporating flexibities at the level of people, process, technology and organization

Introduction

India has currently one of the lowest tele densities in the world. Various reasons for such a low level of Tele density are

- Consideration of a telephone by political decision makers as a luxury rather than a necessity
- Lack of governmental priority in planning and sufficient capital allocation for the telecom sector
- Provision of telecom services by a state monopoly without pressure for innovation
- Organization of telecommunications by a government department lacking initiative, incentive and accountability.

Apart from this various kind of flexibilities exist in any company, which are necessary to increase the tele-density of India are:

- Flexibility in tariff structure
- Flexibility in technical platform
- Flexibility in organizational structure
- Flexibility in marketing
- Flexibility in strategy
- Flexibility in manufacturing
- Flexibility in operation
- Flexibility in finance

- Flexibility in Regulation

The two case studies were undertaken, First of Bharat Sanchar Nigam limited (www.bsnl.co.in) and second of Bharti Tele-Ventures Limited (BTVL) (www.bharti.com). The case study so undertaken gives the results and the impact of flexibility on any company which covers Profile, Operations (Addressable markets, Subscriber growth, Infrastructure and Investments), and Competition trends in the market share, Average revenue per subscriber, and Financials but here not given the detail of the analysis, while the concentration is on the results from the analysis. This also includes from the perspectives of the current flexibilities available.

The organization needs multiple flexibilities to cope up for any change within short span of time with little efforts, less cost with good performance

Types of Flexibility

"Flexibility is the ability to cope up and quick reaction for any change within short span of time with little efforts, less cost with good performance". Lau (1996) defines strategic flexibility as "A firm's ability to respond to uncertainties by adjusting its objectives with the support of its superior knowledge and capabilities". The strategic flexibility provides transformational capability in terms of perpetual renewal of the enterprise as well as dynamic balancing of the paradoxical strategic options (Sushil, 2000). This provides openness, focus, change and resilience in the strategy formulation and implementation.

Integrated Flexibility

In a changeable and volatile global environment, successful companies will have to adapt to systems of operation attend to highly dynamic competitive and environment trend. This requires speedy as well as a quality response. This demands internal process integration, the integration of effort within a function, and external process integration coordinating inter-functional activities. Blended they create "Integrated Flexibility" which constitutes a broader paradigm necessary for competitive advantages.

Tariff Flexibility

Tariff flexibility can be taken as the flexibility provided by the companies to their customers in Tariff plans e.g. Bharat Sanchar Nigam Limited (BSNL) cuts ISD rates for One India; under this new tariff ISD rates to the US, UK and Canada would be Rs 6 per minute (10 second pulse) against the rate of Rs 7.20 per minute under other plans. Another example which would help the readers to understand the Tariff flexibility is the STD rate cuts down by the IDEA Cellular under which STD rate goes down to 99 paise per minute on all GSM phones.

Flexibility in Technical Platform

Technical platform flexibility is understood by the flexibility occurred in the firm for the adoption of new technologies coming day by day in the market, or firm should ready to adapt high rate of change of technical changes.

Organization Flexibility

Any organization should move systematically to overcome the pressure faced by different sources and all the parts of the organizations should coordinate with each other in whole. In other words it can be depicted as the firm should be very flexible. According to Evans (1991) flexibility is composed of a number of "senses" including "adaptability, agility, corrigibility, elasticity, hedging, liquidity, malleability, plasticity, resilience, robustness, and versatility". Organizational flexibility is the change making capability of the organization in its structure, processes, people and culture, so as to carry more than one option on the same continua at the same time and to dynamically interplay across the organizational options.

Marketing Flexibility

"Marketing" is the process of identifying prospects and developing a relationship so a producer can get that first appointment. "Sales" is the process of moving a prospect from an initial appointment to a purchase decision. So, it is necessary for companies to understand the markets they serve and be flexible enough to adjust to changing market conditions.

Strategic Flexibility

Succeeding in today's competitive product markets requires that firms have the strategic flexibility to respond more quickly to changing market demands, to differentiate more product variations for rapidly segmenting markets, and to bring new and upgraded products to market faster-all while meeting

increasingly stringent product and supply chain cost targets. Growing numbers of firms today recognize that the creation of modular platforms is the key to enabling new kinds of strategies for meeting today's escalating market demands. The strategic flexibility approach provides a framework for decision-making that takes into account the varied possible scenarios that can occur in an uncertain future, as opposed to trying to devise a single strategy based on an attempt to predict the future.

Manufacturing Flexibility

Flexible manufacturing systems design is a complex phenomenon, which is concerned with the selection from a wide variety of available system configurations and control strategy alternatives in the light of several criteria (flexibility, quality, productivity, costs etc.), many of which are difficult to quantify (Borenstein et al., 1999).

Operational Flexibility

This can be identified as the rapid response to changes that are familiar. Such changes typically lead to temporary, short term fluctuation in the firm's level of activity. Example of internal operational flexibility are the variation or production volume in the organization, the building up of inventories and the maintenance of excess capacity in terms of financial resources.

Financial Flexibility

It can be defined as an exercise of freedom of choice within the framework of the government's monetary and fiscal policy, capital market regulations, investor's risk-return preferences and corporate strategy to evolve the financial processes with versatility, adaptive ness and transparency so as to have better resonance with the business environment.

Regulatory Flexibility

Regulatory flexibility in communication sector ensures that communication sector is developed in a competitive environment and that market dominance in a converged environment

To achieve regulatory flexibility (www.trai.gov.in), there are various methods, one of which is the so-called "the power of forbearance" of a regulatory authority. One of these principles is to ensure that "the communication sector is developed in a competitive environment and that market dominance in a converged environment is suitably regulated."

Case Studies

Bharat Sanchar Nigam Limited

BSNL is the largest Public Sector Undertaking of India, providing telecommunication services of land-line/GSM/ Braodband and has all India presence except Mumbai and Delhi

On October 1, 2000 the Department of Telecom Operations, Government of India became a corporation and was christened Bharat Sanchar Nigam Limited (BSNL) (www.bsnl.co.in). Today, BSNL is the No. 1 Telecommunications Company and the largest Public Sector Undertaking of India with authorized share capital of $ 3977 million and net worth of $ 14.32 billion. It has a network of over 45 million lines covering 5000 towns with over 35 million telephone connections. State-owned BSNL owns around 85% of India's copper wire local loop networks. The company is the largest telecom operator and the largest public sector enterprise in India, providing basic fixed-line services nationwide, except for the cities of Mumbai and Delhi. BSNL lost its exclusive rights to local access and national telephony in 2001. To compensate for reduced revenues, it built a national GSM network and entered the mobile sector, becoming the country's second largest GSM operator. In February 2003, the company entered the international telephony market. In April 2004, the government moved to unbundled BSNL's copper network to encourage the growth of broadband ADSL access.

BSNL has managed to shoulder these responsibilities remarkably and deftly. Today with over 45 million line capacity, 99.9% of its exchanges digital, nation wide Network management & surveillance system (NMSS) to control telecom traffic and over 4, 00,000 route Kms of OFC network, Bharat Sanchar Nigam Ltd is a name to reckon with in the world of connectivity. Along with its vast customer base, BSNL's financial and asset bases too are vast and strong. Consider the figures, as they speak volumes on BSNL's standing:

- The telephone infrastructure alone is worth about Rs. 1,00,000 crore (US $ 22.74 billion)
- Turnover of Rs. 31,400 crore (US $ 7.14 billion)

Bharti Tele-Ventures Limited

Established in 1985, Bharti (Tele-Ventures) (bhartiteleventures.co) has been a pioneering force

BTVL is the largest Private Sector organisation in India, providing telecommunication services of Land-line/GSM/ Braodband.

in the Telecom Sector. Bharti Tele-Ventures Limited, one of India's leading telecommunications services provider, is to be renamed Bharti Tele-Ventures Limited on January 24, 2006. Bharti gave Delhi its first Mobile Services - Tele-Ventures. Today, Tele-Venture's mobile footprint extends across the country in 21 telecom circles. Its service standards compare with the very best in the world. In fact, that's how Bharti has managed to win the trust of millions of customers and makes it one of the top 5 operators in the world, in terms of service and subscriber base. The company also has a submarine cable landing station at Chennai, which connects the submarine cable connecting Chennai and Singapore. The company provides reliable end-to-end data and enterprise services to the corporate customers by leveraging its nationwide fiber optic backbone, last mile connectivity in fixed-line and mobile circles, VSATs, ISP and international bandwidth access through the gateways and landing station.

Bharti Tele-Ventures Limited is one of India's leading private sector providers of telecommunications services based on an aggregate of 20,925,948 customers as of March 31, 2006, consisting of 19,579,208 GSM mobile and 1,346,740 broadband & telephone customers.

Flexibilities are incorporated both in PSU and Private sector telecom service providers i.e. classical music on telephone/One India plan/ Free Own Network tariff plan etc.

Flexibilities Initiatives

Here are the some results related to the various kinds of flexibilities which are derived from the news which appears in the various news papers, magazines and websites.

1) Launches 1 lakh Easy Music shops – The largest mobile music retail initiative in the world!

- Tele-Ventures Easy Music available in over 100,000 retail outlets
- Downloading music on your mobile easier than ever before
- Now walk into your nearest Tele-Ventures shop & walk out with your favorite song
- Choice of over 18000 songs in over 20 languages across India
- Easy Music slated to capture the music space in India cutting across geographical and socio-economic boundaries through easy access and download convenience

This is an example of strategic flexibility.

2) Tele-Ventures Presents Indian Classical Music on your mobile

- Becomes the first to take Indian Classical music genre to open up new segments.
- Best of Indian classical music now available on Tele-Ventures
- Pt. Ravi Shankar, Ustad Amjad Ali Khan, Ustad Bismillah Khan, Ustad Vilayat Khan, Ustad Alla Rakha,Ustad Zakir Hussain, Pt. Bhimsen Joshi, Pt. Pandit Jasraj among others now on Tele-Ventures
- Pt. Hari Prasad Chaurasia & Pt. Shiv Kumar Sharma launch the Indian classical content on Tele-Ventures in Delhi

This is again an example of strategic flexibility; by the people who are very much interested in classical music will like to purchase the offer.

3) Tele-Ventures and research in notion launch the the BlackBerry 8700g -*the first EDGE-enabled BlackBerry device in India*

- Tele-Ventures expands its BlackBerry product portfolio
- Set to redefine communication for high end enterprise customers
- The BlackBerry 8700g features enhanced performance and a stylish new design
- Features Intel XScale processor technology

This is an example of technical flexibility; Tele-Ventures are ready to adapt the changes in technology.

4) Tele-Ventures launch the 'All for One' plan for its Fixed Line customers

Now call anywhere within the country for Re 1 from your Tele-Ventures fixed line telephone

The comparision of Govt. and Pvt. Telecom service providers shows that Pvt. Sector organisation has the higher flexibility than Govt. sector due to autonomy in terms of finance, operation and organisational processes.

Table 1: Comparison of Flexibilities between BSNL and BTVL

Flexibility	BSNL	BTVL	Overall
Strategic	LOW The organization is not well prepared for long term changes due to the change in various factors including the change in environment. Top management is very much prominent.	HIGH The organization is well prepared for long term changes due to various factors and planning department is also very much supported by the top management.	The complete effect can be seen like the strategic flexibility exist more in private sector as compared to public sector. Since the top management is more effective in public sectors means they consider the view of all.
Organizational	LOW Talented and skilled people are not on the rolls. People got high position on the basis of tenure not by the qualifications only.	HIGH Talented and skilled people are on the rolls. People got high position on the basis of qualifications not only by the tenure. No organizational hindrance.	Here also the same case exist because the promotion is totally based on the tenure basis in public sectors while the new blood is regularly diffused in the higher level which keep the new ideas flow in the company.
Technical	LOW Initially best in the market but now there is not much improvement in the existing technologies so people also not learning the new things. To incorporate new technologies a lot of changes required in the existing technology which may not be liked by many persons	HIGH There is constant up-gradation in the technologies to prove themselves in the market and good training is also provided to the employees for quick learning of the technology.	This is common view that whatever new comes in market is sonly adapted by the private sector while public sector do something experimental after sometime
Marketing	LOW Tariffs plans are not that much flexible rather there will be reduction in the tariffs after seeing the other companies	HIGH Tariff plans are very flexible according to the customer requirements. Like easy recharge coupons, top-up charge scheme etc.	Many people which keeps on marketing good by making the advertisement more attractive, things more attractive. Many easy things exist for customers like top up recharge which was not an implemented by BSNL soon. New schemes usually launched by the BTVL and ring tones, games etc are also the good features.
Financial	LOW The financial matter is also a work at the top level and it requires a lot of clearance if there is any change from the normal one. Even acquisition of any new service and new product requires a lot of clearance.	HIGH There are separate budget for all the units and this is not centralized. If any new things come in the company then there does not exist any cumbersome procedure involved. Each functional area has financial autonomy.	Again here the ball is in the private sector's court because there exist financial autonomy for all the divisions and procedure for any new product and service is not cumbersome. Therefore there exists a good market for private sector.
Operational	LOW The organization is not able to adjust itself when situation changes quickly like many people wants a service of low cost which is provided by the BSNL so certainly there comes a huge number of new customers which makes the operation so poor that people change their services	HIGH The organization is able to satisfy its customers by providing their current demands and they keep their services good. They plan the number of customers in advance which cause no problem in operations. Like in the evening hours also there is less congestion in private sector's network while it is difficult to get through the public sector networks.	The overall impact again favors the private company that is BTVL because they are ready to face any changes which are quite unpredictable. By which they are able to make the market value high.
Regulatory	HIGH Since it is a public sector and operable by the government so regulatory matters are in the favor of it.	LOW Here, most of the rules are not taken by the company willingly because of being private sector and they do not favour its profitability	This is point where BSNL has an edge over BTVL.

- Flat call rate of Re.1 per minute for all STD calls
- Special tariff of Re.1 for 3 minutes for Tele-Ventures to Tele-Ventures fixed line local calls
- All this for a monthly rental of Rs. 299 only

This is an example of tariff flexibility; company is providing the flexibility in tariffs.

5) Tele-Ventures launches a suite of Re. 1 plans – Presents an India without boundaries

- Makes STD calls, Roaming calls and national SMS at just Re.1
- Announces two plans for post paid customers – India Home at Rs. 299 and India Roam at Rs. 499
- Launches new Prepaid recharge coupon - makes Local, STD and SMS at Re. 1 on a Rs. 899 Recharge Coupon
- Launches special tariff of Tele-Ventures to Tele-Ventures, local calls at just Re.1 for 2minutes
- Advantage Tele-Ventures owing to its presence in all 23 circles – Now call from anywhere in India to anywhere in India

This is kind of marketing as well as tariff flexibility.

6) Tele-Ventures announces an integrated structure for all its telecom businesses

- New structure created to take forward the corporate vision of making Tele-Ventures the most admired brand by 2010
- Manoj Kohli to be the President Of Bharti Tele-Ventures
- Joint Presidents appointed for three independent SBUs – K Krishnan (Broadband & Telephone Services); Vinod Sawhny (Enterprise Services) and Sanjay Kapoor (Mobility)
- Tele-Ventures Management Board Chaired by Manoj Kohli to consist of three Joint Presidents and Sarvjit Dhillon (Director -Finance & Business Integration), Jai Menon (Director IT & Innovation), Hemant Sachdev (Director, Marketing & Communication), Don Price (Director, Networks) for Bharti Tele-Ventures.

This is a kind of organizational flexibility. These are the changes for which company in already prepared.

7) Tele-Ventures to launch 3G in Seychelles

- To invest 44 million Seychelles Rupees for the roll-out
- Most advanced network in Seychelles to be at par with the best in world

This is an example of financial flexibility.

8) Sachin & Shahrukh enthrall India – Tele-Ventures showdown culminates amidst unprecedeted revelry & entertainment. Sachin & Shah Rukh also launch "King Khan's Den" and "Master Blaster's Pavilion"– A mobile fan club & exclusive content zone on the two superstars on Tele-Ventures Live

- Customers can also interact with the two super stars on Tele-Ventures Live by sending an SMS to 646
- Tele-Ventures Showdown – A national campaign spanning three months, was backed by extensive internal research – One of the most extensive marketing initiatives undertaken by Tele-Ventures

This is an example of marketing flexibility.

9) Vodafone the world's biggest cellular operator has pick up a 10% stake in Bharti Tele-Ventures Limited, the largest private telecom operator, for a whopping Rs 6,700 crore ($1.5 billion) in cash.

This is an example of financial flexibility.

10) Telcos to share towers

- Skylines in cities to have less of those obnoxious looking towers
- In Delhi, the target is to reduce number of towers from 7,000 to less than 5,000

This is order which is given by Telecom Regulatory Authority of India (TRAI) (trai.gov.in) according to which different service providers have to share the towers; since the customers are increasing day by day but the towers are not increasing by that rate much rate so it will be beneficial if different service providers share the towers.

This is an example of flexibility in technical platform.

11) TRAI recommends separate regulator for content

The TRAI has given its recommendations on convergence and competition in broadcasting and telecommunications, highlighting the need for a legal and regulatory framework and to have a separate regulator for content.

This is an example of regulation flexibility

12) BSNL offers one tariff for whole India as an alternative package i.e. "BSNL ONE INDIA" for Basic and WLL Services

This is a scheme launched by Bharat Sanchar Nigam limited under which the call rate to all over the India is Rs. 1 only on all GSM mobiles.

This is an example of Tariff flexibility

13) BSNL has been decided to allow call forwarding facility from PSTN/ WLL to PSTN/ WLL/Mobile services of BSNL network within the same licensed service area (Circle)

This is an example of Operational flexibility

NOTE: The cases which are taken in this report are on Bharat Sanchar Nigam Limited and Bharti Tele-Ventures Limited; both are telecom operators so manufacturing flexibility is insignificant in this case.

Analysis

Two case studies are taken for the analysis and a finding which gives the kind of flexibilities exists in Bharat Sanchar Nigam Limited and Bharti Tele-Ventures Limited. By this analysis we tried to show that what type of flexibility is more effective in which companies and what is the effect of flexibility in making a good market value of company. To see the results please refer Table 1. The results which are mentioned here are on the basis of conclusions which are drawn form the analysis of questionnaire which was filled by people from different domains in BSNL as well as in BTVL.

Conclusions

The customer satisfaction, quality and cost of services are the main drivers of competitive advantage in telecom service sector which can be upgraded through flexibility route

The customer satisfaction through new services, new schemes, good quality, and cost is most important parameters by which any company can withstand in the competitive market where monopoly does not exist and all these factors leads to the competitiveness via flexibility. As it is observed that in the case of BSNL where the tariff plans are of low cost and quite flexible, but due to the poor quality of services and customer care the ARPU and market share is low. In the case of BTVL, the fundamentals of cost and quality are met and the various flexibilities have become the bases of enhanced competitiveness. Once upon a time almost complete market of telecom was only driven by BSNL but now the scene changes completely because of low quality of services and poor customer care as already mentioned. This report completely shows the effect and the impact of flexibility in any company.

References

Borenstein Denis, João Luiz Becker, Eduardo Ribas Santos (1999), *A systemic and integrated approach to flexible manufacturing systems design*, Journal of Integrated Manufacturing Systems.

Evans, J.S.(1991), *Strategic Flexibility for High Technology Manoeuvres: A Conceptual Framework*, Journal of Management Studies.

Jain P.K., and Sushil (2000), Financial Flexibility for Corporate Performance, in *Cornerstones of Enterprise Flexibility,* Global Institute of Flexible Systems Management, Vikas Publishing House, New Delhi.

Lau R.S.M. (1996), *Strategic Flexibility: A New Reality for World-Class Manufacturing,* SAM Advanced Management Journal.

Momaya K., (2001) International Competitiveness :*Evaluation and Enhancement, Ist edn., Hindustan Publishing Corporation(India)*

Sushil (2000), *Cornerstones of Enterprise Flexibility,* Global Institute of Flexible Systems Management, Vikas Publishing House, New Delhi.

www.asistradehub.com

www.bhartiteleventures.com

www.bsnl.co.in

www.chennaionline.com

www.coai.com

www.dotindia.com

www.idc.com

www.iec.org

www.india-cellualr.com

www.indiainfoline.com

www.itu.int

www.Tele-Venturesenterprise.com

www.trai.gov.in

Reflecting Applicability in Real Life:

1. Flexibility should be an integrated part of any organization and properly operable to attract more customers and make good market.

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