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An attempt of supply chain practices to enhance a country's performance

Balan Sundarakani
University of Wollongong in Dubai, balan@uow.edu.au

Prem Vrat
UP Technical University

Pradeep Kumar
Indian Institute of Technology Roorkee

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Supply Chain as an Enabler for Country's Development

[*]Balan Sundarakani[1], Prem Vrat[2] and Pradeep Kumar[3]

[1]Assistant Professor, Faculty of Business and Management, University of Wollongong in Dubai, Block 14, Room 123, Knowledge Village, Dubai, UAE, Email: balansundarakani@uowdubai.ac.ae

[2]Vice Chancellor, UP Technical University, Lucknow, India- 226016,

Professor Emeritus, IIT Delhi, E-mail: vc@uptu.ac.in

[3]Professor and Head, Department of Mechanical & Industrial Engineering, Indian Institute of Technology Roorkee, Roorkee- 247667, E-mail: kumarfme@iitr.ernet.in

* Corresponding author

Abstract

The fast emerging global economy shattered many traditional boundaries across the continents, resulted in free trade movement. Till last decade, the developed countries were considered as the super power in their economic structure. This trend has got changed recently because of globalization and outsourcing of manufacturing and Information Technology (IT) related services to developing countries like China and India. This paper provides an analysis of considering supply chain as an enabler to develop country's development. Extensive analysis has been performed by using Modified Brown-Gibson model considering situational and operational factors. The results are significant and it shows there is a strong positive correlation between supply chain and country's development.

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1. Introduction

In many verticals India is placed among the top indicators across the world. To mention a few, India continued to be the tenth largest producer of steel in the world during 2000-2001, 2nd best Information Technology exporter, 11th best country in national income (WCI, 2004), 6th best in the number of Scientist and Engineers' production across the world (TI, 2002), relatively good adult literacy 44% (male 68%), world's largest milk producer, 2nd best in cotton export, and world's fourth fastest growing economy. Statistics reveals that India, the fifth largest economy in terms of Gross National Product (GNP) and Purchasing Power Parity (PPP), constitutes one of the fastest growing markets in the world. India is also counted among the richest with regard to cheap skilled labor, scientific and technological resources and entrepreneurial talents. However, India lags behind in competitiveness because of various factors. The Indian infrastructure comprising roads, railways, airports, seaports, usage of Information Technology (IT), and energy production are considered quite poor in comparison to other developed and developing countries. The overall Indian infrastructure is rated 48th among 80 countries (World Bank Group, 2005). India is ranked 53rd and 127th in Human Poverty Index (HPI) and Human Development Index (HDI) among 150 countries (Human Development Report, 2004) respectively. However, Indian organizations were ill prepared for meeting the challenges affected by an open economy and had not developed the required infrastructure to meet the challenges faced by globalization of businesses and deregulation of the Indian economy. Many of the Indian organizations have realized the

importance of the well-developed supply chain and this research is an initiative in this respect.

Quantitative justification of supply chain as a measure to national development is a great challenge to decision makers The present research is aimed to relate the supply chain practices with the country's development index because the economic situation of Less Developed Countries (LDCs) can be greatly improved by conscious and judicious application of science and technology to supply chain problems.

The research was undertaken with the following scope of work:

- To identify the correlation between supply chain and country's development
- To justify supply chain as an enabler to country's development
- To find out the best practices of the country's supply chain attributes and to consider these attributes in strategic planning process

Considering these scopes as objectives, the model and analysis have been performed to identify the best practices that would increase India's development index.

2. Model Development

The following hypotheses were formulated to check the correlation between a country's degree of development and its supply chain attributes:

H_0 : Enhancing the supply chain attributes is not a powerful means for the economic development of a country and there is no correlation between them.

H_1 : Enhancing the effectiveness and efficiencies of supply chain is a powerful means for the economic development of a country and there is a strong correlation between these two.

A country's economy can be characterized by many economic parameters. In the analysis supply chain can be visualized as a means to develop a national economy is proposed. To test the hypothesis, the analysis is carried out with three alternatives: supply chain, quality of life and economic conditions. The model is proposed by considering objective factors affecting supply chain and subjective factors affecting supply chain as well as risk factors associated with supply chain. In this strategic decision making model the objective factors are measured from the indices of the best indicators of the world economy. The subjective factor measure is performed using the rating approach of the Analytic Hierarchy Process (AHP). A method similar to that discussed by Brown and Gibson (1972) is considered for the analysis and it is modified to match with the objective, subjective and risk factors. The Brown Gibson model originally considered discrete, finite and mutually exclusive factors in a quantitative framework for the facility location problem applied to a multi-plant location problem.

4. The Modified Brown Gibson Model

The proposed model is derived from the conventional Brown-Gibson model in which National Development Index *(NDI)* is considered as the overall objective. This paper is an early form of our extended research appeared in Balan et al. (2007) explains here the detailed conceptual framework and hypothesis testing. Both the objective and subjective factors are converted into consistent and dimensionless indices to measure the *NDI*. The modified Brown-Gibson model including the Risk Factor, Internal Factors affecting supply chain and External Factors affecting supply chain can be expressed as:

$$NDI_i = (1 - RF_i)\left[W\left(\frac{OF}{\sum_i OF_i} \right) + (1 - W)(SF_i) \right] \quad (1)$$

Where :

NDI_i = National Development Index for alternative i

W = Operational Factor decision weight $(0 \le W \le 1)$

RF_i = Risk Factor in a scale 0 to 1 for alternative i

OF_i = Operational Factor measure for alternative i

SF_i = Situational Factor measure for alternative i

The operational factors are task environment related factors or micro environment factors which influence directly the supply chain performance. Whereas the situational factors are global macro environment related factors which affects externally the National Development Index (*NDI*) as shown in Fig.1. The operational factor measurement is done quantitatively and the global macro environment related factors measurement is done using Analytic Hierarchy Process (AHP) approach. In this model internal factors affecting supply chain are considered as operational factors and external factors affecting it are considered as situational factors. Any increase in National Development Index (*NDI*) will increase the Supply Chain Performance and this will further improve the Supply Chain Management Index (SCMI).

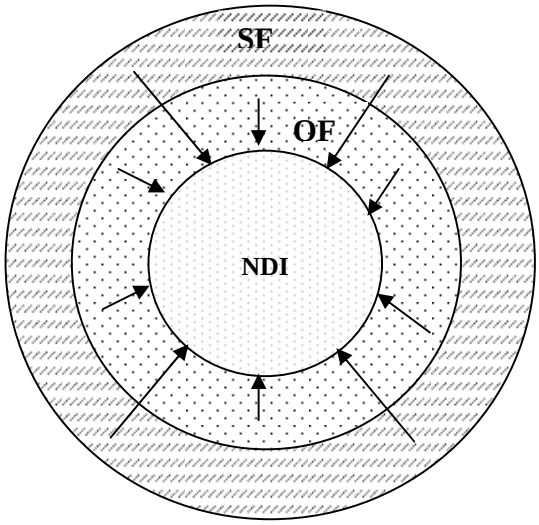

Fig. 1. Pictorial Representation of National Development Index against its Variables

4.1 Operational Factor Measurement

The Operational Factor measurement is done for all the chosen Internal Factors (*IF*) influencing the degree of development of a country. The *IF* is selected from the worldwide best indicators and India's *IF* affecting supply chain management index (I_{SC}), quality of life index (I_{QoL}) and economic factor index (I_{EF}) have been derived from the variables against the best in the world. The data collected are based on international statistics, which came from a variety of organizations and statistical databases such as:

- Annual Human Development Index Reports (HDR, 2004)
- Annual Reports from International Road Federation (IRF, 2004)
- Statistics from International Road Traffic and Accident Database (IRTAD)
- Statistics from World Bank Group (WBG, 2005)
- Data from World Economic Forum (WEF, 2000)
- Data from Word Development Indicators and World Fact Book (WFB, 2004)

- Time Series Data from RetsNet project (Regional Traffic Safety Network), Sweden
- Different research & Data reports
- Global Competitiveness Report (GCR, 2004)
- United Nation Development Reports (UNDR, 2004)
- Business Guide, ERNST & YOUNG, India, 2005
- Annual Development Report, Government of India, 2004

The chosen indicators and their indices are converted into a dimensionless scale using Eqn. (2).

$$I_j = \frac{(\text{Country value - Sample minimum})}{(\text{Sample maximum - Sample minimum})} \tag{2}$$

Where, I_j represent indices and subscripts j represents $SC / QoL / EF$

The sample minimum and sample maximum are the lowest and highest values of the overall sample, respectively.

The operational factor measure is calculated from:

$$OF_i = \frac{1}{n}\left[\sum_{j=1}^{n} I_j\right] \tag{3}$$

Where, n denotes the number of indicators and for each alternative i.e. *SC/QoL/EF* six indicators are selected.

$$\left.\begin{aligned} \sum I_{SC} &= (SRI + SCLI + PI + IWI + QCI + CRI) \\ \sum I_{QoL} &= (LEI + HDI + MEI + EdI + TDI + PII) \\ \sum I_{EF} &= (GDPI + PI + GCI + PUI + MEI + TDI) \end{aligned}\right\} \tag{4}$$

Where,

OF = Operational Factor measure

SRI = Suppliers Relationship Index

SCLI = Supply Chain Logistics Index

PI = Productivity Index

IWI = Inventory control and Warehousing Index

QCI = Quality Competitiveness Index

CRI = Customer Relationship Index

LEI = Life Expectancy Index

HDI = Human Development Index

MEI = Macroeconomic Environment Index

EdI = Education Index

TDI = Technology Development Index

PII = Public Institutions Index

GDPI = Gross Domestic Product index

GCI = Growth Competitiveness Index

PUI = Public Utility Index

Using Eqn (2) India's relative indices for all the alternatives are calculated. For example, the Supplier Relationship Index (SRI) of India is calculated as, I_j = (3.34-0) / (4.35-0) = 0.768. Using Eqn (4) I_j for each alternative is calculated.

$$\sum I_{SC} = 0.768 + 0.635 + 0.522 + 0.548 + 0.432 + 0.483 = 3.388$$
$$\sum I_{QoL} = 0.703 + 0.617 + 0.660 + 0.595 + 0.584 + 0.658 = 3.817$$
$$\sum I_{EF} = 0.555 + 0.483 + 0.548 + 0.464 + 0.66 + 0.584 = 3.294$$

Using Eqn (3) the objective factor measures for the alternatives are calculated and are,

OF_{SC} = 3.388 / 6 = 0.5646

OF_{QoL} = 3.817 / 6 = 0.6360

OF_{EF} = 3.294 / 6 = 0.5490

The values are substituted in expression $(OF_i)/\sum_i OF_i$ and the decision should not be taken solely based on this measure because Situational Factor (SF) measures are also involved in the analysis. The following part discusses the Global Macro Level Environmental Factor or Situational Factor measurement.

4.2 Situational Factor (SF) Measurement

Analytic Hierarchy Process (AHP) technique is used to evaluate the Global Macro Level Environmental Factors (GMLEF) and their measurement. The chosen situational factors are Gross Domestic Product (GDP), Human Development (HD), Technological Development (TD), Education (Ed), Public Utilities (PU), Research and Developments (R&D) and Per capita income (Pci). Some of the chosen factors (GDP, HD and TD) are relevant to national development for both counts. AHP is an intuitive method for formulating and analyzing decisions [Saaty (2001), Saaty (1984) and Saaty (1988)]. AHP has been applied to numerous practical problems in the last few decades. Because of its intuitive appeal and flexibility, many corporations and governments routinely use AHP for major policy decisions. The flow diagram of the complete structure of AHP is shown in Fig. 2 and its application in a decision making involving four steps as follows:

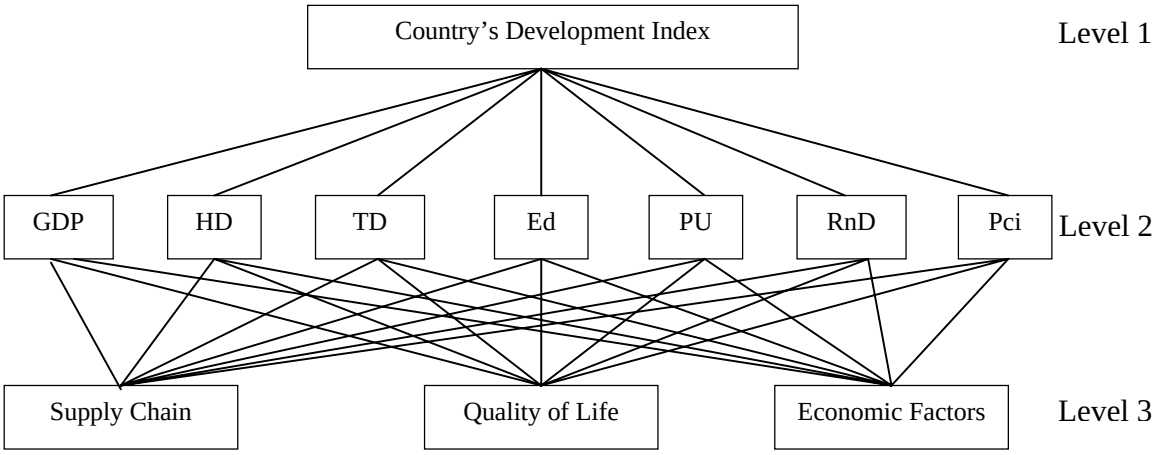

Fig. 2. AHP Model of a Country's Development Index

By applying the AHP method the global weights of all alternatives with respect to each criterion have been calculated and the values are given in Table 2. All other calculations are not included to reduce the paper length. The author's web-link can be referred for full details of the calculations (www.geocities.com/balanrec).

Table 2. Global Weight Calculations of All Alternatives

Alternatives	Criterion							Final Weight
	GDP	HD	TD	Ed	PU	RnD	PCI	
	0.0712	0.0418	0.3655	0.2607	0.0959	0.0310	0.1339	
Supply Chain	0.3151	0.1179	0.6485	0.0782	0.5485	0.6687	0.0694	0.3674
Quality of Life	0.0824	0.6806	0.2248	0.4866	0.2106	0.0882	0.2981	0.3062
Economic Conditions	0.6025	0.2014	0.1267	0.4353	0.2409	0.2431	0.6325	0.3264

$$SF_{SC} = (0.0712 \times 0.3151) + (0.0418 \times 0.1179) + (0.3655\times 0.6485) + (0.2607 \times 0.0782) + (0.0959 \times 0.5485) + (0.0310 \times 0.6687) + (0.1339 \times 0.0694) = 0.3674 \quad (5)$$

$$SF_{QoL} = (0.0712 \times 0.0824) + (0.0418 \times 0.6806) + (0.3655\times 0.2248) + (0.2607 \times 0.4866) + (0.0959 \times 0.2106) + (0.0310 \times 0.0882) + (0.1339 \times 0.2981) = 0.3062 \quad (6)$$

$$SF_{EC} = (0.0712 \times 0.6025) + (0.0418 \times 0.2014) + (0.3655\times 0.1267) + (0.2607 \times 0.4353) + (0.0959 \times 0.2409) + (0.0310 \times 0.2431) + (0.1339 \times 0.6325) = 0.3264 \quad (7)$$

From the outcome of the subjective factors measure, it is also possible to decide that the supply chain has an impact on a country's development followed by economic factors and quality of life factor. However it is recommended that the micro level factor and macro level environmental factor together must be considered before making any decision.

From the analysis, it is identified that the supply chain can be considered as a preferred alternative and the contribution of this over the country's development index is vital next to quality of life and economic conditions. Hence the initially defined null hypothesis has been rejected and the alternate hypothesis has been accepted. Hence improving Supply Chain Management Index (*SCMI*) and its operational variables such as, Supplier Relationship Index (*SRI*), Supply Chain Logistics Index (*SCLI*), Productivity Index (*PI*), Inventory and Warehouse Index (*IWI*), Quality Competitiveness Index (QCI) and Customer Relationship Index (*CRI*) will improve the National Development Index (*NDI*). It implies that supply chain is a powerful means for the economic development of a country and there is a strong correlation between these two variables. But, how much it contributes to the development of the country are the things to be explored in detail.

5. Conclusion

In this paper, an analysis has been carried out to examine the impact of supply chain performance on the national economy. A Modified Brown-Gibson (MBG) model is proposed to include the operational, situational and risk factors. This paper is an early form of our research work focused on the functional aspects of the model appeared in Balan et al. (2007). The operational factor measure is estimated for the three alternatives by benchmarking the indices with the best global indicators. The situational factor measure is estimated by using AHP. This research has demonstrated that supply chain acts as a means for the development of a country and there is a strong correlation between these two factors [Degree of Development (*DOD*) and National Development Index (*NDI*)].

Reference

1. Annual Development Report, Government of India, (2004), Accessed: March 15, 2005.
2. Balan, S., Kumar, P., Vrat , P. (2007) A strategic decision model for the justification of supply chain as a means to improve national development index, International Journal of Technology Management, Vol. 40, No.1/2/3 69 – 86, 2007
3. Brown, P, A. and Gibson, D, F., A quantified model for facility site selection application to multi plant location problem, *AIIE Transactions*, 4(1), 1-10, 1972.
4. Business Guide, *ERNST & YOUNG*, India, 2005, Accessed: March 15, 2005.
5. Global Competitiveness Report (GCR) 2004, Accessed: March 15, 2005.
6. Human Development Report, (2004), http://www.worldbank.org.in, Accessed: March 15, 2005.
7. International Road Federation Report (IRFR) 2004, Accessed: March 15, 2005.
8. Saaty, T, L., *Decision Making with Dependence and Feedback: The Analytic Hierarchy Process*, RWS Publications, Pittsbugh, PA, 2001

9. Saaty, T, L., *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*, RWS publications, Pittsbugh, PA, 1984.
10. Saaty, T.L., How to make a decision: The analytic hierarchy process, *European Journal of Operational Research*, 48, 9-26,1988
11. Saxena, K, B. and Sahay, B, S., Managing IT for world class manufacturing: the Indian scenario, *International Journal of Information Management*, 20, 29-57, 2000.
12. United Nations Development Program, *UNDP Report 2004*, Accessed: March 15, 2005.
13. World Bank Group: India, http://www.worldbank.org.in, Accessed: March 15, 2005.
14. World Economic Forum, (2000), *Global Competitiveness Profile of India 2000*, Cologny, Geneva, Accessed: March 15, 2005.
15. World Economic Forum, (2004), *Annual Human Development Index Reports*, Accessed: March 15, 2005.
16. World Fact Book (WFB, 2004), Accessed: March 15, 2005.