Chapter 1

INTRODUCTION

1.1 Logistics Management

Over the past years, globalization has caused a growth in trade, leading to the growing strategic importance of the logistics function within the organization. Presently, improvements in logistics have been the prime source of improved profits for companies, allowing them to maintain their competitive advantage (Kunadhamraks and Hanaoka, 2007). Logistics have become an important source of sustainable competitive advantage (Celebi et al., 2010).

High logistics costs and low levels of service are a barrier to trade and foreign direct investment and thus to economic growth (Arvis et al., 2007). Inefficiencies in logistics have been highlighted as an important factor on firm's productivity, investment climate and trade facilitation of a nation (Hausman et al., 2005) and quality of life of the citizens (Gil and Duran, 1997). Therefore, improving logistics performance should be at the core of policies to bolster competitiveness and to boost trade integration for any country (Arvis et al., 2014).

Logistics concerns the efficient transfer of goods from the source of supply through the place of manufacture to the point of consumption in a cost-effective way whilst providing an acceptable service to the customer (Islam, 2013). The CILT in the UK describes logistics as delivering the right product to the right place in the right quantity at the right time in the best condition and at an acceptable cost (Mangan et al., 2008). The Council of Supply Chain Management Professionals (2007) defines logistics management as that part of the supply chain management process which plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements (Green et al., 2008). It can also be defined as the process of strategically managing the procurement, movement and storage of materials, parts and finished inventory (and the related information flows) through the organisation and its marketing channels in such a way that current and future profitability are maximised through the cost-effective fulfilment of orders (Christopher, 2011).

The definition includes "service" and "information" that go beyond the transportation of

goods. Shortening of production cycles, intensification of competition worldwide, sharing and outsourcing of production function, shorter delivery times and excess of choices for customers has made logistics as a basis of competitive advantage. To sustain in this era of globalisation, organisations are persistently searching for more efficient and cost effective logistics solutions, which would make them stand strong against their competitors in national and international markets.

With the world economy changing and globalization overpowering, the world is becoming an open market. It becomes necessary for every company to response quickly to consumer demands, reduce lead times, maintain quality at the right cost and be flexible to achieve the competitive advantage. The solution to achieve this is to have an efficient logistics system. Having good logistics infrastructure and culture is becoming a prerequisite for attracting global manufacturing and service companies into the country (Viswanadham, 2003). The Indian GDP is growing steadily at 6% to 7% (figure 1.1) compared to the world GDP growth rate of 3% (WEO, 2016), which is one of the biggest motivation for India to develop its logistics infrastructure in order to entice foreign investors and augment global trade.

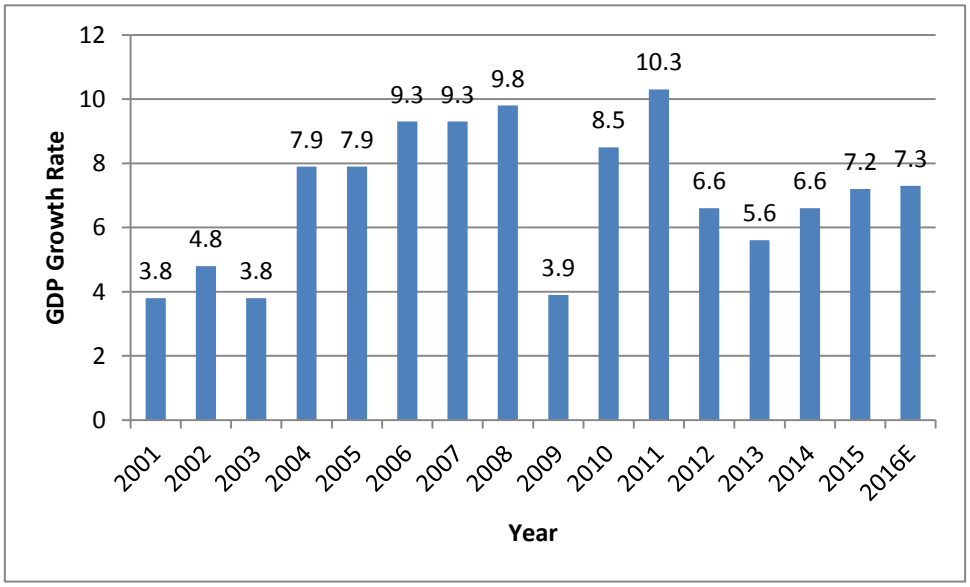


Figure 1.1 India's GDP Growth Rate

Source: Haque (2016)

Since the logistics function is shifting to a strategic role from operational and third party logistics service providers becoming strategic partners, logistics management in today's environment has become more complex. Logistics providers today are expected to provide complete end-to-end logistical support throughout the supply chain cycle of a business,

cutting down costs, lead time and offer integrated one-stop logistics solution for businesses to maintain their bottom line. To achieve this goal, managers need to increase their investments in technology and human capital development and to reduce their current liabilities (e.g. borrowings) while government and regulatory bodies could implement suitable policies and finance programs to help logistics companies (Wong et al., 2015). There is a need for a collaborative mindset from the public and private sector, i.e. both the government of India and private logistics companies to work together to identify what it takes to make India realize its true potential and how logistics infrastructure can be the biggest driver of the economy (Kaur, 2011).

The logistics industry in India is in a nascent stage. India's spend on logistics, 14% of its GDP is much higher than that of the developed economies like the US (10%), Europe (11%) & Japan (10%) (Alexander, 2013). This study is an attempt to identify the problems faced by the Indian logistics industry, to identify the reasons for such high logistics cost, areas of improvement and to study the effects of improvement if any on the competitiveness factors chosen.

1.2 Logistics and Competitiveness

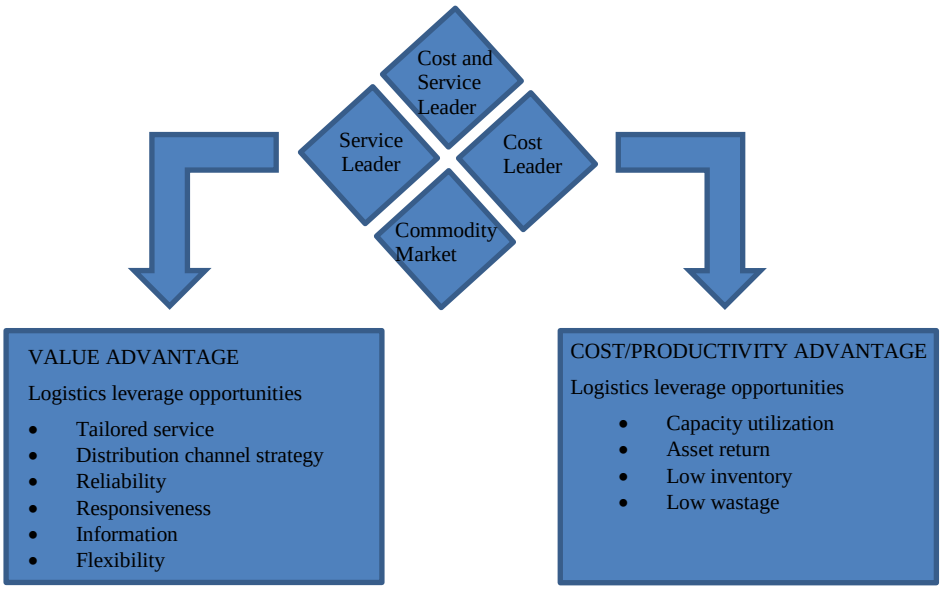


Figure 1.2 Logistics and Competitiveness

Source: Rushton et. al., 2010

Earlier, it was considered that spending on logistics only created additional cost. Even though there is a cost related to the movement and storage of goods, it is now acknowledged that it

also provides a very positive contribution to the value of a product and service. As the basic task of logistics is to make the product available to the customer or end user in the proper condition and required location at an affordable cost. Consequently, the companies can contest by providing the product either at the lowermost cost or at the uppermost possible value to the customer (customized product as per customer's requirement) or both.

As shown in figure 1.2, the company may contest as a service leader, where it is trying to gain an advantage over its opponents by providing several key service elements like tailored service, reliable delivery, quick responsiveness, flexibility or providing necessary information throughout the delivery process to distinguish itself. It may compete as a cost leader where it is trying to utilize its assets so that it offers the product at the lowest possible cost through maintaining low inventory, complete asset utilization, reducing wastage, reduction in accidents thus gaining a productivity advantage. Therefore, logistics play a very important role in improving the competitiveness of the organization.

1.3 Indian Logistics Industry

The Indian logistics industry was valued at an estimated US$ 130 billion in 2012–13 (IBEF, 2013). Transport Intelligence conducted an emerging market survey in 2011 and highlighted that India has a strong growth area for logistics in future and it is emerging as a major logistics hub. India's need for infrastructure creation in the logistics sector is striking. In just a decade, India has seen its economic size more than double to $ 1.37 trillion (2012) and total foreign merchandise trade multiply from 20% of GDP (2000) to 42% of GDP (2012) (Deloitte, 2014).

Table 1.1 Challenges in the Indian Logistics Industry

S.No	Factors \ Author/s	Viswanadham (2004)	Srivastava (2006)	Chandra & Jain(2007)	Mitra (2008)	Tiwari (2008)	Parkan (2009)	Chow (2010)	Kaur (2011)	Frentzel(2011)	LCL (2011)	Ravi and Kumar (2012)	Deloitte (2012)	EBTC (2013)	KPMG (2014)
1	Insufficient transport infrastructure	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	Poor condition of storage facilities			✓		✓			✓	✓		✓	✓	✓	
3	Complex tax structure	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4	Low rate of technology adoption	✓	✓	✓	✓	✓	✓				✓		✓	✓	
5	Poor skills of logistics professionals	✓	✓	✓	✓		✓	✓		✓	✓		✓	✓	
6	Low usage of third party logistics (3PL)				✓							✓			
7	Highly fragmented market	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓

Although the growth is exponential, it is faced by numerous problems, leading to very high logistics cost as shown in table 1.1.

India ranks 86th in quality of infrastructure by World Economic Forum 2012, 85th in quality of roads, among 142 countries and the Indian business community continues to cite infrastructure as the single biggest hindrance to doing business in the country (Schwab, 2011). In India, freight movement is dominated by the roadways (figure 1.3). India's resilience on roads is more than three times that of China (Mckinsey, 2010).

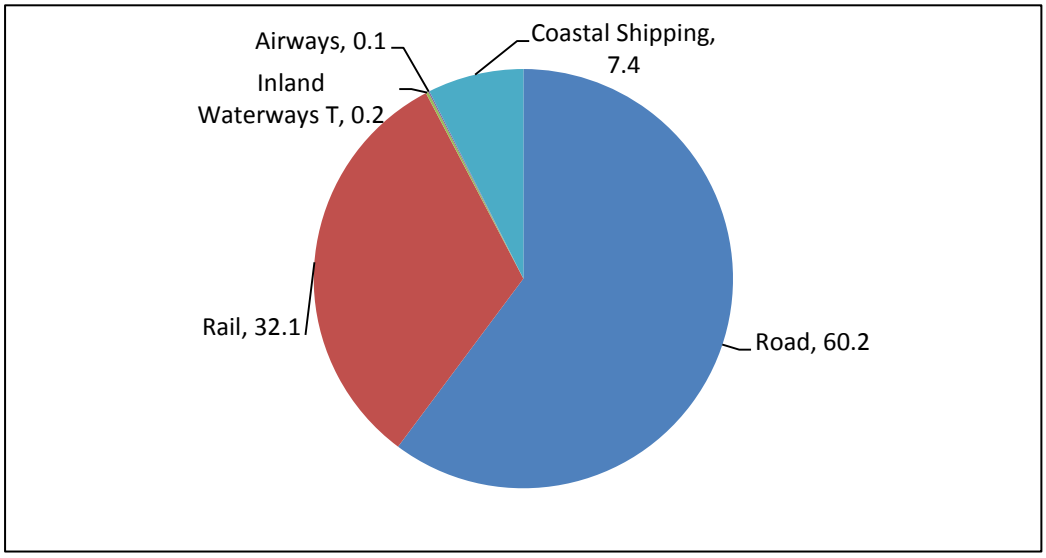


Figure 1.3 Total Freight Transport Modal Mix

Source: IBEF (2013)

The poor condition of roads translates directly to high vehicle turnover, which increases operating costs and reduces efficiency and surges the rate of accidents. These inefficiencies are passed on to the logistics industry, with transportation costs accounting for nearly 40% of logistics costs (figure 1.4) and the losses due to accidents and mishandling accounting for nearly 14% of logistics costs (Pandey and Sahai, 2012). In addition to increasing the logistics cost, the transit time also gets increased and the useful assets like the driver, labour and truck are deployed for a longer period of time to complete a delivery. India's freight traffic comprises of bulk material that moves over long distances through road, leading to an unbalanced modal mix. A balanced modal mix can be achieved which can be more economically served by railways and waterways by thorough planning by the government.

One of the barriers to the Indian logistics system is the tax infrastructure. With state owned tax structure, along with other taxes, movement of goods becomes costly and inflexible. Also,

the movement is hauled by police check posts, tolls etc., which increases the cost, wastes time and fuel. Government regulations play a very important role in converting the disorganized industry into an organized one. Due to the different taxes warehouses are located outside the cities, goods are moved to low tax zone and are sold from there. Trucks are overloaded, leading to pollution, damaging the roads and creating unsafe situations. The permit required hampers interstate trading. Internationally, while truck drivers do an average of greater than 600 km per day, in India the struggle is to get to 400 km per day (Viswanathan, 2014).

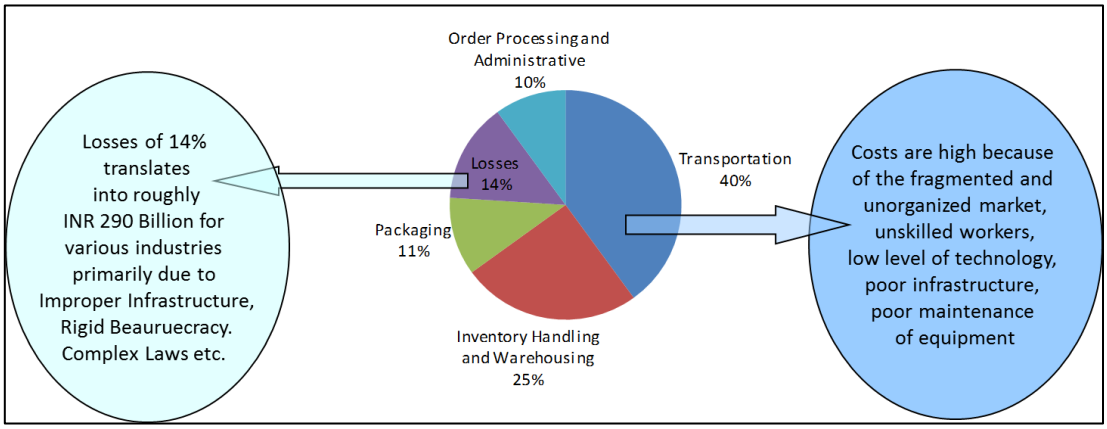


Figure 1.4 Break-up of Logistics Cost in India

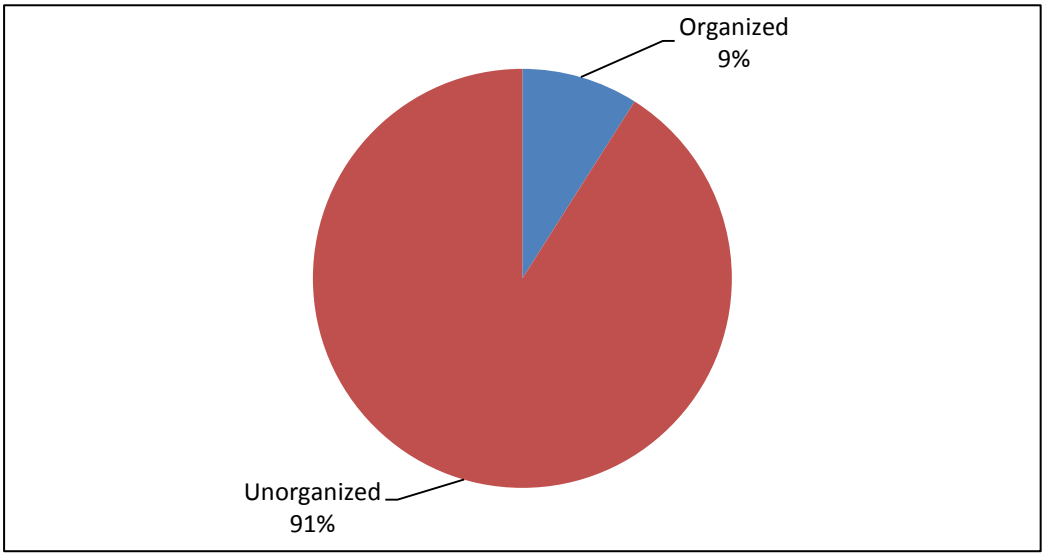


Figure 1.5 Status of Indian Logistics Industry

Source: Technavio, 2015

Unorganized industry compromises of owner of less than five trucks. As shown in figure 1.5, 91% of Indian logistics industry comprises of unorganized players. Unorganized players do

not pay proper taxes, due to which government do not get their revenues. As they work on low margins, overloading of trucks is very common leading to accidents or damage to freight. The staff such as drivers, loaders or handling staff employed is unskilled. The condition of vehicle is poor leading to further damage to roads, environment, freight etc.

Furthermore, the logistics cost as a percentage of the product cost is 20–21%, which is very high compared to 4-5% in developed economies (Kaur, 2011). Reduction in logistics cost by 1% of GDP in India will translate to savings over Rs. 6,000 crores (FICCI, 2011). Greater productivity, cost efficiency and competitiveness are the rewards of a well-developed logistics sector and a driving force for sustainable development (Colona, 2012). It is high time for India to realize it, else the waste caused by poor logistics infrastructure will increase from the current 4.3% of GDP to 5% of GDP by 2020 (Mckinsey, 2010).

1.4 Need for Research

The need for the research is as follows:

1. Indian economy is growing at the rate of 6-7% of the GDP despite global slow down.
2. To sustain this growth, logistics play a very important role but at present it is not in a very good shape.
3. Thus research is needed to investigate the areas of improvement, investment required and more importantly, how to invest the given budgets for the improvements in logistics.
4. The literature review shows that not much research is reported to study the investment strategies for the improvement in logistics performance.
5. For campaigns like ‘Make in India’ to be successful, it is imperative to improve logistics performance.

1.5 Research Objectives

The main objective of this study is to improve the logistics performance of India, as it directly impacts the competitiveness of Indian organizations. To achieve this, the following objectives were formulated.

1. To study the logistics scenario in India and compare it with the developed economies.
2. To identify and understand the challenges of the Indian logistics sector at state and organizational level.
3. To identify the focus areas for the improvement in logistics.

4. To develop dynamic models for the focus areas of logistics improvement like
    a. Human Resource
    b. Information Technology
    c. Infrastructure Development
    d. Government Regulation
5. To generate scenarios of logistics improvement under different investment strategies and suggest the strategic approach.

1.6 Scope of Study

1. Scope is limited to identifying investment areas and strategies for logistics improvement.
2. Cost, Time, Reliability, Flexibility and Safety are considered as components of Logistics Performance Index.
3. Four areas of improving logistics performance are:
    a. Human Resources – training, wages, working conditions, welfare
    b. Information Technology – RFID, EDI, GPS/GIS,ERP
    c. Infrastructure Development- capacity building, network integration and maintenance
    d. Improvement in Government Regulations – single window, implementation of GST and electronic toll collection system
4. Development of only causal loop diagram and stock and flow diagram for investment by government.

1.7 Research Plan

1. Literature review to identify the problem, understanding logistics issues in India and comparing with best economies, identifying research gaps.
2. System Dynamics modeling for evaluating the various investment strategies in the focus areas.
3. Simulation of system dynamics models for scenario generation for making suggestions for investment and logistics improvement.
4. ISM model to develop structural relationship among the variable for the improvement in logistics and to identify the focus areas.

1.8 Organization of Thesis

The result of this research work is summarized in eight chapters of dissertation. For

completeness, the dissertation provides comprehensive literature review, dissertation summary and complete list of references. Figure 1.6 shows the chapter framework for this research.

Chapter 1 covers the introduction of study, logistics scenario in India, the need of the study, objectives of the research and outline of the thesis.

Chapter 2 is devoted to the review of literature. The chapter provides an exhaustive literature review on the industry profile and the research techniques used to conduct research in the logistics context. Also, a detailed literature review is done on the two research techniques, i.e. system dynamics and interpretive structural modelling. On the basis of this literature, gaps have been identified to set the objectives for present research work.

Chapter 3 deals with the research methodology adopted for conducting the study. On the basis of gaps identified from literature, major objectives have been framed. To achieve objectives, research strategy is discussed. The procedure of system dynamics and interpretive structural modelling is discussed in detail.

Chapter 4 studies the effect of investment in human resources on the logistics performance index. Training, improvement in wages, improvement in working conditions and welfare of the employees are chosen as the four areas for improvement in human resources. The aim of this chapter is to identify the investment area/s, which will maximize logistics performance, to develop a dynamic model using system dynamics modelling for the investments in human resources, to evaluate the various investment plans for the decision maker to formulate the investment strategy which best meets the requirements of the business, to quantify the relationship between performance measures like logistics cost, delivery time, reliability, flexibility and safety and logistics performance and to study the effect of improvement in logistics performance, if any, on the profit of the firm. Causal loop diagram is discussed in detail to study the cause and effect relationship on the four areas and the competitiveness factors chosen. The other steps of system dynamics modelling have been applied in detail.

Chapter 5 studies the effect of investment in information technology on the logistics performance index. The aim of this chapter is to identify the technologies, which will maximize logistics performance, to develop a dynamic model using system dynamics modelling for the investments in IT, to evaluate the various investment plans and scenarios for the decision maker to formulate the investment strategy which best meets the

requirements of the business, to quantify the relationship between performance measures like

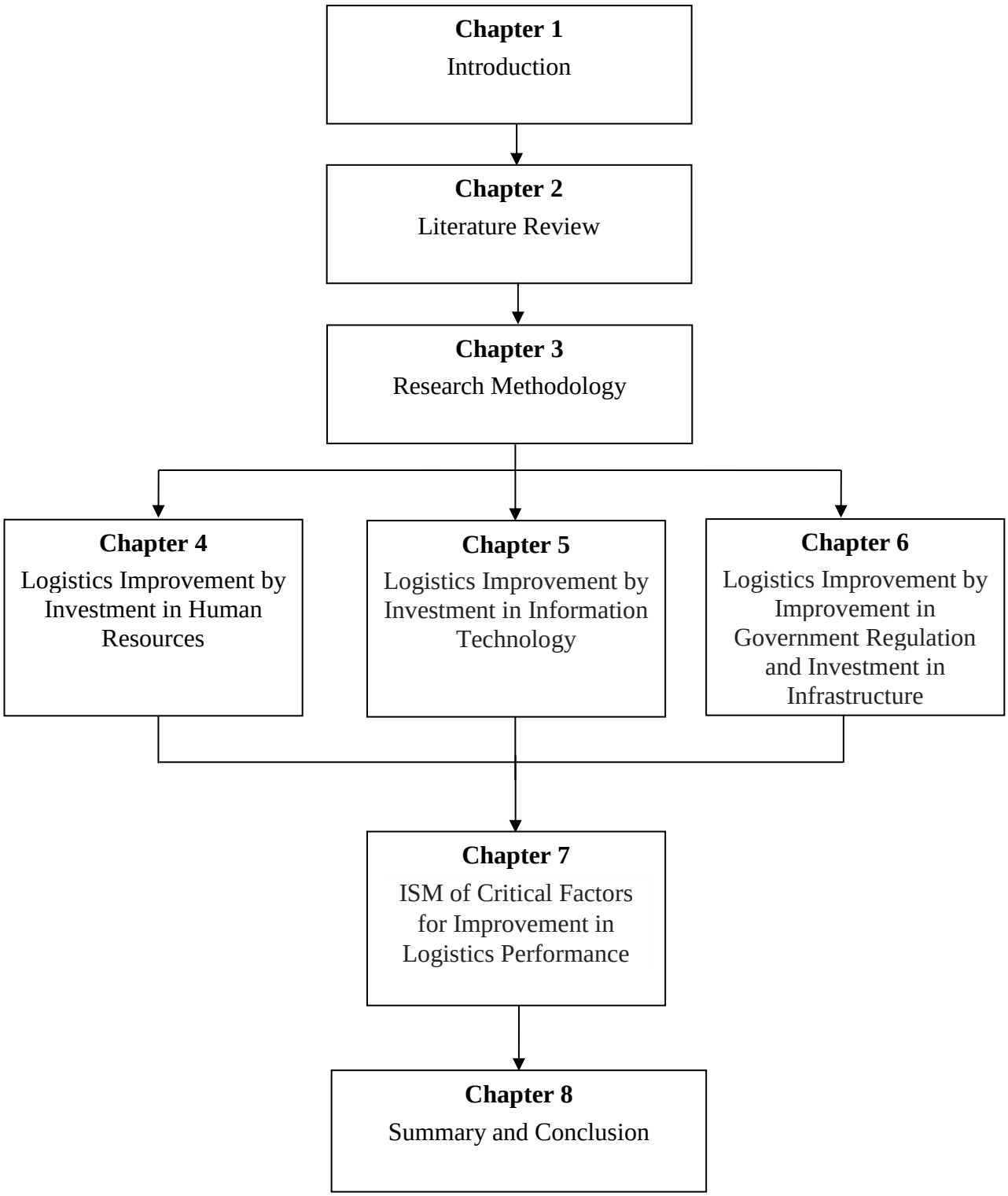


Figure 1.6 Chapter Framework

logistics cost, delivery time, reliability, flexibility and safety and logistics performance, to

study the effect of improvement in logistics performance, if any, on the profit of the firm. RFID, EDI, GPS/GIS and ERP are chosen as the four technologies for investment in information technology. These four technologies will enhance the tracking and tracing, planning and forecasting, transportation automation, coordination with suppliers and customers and decision optimization. Improvement in these processes will help in improving the performance measures like logistics cost, delivery time, reliability, flexibility and safety which will improve the logistics performance index. Causal loop diagram is discussed in detail to study the cause and effect relationship of the investment on the four technologies and the logistics performance index. The other steps of system dynamics modelling have been applied in detail.

Chapter 6 studies the effect of investment by the government on the development of infrastructure and improvement in government regulations. Initiatives taken by different countries for logistics improvement are identified. The aims of this chapter are to identify the areas of investment which will maximize logistics performance and to develop a dynamic model using system dynamics modelling. Chosen areas of investment are development of infrastructure and improvement in government regulations. Investment in infrastructure will help in development of roadways, railways, ports, logistics parks which will build the capacity, integrate the network and to maintain it in the long run. National level single window system, implementation of GST and electronic toll collection system are chosen for improvement in government regulation.

Chapter 7 identifies the factors responsible for improving the logistics performance. Sixteen enablers are identified for improving the logistics performance and uses ISM to find the structural relationship between these factors. Based on this analysis the investment areas and the actors responsible for the investment are identified. The model shows the arrangement of these 16 enablers at six different levels and their relationship with each other. The drive power and dependence power of the enablers is identified through MICMAC analysis.

Chapter 8 gives the contributions of study, limitations and scope for future work and concluding remarks for the research work.

1.9 Conclusion

This chapter introduces the concept of logistics management, its relation with competitiveness and the present status of the Indian logistics industry. On the basis of the

problems faced by it, the need for research is identified and objectives for conducting this study are laid down. The chapter also discusses the research plan and scope of the study. The chapter framework of the thesis is also presented here.

Based on the discussion in chapter 1, detailed literature review is conducted on various aspects of logistics management and compiled in chapter 2.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

Chapter 1 provided a brief introduction to the research topic, identified the main aim and objectives to be addressed in this dissertation and outlined the research plan undertaken in pursuit of attaining the research objectives.

This chapter focuses on the exhaustive literature review done to understand the aspects of logistics management. The review carried in this research in done in two directions. The first stage of review is done to study the industry profile and the studies conducted on logistics management. This review helps to find the issues that need to be looked in context with the study and to identify the gaps. The second stage reviews the tools/techniques used to solve the issues involved. Figure 2.1 depicts the various areas in which the review is conducted.

The chapter is organized in the following way. Section 2.2 and 2.3 discusses the various studies conducted on logistics management and various research techniques respectively. The literature review on the two techniques used in the research, system dynamics and interpretive structural modelling, is also discussed in section 2.3. Section 2.4 defines the gaps found in the literature review. Chapter is concluded in the last section.

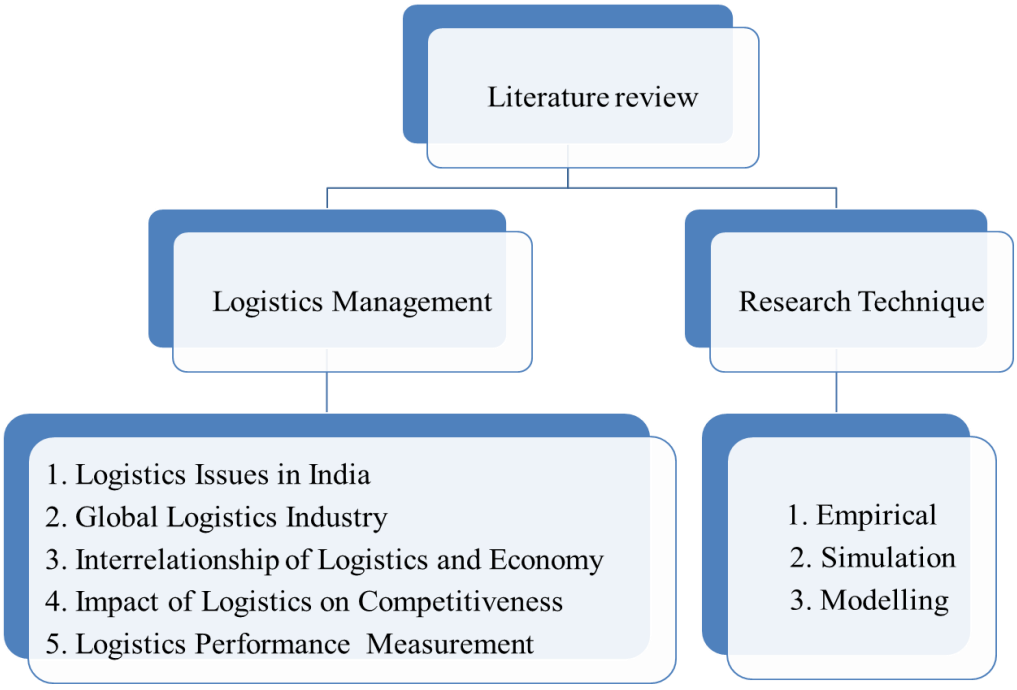


Figure 2.1 Literature Review

2.2 Logistics Management

2.2.1 Logistics Issues in India

Table 2.1 discusses the various issues studied by the authors in the Indian context. Various issues like the condition of logistics industry, present status, problems faced, and the status of 3PL in India are studied in detail. Srivastava (2006) concludes that India needs to overcome its infrastructural bottlenecks, ICT implementation and utilization needs to be spruced up and government should move from regulator's role to facilitator's role.

Table 2.1 Logistics Issues in India

S.No	Author	Findings
1.	Raghuram and Shah (2003)	The paper assesses the overall performance of logistics in India, followed by a framework of 'unholy equilibrium' that seeks to explain the present logistics conditions. It also discusses actor wise agenda as the roadmap to achieve logistics excellence.
2.	Srivastava (2006)	Comprehensively examine and present state of logistics and supply chain management in India separately, as they still have not integrated in the Indian context. Issues related to managers, policy makers and stakeholders are highlighted and addressed.
3.	Mitra (2006)	3PL market, which is at its infancy and highly fragmented in India, is studied in this paper. The growth of 3PL will not only contribute to the GDP but also lead to employment opportunities.
4.	Sahay and Mohan (2006)	A comprehensive survey on 3PL practices in India is done to establish the impact of usage of 3PL on business results.
5.	Chandra and Jain (2007)	The paper gives insight to the logistics infrastructure in India, government regulation and initiatives taken by some firms and industries to compete through excellence in managing their logistics.
6.	Sharma and Vohra (2008)	The current status of road infrastructure in India is examined and compared with other economies. It assesses the need of private sector participation in road infrastructure development.
7.	Vijayvargiya and Dey (2010)	Using analytical hierarchy process (AHP), provides a structured decision making model to select a suitable logistics service provider on criteria like freight charges, flexibility, track and trace system, port presence and custom clearance.
8.	Nagarajan et al. (2013)	The aim of this paper is to examine the connection between environmental uncertainty, information quality, and proactive logistics practices on supply chain flexibility in India and concluding that to ensure improved supply chain flexibility, firms must work to improve information quality.
9.	Neeraja et al. (2014)	The paper highlights the importance of logistics in the present day business development.
10.	Jena and Seth (2016)	The purpose of this paper is to understand the role of economic and social factors influencing the logistics cost for the Indian steel sector and its relationship with the service quality. The findings of this study showed positive relationship between logistics cost and service quality.

Sahay and Mohan (2006) studied the 3PL market in India, concluding that through outsourcing companies can focus on core business leading to logistics cost reduction and improved supply chain efficiency. Sharma and Vohra (2008) advocates that the present pace of road infrastructure development is inadequate in India vis-a-vis other developing economies. The quality of roads compared with China is far below expectations and this poor hinterland connectivity is affecting the trade growth in the country. Nagarajan et al. (2014) through their study stresses on the importance of investment in IT to be able to respond to changes in business environment, to handle environmental uncertainty and to improve supply chain flexibility. Neeraja et al. (2014) concludes that logistics infrastructure is an important yard stick to measure India's economic development and the deficit will put India's growth at risk.

2.2.2 Global Logistics Industry

Globally logistics practitioners are giving importance to the use of information technology, outsourcing logistics function, use of tracking and tracing, importance of maintaining healthy relations with suppliers and customers and imparting the correct logistics education for creating excellent logistics professionals are few of the issues discussed in table 2.2. Bookbinder and Tan (2002) suggest that the main factors for logistics excellence are investment in development and maintenance of infrastructure, adopting business friendly processes and active promotion of harmonious relationships between unions and employers. Rodrigues et al. (2005) estimated the magnitude of global logistics expenditures to be 13.8% of the world gross domestic product for the year 2002 and concluded that logistics efficiency has increased for the developed nations, but there is a strong necessity for logistics infrastructure investment and efficiency improvement throughout developing nations. Kayikci (2010) concludes that an efficient logistics centre may lead to significant profit and return on investment as well as significantly increased competitive advantage in the market place. Gracht and Darkow (2012) presented a research on global logistics scenarios 2025 with focus on the future contribution the logistics industry can make to the triple bottom line – people, planet and profit and made 20 key Delphi projections for global logistics in 2025. Wu et al. (2013) states that globally, significant difference exist between industry practitioners and educators as the former believe that cross-functional marketing skills are critical and emphasize the importance of risk and financial management and in contrast, logistics educators consider the traditional logistics management skills, such as demand forecasting, sourcing, planning, and system integration, as key priorities.

Table 2.2 Global Logistics Industry

S.No	Author	Findings
1.	Rao and Young (1993)	The global supply chain firmly bonds logistics functions to other activities of the firms. To focus on the core competencies, firms should identify the functions which can be completed through partnerships with logistics service providers.
2.	Bowersox and Calantone (1998)	The importance of information technology and logistical competency to the realization of truly global marketing is discussed. Supported by global information networks, leading logistical competency provides the operational support to embrace truly global marketing.
3.	Bookbinder and Tan (2002)	The research compares the logistics system of Asia and Europe and categorizes them into distinct level of logistic excellence
4.	Green et al. (2008)	The logistics performance is positively impacted by supply chain management strategy and both of them are positively impacted by the marketing performance which impacts the financial performance.
5.	Kumar (2008)	A comparison is done to identify the commonalities and differences between the supermarket industry and its logistics capabilities in North America, Japan, European union and India.
6.	Gracht and Darkow (2010)	Scenario planning is applied using Delphi technique to study the future of the logistics service industry in the year 2025.
7.	Kayikci (2010)	Artificial neural network and analytical hierarchy process method is used in the process of decision making in order to select an appropriate location.
8.	Maleki and Meiser (2011)	The analysis and documentation of the physical flow and the information flow associated with the containers and the investigation of new technologies to improve the automatic identification and tracking of containers. An analysis is done for all the tracking technologies.
9.	Wu et al. (2013)	In dealing with globalization, a logistician needs to be able to integrate, communicate, and analyse from an international perspective, perform financial analysis, maintain good industry and customer relations, exhibit strong people skills, stay healthy, and understand laws and regulations.
10.	Trautrims et al. (2016)	The purpose of this paper is to present and examine the use and effects of global virtual teams as a tool in the logistics and supply chain management classroom to prepare students in a simulation environment for the demands of their future careers in the profession.

2.2.3 Interrelationship of Logistics and Economy

Table 2.3 discusses the various studies conducted to prove that development of logistics sector plays a very substantial role in the social development, GDP growth, development of national economy, improving the competitiveness and prosperity of a nation. Liu et.al (2009) introduced the concept of adaptability index to study the connotation between logistics and economy.

Table 2.3 Interrelationship of Logistics and Economy

S.No	Author	Findings
1.	Liu et al. (2006)	By co-integration analysis and error correction model investigates the long run and dynamic relationship between logistics development and GDP.
2.	Zhang (2007)	Studied the conditions of transport on the economic growth and the impact of the economic zone. Taking into account transport as the most important part of logistics, and the research of the relationship between transportation and regional economic can reflect its intrinsic role at a certain extent.
3.	Li and Han (2009)	Showed that there is cooperation and interactive causal relationship between logistics capacity and GDP and the development of logistics industry plays an important role in the increase of GDP.
4.	Wang (2010)	Using Gragner Causality Test method analysed the regional GDP growth in the domestic and regional freight turnover.
5.	Zheng (2010)	Illustrated a coordinated relationship between logistics GDP and social cargo turnover using SPSS software.
6.	Chen (2011)	Established a model of logistics and economic growth, with cargo turnover expressing the logistics performance and GDP representing the development of national economy.
7.	Coe (2014)	Article seeks that logistics services, and the independent logistics industry in particular, should be afforded much more attention within political economy approaches to the global economy.
8.	Civelek et al. (2015)	Logistics sector plays a critical role in social and economic developments of a country and the result of the research suggested that the logistics ability of a country dominated the relation between competitiveness and prosperity.
9.	Hayaloglu (2015)	In this study, the impact of developments in the logistic sector on economic growth has been investigated for 32 OECD countries covering the period 1994-2011 using static panel data analysis. The findings revealed that the relationship between developments in the logistic sector and economic growth differs depending on the indicator used.
10.	Liu (2016)	The paper studies the initiatives taken by the Thailand government and also suggests that special attention should be paid to the relation between the logistics costs and economic development to develop appropriate logistics policies to accommodate the need of economic development.

Zheng (2010) suggests that logistics industry not only plays a fundamental role in regional economy, but also determines the economic operation speed and efficiency of that region. Chen (2011) established a model of logistics and economic growth, with cargo turnover expressing the logistics performance and GDP representing the development of national economy. The stability analysis of this model indicates that the logistics industry has made continuous contribution to the economic development. Liu (2016) suggests that for all overall development of the logistics industry Thailand government should concentrate on investment in human resources and ICT along with investment in infrastructure which will not only reduce the logistics cost structure but logistics cost relative to GDP will also be reduced.

2.2.4 Impact of Logistics on Competitiveness

Table 2.4 Studies Conducted on Logistics and Competitiveness

S.No	Author	Findings
1.	Ahn et al. (1999)	Delivery and cost are the most important dimension for supply chain competitiveness of manufacturing perspective.
2.	Tongzon (2004)	Author suggests that countries should make freer trading and investment environment, increase number of logistics professionals, transparent and consistent government policy, efficient and simple administrative procedures, good partnership between public and private sector to take advantage of the economic opportunities from logistics.
3.	Liu et al. (2010)	Service quality, operations management, cost management and customer relationship management are the main capabilities that contribute to LSP competitiveness in the context of China
4.	Placzek (2011)	Cost optimization, speed and timeliness of order fulfilment, skillful use of resources, flexibility, maintaining quality standards are some of the factors for achieving competitiveness by logistics service providers.
5.	Navickas et al. (2011)	The paper studies the logistics systems impact on the growth of country's economy and its competitiveness and concludes that country's competitiveness and economy growth is dependent on investment into logistic infrastructure.
6.	Kirby and Brosa (2011)	Deficiencies in logistics education and training; limited access to best practices, technologies, and methodologies for improving scm performance; difficult access to advanced 3PL logistics services; and a lack of collaboration to reach sizes sufficient to compete globally are hampering competitiveness of SME's in Latin America and the Caribbean.
7.	Roman et al. (2012)	Strategic alliances, human capital, reliability, knowledge, cost, cultural factors, flexibility, innovation, quality, speed, customer relations, social responsibility, control systems, production techniques, and information and communication technologies are the 15 factors influencing organizational competitiveness.
8.	Bajec et al. (2015)	Paper investigates the prevalence of the application of standards and their positive influence on the efficiency and competitiveness of Slovenian LSPs and an analysis is done on the relationship between the adoption of the environmental standard and greater concern for the environment.
9.	Sujeta et al. (2014)	The objective of the study is to analyse the impact of port logistics systems using the concept of port-centric logistics systems in small countries with the aim to increase their competitiveness.
10.	Subramanian et al. (2016)	The paper proposes six elements (synergy of logistics, expansion of industrial chain, financial ability, creativity and innovation ability, cooperation of companies and flexibility of supply chain) that comprise collaborative operational capabilities, and highlights the role of "creativity and innovation ability" and "supply chain flexibility" in the use of 4PL for industrial cluster competitiveness in Chinese context.

Cost optimization, speed and timeliness of order fulfilment, skillful use of resources, flexibility, maintaining quality standards, reliability, innovation, customer relationship management are few of the factors for achieving competitiveness by logistics as shown in table 2.4. Ahn et al. (1999) concluded that delivery and cost are the most important dimension for supply chain competitiveness of manufacturing perspective. Mutual co-operative behaviour, specificity of transaction-related assets and "criticalness" of traded parts are the other factors influencing it.

Wu and Lin (2008) study's findings suggest that in terms of India's logistics competitiveness, its freight industry is relatively competitive while its transportation industry is not. India's largest container port (Jawaharlal Nehru) is not very efficient; the RCA analysis shows that India still has a relative comparative advantage over its industrialized counterparts except for Japan and France in the transportation service industry. Roman et al. (2012) concluded that strategic alliances, human capital, reliability, knowledge, cost, cultural factors, flexibility, innovation, quality, speed, customer relations, social responsibility, control systems, production techniques and information and communication technologies are the 15 factors influencing organizational competitiveness.

2.2.5 Logistics Performance Measurement

SCOR, SEM, TOPSIS, FAHP, benchmarking are few of the methodologies widely used to measure the performance of a logistics system is shown in table 2.5. Stainer (1996) suggests that a goal-focused productivity and performance measurement system is the best channel for institutionalising targeted improvements in the logistics arena and invigorating management action. Lai et al. (2002) constructed a 26-item measurement instrument and it can be used as a self-diagnostic tool to identify areas where specific improvements are needed and pinpoint aspects of the firm's SCP that require improvement actions. Green at al. (2008) concludes that logistics performance is positively impacted by supply chain management strategy and that both logistics performance and supply chain management strategy positively impact marketing performance, which in turn positively impacts financial performance. The framework proposed by Garcia et al. (2012) will help the wine companies to focus on processes to improve, to formulate new strategies, on resource optimization to increment final consumer's satisfaction level, and to lower costs and delivery times. Barros et al. (2013) identified waste, uncertainty, vulnerability, congestion, bullwhip, diseconomies of scale and self-interest through literature review and secondary case studies as factors that deters

superior supply chain performance.

Table 2.5 Studies Conducted on Logistics Performance Measurement

S.No	Author	Findings
1.	Stainer (1996)	Highlighting the main ingredients of strategic logistics performance as quality, productivity, speed and innovation, author has developed analytical frameworks and models to aid management in planning and decision making, both operationally and strategically.
2.	Lai et al. (2002)	This study aims to develop a measurement instrument for SCP in transport logistics based on the SCOR and empirical findings for this framework suggest that the measurement instrument is reliable and valid for evaluating SCP in transport logistics.
3.	Green et al. (2008)	A logistics performance model using SEM methodology is developed and analysed using empirical data.
4.	Dubey (2011)	Model which is proposed using the Partial Least Squares and tested empirically to understand the impact of a set of logistics activities on firm's performance. It is well understood from literature review that logistics activities has positive impact on firm's performance.
5.	Garcia et al. (2012)	In this paper a logistics benchmarking framework for the wine industry is proposed and a benchmarking study considering several wineries from Mendoza (Argentina) is presented as a case study, in order to demonstrate the validity of the developed framework.
6.	Barros et al. (2013)	A framework for the selection of tailored practices for SCM is developed. A case study research is used to validate the value of the framework.
7.	Jothimani and Sarmah (2014)	Paper illustrates the use of the integrated approach of SCOR, FAHP and TOPSIS for measuring the SCP for a real life case study company.
8.	Schiffling and Piecyk (2014)	The objective of this study is to develop a performance measurement framework that takes into account the key stakeholders of the logistics departments or personnel in humanitarian organisations.
9.	Bühler et al. (2016)	This paper aims to investigate the role of upper management in designing PMS that account for external turbulence of the organization and to show how it impacts organizational resilience and distribution service performance.

2.3 Research Technique

2.3.1 Empirical Studies

Empirical studies conducted on various aspects of logistics management are shown in table 2.6. Tummala et al. (2006) concluded that resource allocation can be improved in the areas of improved information systems, more commitment, setting clear-cut objectives, better training, more personnel, and line up SCM initiatives with current priorities and resource

commitments. Rajesh et al. (2010) using multiple regression analysis proved that 3PL providers should spot out services that will significantly enhance the performance of their clients and establishing better client relationships.

Table 2.6 Empirical Studies Conducted in Logistics Context

S.No	Author	Findings
1.	Tummala et al. (2006)	Reducing cost of operations, improving inventory, lead times and customer satisfaction, increasing flexibility and cross-functional communication, and remaining competitive appear to be the most important objectives to implement SCM strategies.
2.	Ishfaq and Sox (2010)	Study conducted on subset of US freight flows shows that location of hubs in OTR structure and IM logistics networks differed greatly. The choice of the best hub locations in the IM networks is affected by the network parameters, whereas the hub locations in OTR networks were very robust.
3.	Rajesh et al. (2010)	Study proves that there is a positive influence in the performance indicators for clients who are in association with a 3PL provider. Also, the clients distinguish a 3PL provider as providing them with a potential pathway to a more innovative business model.
4.	Fugate et al. (2010)	Research suggests that for strategy formulation, logistics professionals should pursue efficiency, effectiveness and differentiation, the three components of logistics performance dimensions simultaneously and not separately which will force managers to be innovative.
5.	Prajogo and Olhager (2011)	Logistics integration has a significant effect on operations performance. IT capabilities and information sharing both have significant effects on logistics integration. Furthermore, long-term supplier relationships have both direct and indirect significant effects on performance; the indirect effect via the effect on information integration and logistics integration.
6.	Sillanpää (2013)	The key elements for SC performance measurement were defined as time, profitability, order book analysis and managerial analysis.
7.	Wong et al. (2015)	The paper assesses the efficiency, effectiveness and performance of logistics companies in Singapore and Malaysia and concludes that small companies have better resource utilization (efficiency) and revenue generating capability (effectiveness) in both the countries.
8.	Liu et al. (2015)	Integrative mechanisms are helpful for logistics outsourcing (basic, customized, and advanced outsourcing) and information sharing contributes to customized and advanced outsourcing, but has no significant effect on basic outsourcing.
9.	Jahre et al. (2016)	Paper contributes to a more complete understanding of logistics preparedness and lack of a common understanding has resulted in low visibility of efforts and lack of knowledge on logistics preparedness.

Wong et al. (2015) concludes that performance is affected by how well managers utilize internal capabilities but also on the effect of investment especially on RFID and human capital development as investment in small firms can generate speedier results. Liu et al.

(2015) using SEM concluded that process coordination improves basic and advanced outsourcing, but insignificantly influences customized outsourcing and each type of logistics outsourcing differently affects 3PL user's performance.

2.3.2 Simulation Studies

Table 2.7 discusses the various simulation studies conducted on logistics management. Yin and Khoo (2006) developed an e-business chain model which can be used to realize management level strategies, and facilitate the planning and control of detailed operation schedules of supply chain units in an e-supply chain environment. Vidalakis et al. (2010) simulated a mathematical model highlighting the importance of incorporating intermediary organisations and reveals the implications of varying demand on logistics performance related to inventory and transportation costs. Higgins et al. (2015) developed a transportation simulation model which can address very complex transport problems with 89,000 unique origin to destination combinations in multiple directions, confounded with vehicle access and biosecurity regulations in livestock transport. Salam and Khan (2016) demonstrates how a simulation-based tool can be used to reduce freight cost, cycle time, instill waste minimization and improve overall value addition and offers a method for optimizing a loading decision to optimize container space utilization.

2.3.3 Modelling Studies

Table 2.8 discusses the modelling studies conducted in logistics context. Bhatti et al. (2009) developed an AHP model for 3PL selection in global LLP environments because AHP deployment in modelling problems leads to a structured presentation of the problem and the constructs of the solution and 3PL service providers can also be suitably compared in quantitative terms on a common index. Azevedo and Carvalho (2011) proposed a model using inductive theory approach where theory emerges from empirical observations to identify the main architectural characteristics, advantages, disadvantages and barriers of RFID technology in FSC. Ralston et al. (2013) using SEM suggested that logistics salience positively impacts both logistics innovativeness and logistics service differentiation, which positively influence logistics performance and these findings give importance to the RBV of the firm which states that resources lead to capabilities which leads to performance. Lam and Dai (2015) applied ANP-QFD approach based on a three-stage process of desk research, content validation test, and in-depth case study to formulate systematic metrics for logistics

service providers to develop their security design requirements to meet customer demands and can quantify the customers' expectation using ANP-QFD approach.

Table 2.7 Simulation Studies Conducted on Logistics Management

S.No	Author	Findings
1.	Yin and Khoo (2006)	The model is based on an e-business information flow network in order to respond rapidly to the dynamics of e-supply chain and market.
2.	Huq et al. (2009)	Using mathematical programming model was tested and it was found that transportation costs significantly impact the performance of the model proving the important role transportation issues play in the consideration of integrated SCM costs.
3.	Vidalakis et al. (2010)	The paper develops a conceptual logistics model facilitating experimentation using simulation modelling of construction supply chains.
4.	Sari (2013)	A quantitative methodology based on a structured framework using MonteCarlo simulation, for the selection of the most appropriate RFID solution provider is proposed in the paper.
5.	Jonsson and Mattsson (2012)	A simulation study is conducted to show that the value of information sharing increases when having fewer customers, and when the order quantities are large. Sharing point-of-sales data is not valuable, regardless of the demand type.
6.	Sandhu et al. (2011)	The simulation model is proposed for steel industry showing that the information sharing is able to mitigate the bullwhip effect in the steel supply chain by extending the order interval and minimising the order batch size.
7.	Hussain et al. (2011)	Taguchi DOE and SD are used to prove that time to adjust inventory error and production lead time have a particularly strong impact on the order variance compared to other parameters
8.	Glock and Kim (2014)	The paper develops mathematical models for a supply chain consisting of a single vendor and multiple retailers that uses returnable transport items and derives optimal solutions for the cycle time, the container size, the individual order quantities of the retailers and the shipment sequence with the intention to minimize the average total costs of the system.
9.	Higgins et al. (2015)	A simulation model named TRANSIT was developed to identify and test scenarios for infrastructure investment and policy changes in agricultural and livestock industry for Australia predicting huge and to test combinations of infrastructure investment and policy change to the transport system.
10.	Salam and Khan (2016)	A simulation-based DSS and application of an optimization method contributes to the reduction of container shipment volume, and saves logistic costs and its delivery time.

Chithambaranathan et al. (2015) applied fuzzy TOPSIS and fuzzy VIKOR as they have the have most desirable properties such as robustness, capable to capture holistic aspects,

suitability at different levels, simple to use and easy to implement to develop a framework for analysing the performance of member firms of the supply chain.

Table 2.8 Modelling Studies

S.No	Author	Findings
1.	Bhatti et al. (2009)	AHP modelling has been carried out after questionnaire-based survey to model the choice parameters for selection of third party logistics service providers in global LLP environments.
2.	Tako and Robinson (2011)	This paper explores the application of DES and SD as DSS for LSCM by looking at the nature and level of issues modelled.
3.	Azevedo and Carvalho (2011)	An inductive theory building approach is used to develop a conceptual model for RFID deployment in the fashion SCM context.
4.	Ralston et al. (2013)	The purpose of this manuscript is to assess the impact of logistics salience on logistics capabilities and performance using structural equation modelling.
5.	Ghadge et al. (2013)	A framework for SCRM is developed using the systems approach for modelling and tested using an industrial case study.
6.	Soni and Chaoudhary (2013)	The objectives of this paper are to explore the element of internal supply chain management in manufacturing industry, to go through the effects of supply chain drivers on synchronization of inter departmental activity, to build up the framework to establish the relationship between supply chain integration & business performance and to assign the relationship among the drivers in SAP-LAP perspective using self-interaction& cross interaction matrix.
7.	Gómez-Cedeño et al. (2015)	The purpose of this paper is to demonstrate HRM has an impact on scm, which in turn has a significant impact on customer satisfaction and organisational performance using the partial least squares SEM.
8.	Lam and Dai (2015)	The study demonstrates an integrated analytical approach which combines ANP with QFD for LSPs to develop their security design to meet customer demands.
9.	Chithambaranat-han et al. (2015)	In this paper a MCDM framework comprising of two MCDM approaches namely fuzzy TOPSIS and fuzzy VIKOR is proposed for analysing performance of supply chain members.
10.	Alkhatib et al. (2015)	This paper proposes an integrated logistics outsourcing approach to evaluate and select LSPs based on their logistics resources and capabilities combining a FDEMATEL and FTOPSIS methods.

2.3.4 System Dynamics

System dynamics applied to logistics management studies are discussed in table 2.9. Sharma et al. (2004) used SD approach to help organizations use this tool to evaluate the channel objectively and relatively and evaluating not only distributors' performance, but the effectiveness of the support budgets to the distributors. Ashayeri and Lemmes (2006)

developed a model that provides the managers with an opportunity to simulate different scenarios to improve the demand and sales planning. Aschauer et al. (2015) concludes that as efficient freight transport operations are a crucial part within securing the competitiveness of a company, the "right" logistics strategy plays a key role within realization of efficient transportation movements lowering environmental impacts.

Table 2.9 Studies Conducted on System Dynamics

S.No	Author	Findings
1.	Sharma et al. (2004)	Taking India, an emerging market, the study proposes a composite DPI to evaluate distributor performance.
2.	Shouping et al. (2005)	Developed a system dynamics model for the area logistics system and conducted numerical simulations to analyse the model. The model reflected the actual state of the system and can be used further for policy design.
3.	Ashayeri and Lemmes (2006)	A framework is developed to that allow managers to examine how improvements in demand reliability impact the corporate bottom line.
4.	Yang et al. (2009)	Developed a model to study the complex operation system of logistics finance management of supply chain in ports hinterland so as to improve the whole performance of the system.
5.	Campuzano et.al (2010)	A model is prepared to show that the bullwhip effect and amplification of inventory can be effectively reduced using system dynamics and fuzzy estimations.
6.	Wang et al. (2010)	A model to study the relationship between logistics and economy is developed showing that growth of logistics and economy are interlinked.
7.	Xufeng (2010)	Developed a logistics distribution system model to lower the logistics cost and rationalize the distribution process and its efficiency.
8.	Aschauer et al. (2015)	Paper aims to present a system dynamics model for the interdependencies between logistics strategies and freight transport.
9.	Shamsuddoha (2015)	The current research attempts to develop an integrated supply chain model in the context of poultry industry in Bangladesh by placing the forward and reverse supply chains in a single framework to solve existing problems to gain economic, social and environmental benefits, which will be more sustainable than the present practices.
10.	Brockhaus et al. (2016)	The purpose of this paper is to explore supply chain dynamics as they relate to sustainable product programs and to empirically develop a framework to align efforts across the supply chain to bring sustainable products to market.

Shamsuddoha (2015) concludes that that integration of the supply chain can bring economic, social and environmental sustainability along with a structured production process and the poultry industry in Bangladesh can follow the proposed supply chain structure and test various policies via simulation prior to its application to achieve the

desired changes within the industry and their supply chain networks. Brockhaus et al. (2016) developed a framework that provides a much needed source of clarity to mitigate role ambiguity, reduce compliance costs, and promote collaborative behaviour in bringing sustainable products to market.

2.3.5 Interpretive Structural Modelling

ISM studies conducted in logistics and supply chain management context are discussed in table 2.10.

Table 2.10 Studies Conducted on ISM

S.No	Author	Findings
1.	Jharkaria and Shankar (2005)	ISM is applied to identify barriers that affect each other and also severely affect the IT-enablement of a supply chain
2.	Diabat and Govindan (2011)	A model is developed to identify the drivers affecting the implementation of GSCM. The model developed is validated on a case study involving a manufacturing firm in southern India.
3.	Faisal (2010)	Using interpretive structural modelling, the paper presents a hierarchy-based model and the mutual relationships among the enablers of sustainability in a supply chain.
4.	Pfohl et al. (2011)	ISM was used to identify inter-relationships among supply chain risks. The theoretical findings of the modelling and the applicability for practical use have been tested in two case studies with two German industry and trade companies.
5.	Luthra et al. (2011)	Structural model of barriers to implement GSCM in Indian automobile industry has been put forward using ISM and classification of barriers has been carried out based upon dependence and driving power with the help of MICMAC analysis.
6.	Shahabadkar et al. (2012)	The purpose of this paper is to review the literature relating to ISM and its deployment for modelling variables of supply chain management.
7.	Azevedo et al. (2013)	Author studied the automotive supply chain concluding that, inventory level and lead time are the two performance measures at the bottom level of the hierarchy, implying higher driving power.
8.	Govindan et al. (2013)	Author applied ISM to GSCM and concluded that commitment to GSCM from senior managers and cooperation with customers for cleaner production occupies the highest level within Brazilian electrical/electronic industry for adoption of GSCM.
9.	Katiyar et al. (2015)	In this paper ISM is applied to investigate the factors helpful to measure supply chain performance and concluded that top management should focus on the order entry method and order lead-time as they are the significant key factors, showing a higher driving power at the bottom of the hierarchy.
10.	Girubha et al. (2016)	Paper studies the application of ISM integrated with MCDM techniques for enabling the sustainability supplier selection.

Diabat and Govindan (2011) applied ISM to implementation of GSCM and concluded that government regulation and legislation and reverse logistics are significant drivers which will help in achieving the certification of suppliers' environmental management system driver. Azevedo et al. (2013) concluded that operational costs, business wastage, environmental costs, delivery time and customer satisfaction are identified as autonomous measures, implying that they are relatively disconnected from the other suggested performance measures and the cash-to-cash cycle is a weak driver but strongly dependent on the other performance measures. Katiyar et al. (2015) also adds that post-transaction measure of customer service and customer query time are highly dependent on other factors and such relationships among the key factors can help a firm's top management to make essential judgments in order to solve the overall SC problems and provide a better approach to proactively deal with problems.

2.4 Gaps in Literature review

Following gaps were identified from the literature review:

1. Many studies have been conducted to study the logistics scenario in India and which suggest the ways to improve it. But the researchers did not encounter any study in which modelling is done or applications of the suggestions have been studied.
2. Although ISM is a very common technique and have been applied on various issues of supply chain management at the micro level. But there is dearth in studies conducted on the logistics sector and also at the macro level.
3. Exploration of role of human resources is relatively a new domain in the logistics sector. Moreover, most of the studies conducted on human resources cover the role or effects of training, role or skill sets required for logistics mangers. Limited studies are conducted to actually study the effects of improvement in human resources on logistics. Also, welfare is relative a new topic and not many studies are conducted in the logistics context.
4. Authors encountered many studies which were conducted using individual or at the maximum two technologies. This study is unique because it studies more than four technologies and also studies its impact on the various logistics processes.
5. Sachan and Datta (2005) cited the following research gaps in supply chain management and logistics research:
    a. there are very few inter disciplinary studies
    b. innovative application of secondary data is lacking

c. Research at inter organisation level is scanty; and the current state of research has failed to integrate all the firms in the value chain and treat them as a single entity.

This research is an attempt to fill the gap cited in (a) and (b).

6. Safety in logistics is relatively a new concept with very few papers studying it in the last five to six years. Safety is one of the important components of this paper, which will reduce the gap in the current literature.
7. LPI was the term coined by the World Bank (Arvis et al., 2007). Researchers did not encounter any study conducted taking LPI as the main component, although it has been cited by few authors.

2.5 Conclusion

The chapter discusses the various studies conducted in different areas related to logistics and supply chain management. After the literature review, gaps were identified and objectives were formulated which are discussed in chapter 1.

Through literature review the areas chosen for logistics improvement are human resources (Liu et al (2010); Wong et al. (2015)), information technology (Srivastava (2006); Nagarajan et al. (2013)), government regulation (Bookbinder and Tan (2002); Diabat and Govindan (2011)) and infrastructure development (Neeraja et al. (2014); Rodrigues et al. (2005)). The next chapter gives the detailed explanation of research methodology followed in conducting the research.

Chapter 3

RESEARCH METHODOLOGY

3.1 Introduction

In previous chapter gaps are identified using extensive literature review. The purpose of this chapter is to provide an overview of the research design adopted for conducting the study. This chapter discusses the research strategy implemented to achieve the objectives and continues with the explanation of the research techniques employed for the study.

This chapter is organized as follows. Section 3.2 discusses the research strategy. Section 3.3 explains the research technique, system dynamics used in the study. Section 3.4 introduces the most important component considered for improvement i.e. LPI. Section 3.5 gives light on the company where case studies used in the study were carried out. Section 3.6 and 3.7 explains the data collected and data required for simulation. Section 3.7 explains the second research technique used i.e. interpretive structural modelling and MICMAC analysis. Chapter is concluded in last section.

3.2 Research Strategy

For meeting the objectives mentioned in chapter 1, the following research strategy is adopted and discussed in this section. The brief view of research strategy is discussed in the flowchart shown in figure 3.1. The strategy adopted is as follows:

1. The gaps are identified using extensive literature review on logistics management and research techniques used to conduct studies on logistics management. Based on the literature review and discussions with experts from academic and industry, the problem is formulated.
2. A detailed study was conducted to identify the various issues faced by the Indian logistics industry and a comparison was done with the developed economies.
3. Through the comparison the various gaps were identified faced by Indian logistics industry and also, the various policies and strategies adopted by the developed economies for logistics improvement were analysed.
4. Based on the analysis, the actors and areas for logistics improvement were identified. Investment will be done by the Government and LSPs. Government will focus on

investment in infrastructure and improvement in government regulations. LSPs will invest in improvement in human resources and adoption of information technology.

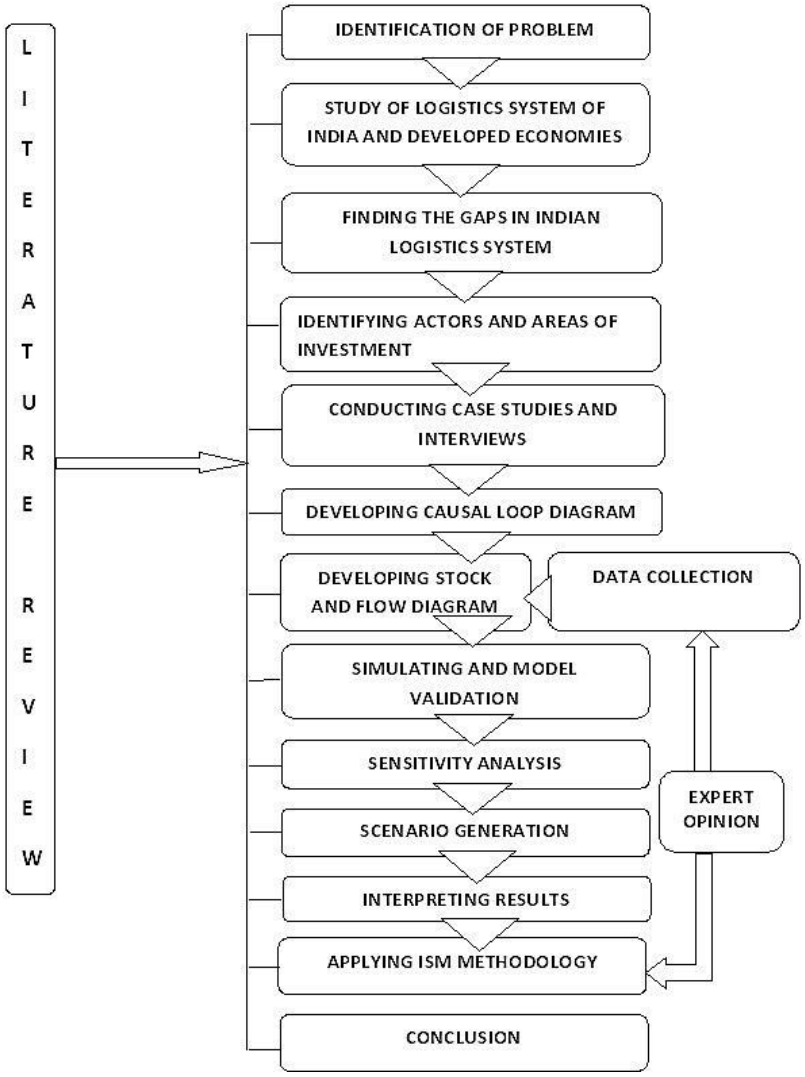


Figure 3.1 Research Strategy

5. Case organization was identified and various interviews were conducted to understand the problems faced by logistics professionals, the expectations of the company from the study and to identify the various variables of the model.
6. Causal loop diagrams were developed through the information collected from the case organization. Causal loop were converted into system dynamic models and data was collected from the company for simulation. Simulation modelling was conducted and various steps of system dynamics modelling like model validation, sensitivity analysis and scenario generation were carried out.

7. Causal loop diagram was also developed for investment by government through literature review.
8. ISM modelling was applied to all the critical factors of the study to understand the ultimate effect of the investments done by the government and the LSPs at the macro and micro level.
9. Conclusion and recommendations are given for the study.

3.3 System Dynamics

System dynamics has its origins in control engineering and management. The approach uses a perspective based on information feedback and delays to understand the dynamic behaviour of complex physical, biological and social systems (Angerhofer, 2000). SD is currently expanded and is known as business dynamics (Sterman, 2000). It is one of the efficient tools in real and dynamic conditions which was developed by Forrester for the first time in 1950s and has grown rapidly in last 50 years (Forrester, 2007).

It is a computer-based simulation method that allows the modeller to graphically represent a system of differential non-linear equations and to have the computer do the discrete-step computational effort over a pre-set time frame (Marco and Rafele, 2007). It is an approach to discover nonlinear dynamic behaviour and study structure and parameters of the system. The other main objective of it is designing the effective and stable policies that modify system performance. It also provides the possibility of testing new procedures and policies before performance (Sterman, 2010).

The system dynamics approach begins with defining complex problems and uses different tools to reach its goals and to support decision-making processes. The tools are both qualitative (diagramming tools, as causal loop diagrams, stock and flow diagrams) and quantitative (formal model based on rigorous mathematical language, equations). For the present study, system dynamics modelling has been found appropriate to develop dynamic model for studying the investment strategies for logistics improvement. The systematic procedural steps in SD modelling include the following (Roberts, 1978):

1. Define the problem to be solved and goals to be achieved.
2. Describe the system with a causal loop/influence diagram.
3. Formulate structure of the model, i.e develop the flow diagrams and associated mathematical models that represent rates of change through different interactions.
4. Collect the initial data needed for operations of the model either from historical data

or from discussion with the executives/planners having knowledge and experience of the system under study. These are initial values of all the level variables, constants, multipliers etc.

5. Validate the model using appropriate criteria to establish sufficient confidence in the model.
6. Use the model to test various actions to find the best way to achieve prescribed goals.

Following the above steps, the tools used for conducting this research are explained as follows:

3.3.1 Causal Loop Diagram

The causal loop diagram in system dynamics focuses on the structure and behaviour of the systems composed of interacting feedback loops (Kiani et al., 2009). It is an important tool which helps the modeller to conceptualize the real-world system in terms of feedback loops (Sachan et al., 2004). It is a very effective systems thinking tool which shows relationships between variables and also help to convert mental model into systems model. It is a simplified map of the connections in a closed system of cause-and-effect relationships. Variables are connected to each other with the help of arrows, to which polarity either negative or positive is assigned. A positive sign '+' means that if the cause increases or decreases, then the effect will also increase or decrease in the same direction. It is also known as reinforcing loop, which is denoted by 'R'. A negative sign '-' means that if the cause increases or decreases, then the effect will increase or decrease in the opposite direction. It is also known as balancing loop, which is denoted by 'B'.

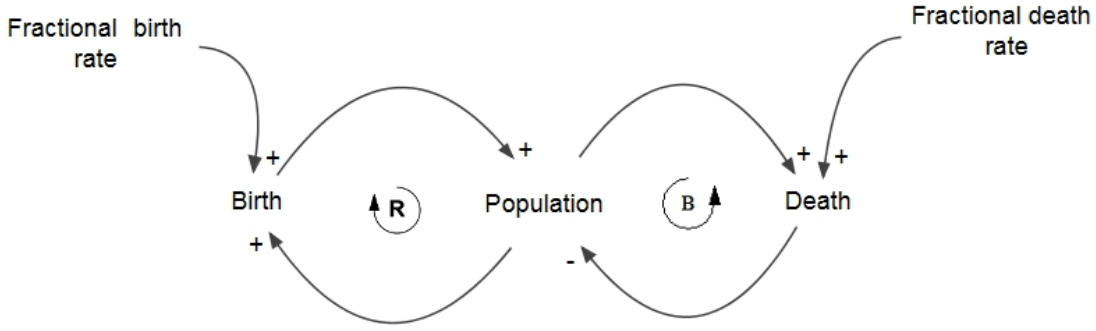


Figure 3.2 Causal Loop Diagram for Population Model

In other words, the arrows indicate the direction of influence, and the plus or minus sign the type of influence. All other things being equal, if a change in one variable generates a change in the same direction in the second variable, relative to its prior value, the relationship

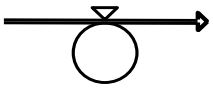
between the two variables is referred to as positive and the loop is known as reinforcing loop. If the change in the second variable takes place in the opposite direction, the relationship is negative (Forrester, 1985) and the loop is known as balancing loop.

For example, figure 3.2 shows a causal loop model for a simple population model. As the number of birth increases, the population will increase. The increase in population will leads to further increase in the number of births, as more people are available for reproduction. Therefore, the loop between birth and population is reinforcing loop. Now, as population increases, death will also increase and an increase in death will reduce the population. Therefore, the loop between population and death is balancing loop. Fractional birth rate represents the number of births that occur per unit population per unit time and fractional death rate represents the number of deaths that occur per unit population per unit time. Both are exogenous variables.

3.3.2 Stock and Flow Diagram

The causal loop diagrams help to create the flow diagram, which is the ultimate diagramming aid that represents the feedback structure in terms of physical and information flows and stocks and is also known as stock and flow diagram.

Table 3.1 Description of Important System Dynamics Components

S.No.	Variable Name	Symbol	Description
1.	Level	 Level	It accumulates changes and is influenced by flows
2.	Auxiliary	 Auxiliary	A variable type, which contains calculations based on other variables
3.	Flow with rate		It influences levels. The flow is controlled by the connected rate variable, normally an auxiliary variable

Source: Verma, 2004

The stocks and flow are the basic building blocks in system dynamic modelling. A stock represents accumulations in the system and describes the condition or state of the system at any particular time. Flow variable shows how fast the stocks are changing. The third component, auxiliary variable is also known as the converter. It is used to hold the values for constants, external inputs to the model and used in graphical function. Table 3.1 denotes the three symbols used in system dynamic modelling.

3.3.3 Equations

In figure 3.3, population represents the stock. The equation of the stock is given by equation 3.1.

$$\text{Population}(t) = \text{Population}(t-dt) + (\text{birth\_rate} - \text{death\_rate})*dt \quad \ldots\ldots 3.1$$

where Population (t) = the value of population in the next interval

Population (t-dt) = the value of population at the last interval

dt = length of each segment

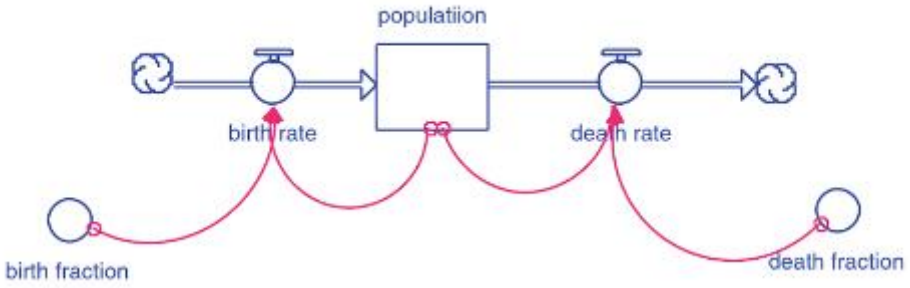


Figure 3.3 Stock and Flow Diagram for Population Model

Birth rate and death rate are the flow variables in figure 3.3. Birth rate represents the inflow and death rate represents the outflow. The inflow and outflow equation are given by equation 3.2 and equation 3.3 respectively.

$$\text{birth rate} = \text{population} * \text{birth fraction} \quad \ldots\ldots 3.2$$

$$\text{death rate} = \text{population} * \text{death fraction} \quad \ldots\ldots 3.3$$

Birth fraction or death fraction in equation 3.2 and 3.3 represents the auxiliary variable.

3.4 Logistics Performance Index

The logistics performance index was a term coined by the World Bank (Arvis et al., 2007). It is a comprehensive index created to help countries identify the challenges and opportunities they face in trade logistics performance. The LPI assesses the performance of countries in the following areas and is an equally weighted average of these six components. They are namely

customs, infrastructure, international shipments, logistics competence, tracking and tracing and timeliness which affect the supply chain performance measures measured in terms of time, cost, reliability and flexibility (Arvis et al., 2012). Safety in logistics is a major concern for India, with an economic loss estimated to be exceeding Rs. 550 billion, with majority attributing to the truck fleet (World Bank, 2005). Therefore, the authors have taken the fifth component as safety.

Table 3.2 depicts the LPI score of India. The LPI rank of India dropped from 39 in 2007 (Arvis et al., 2007) to 54 in 2014 with a score of 3.07 to 3.08 respectively (Arvis et al., 2014). This shows that the logistics scenario did not change much in the Indian context, but other countries have started gearing up to improve the logistics performance. India ranked 58th among 166 countries in the quality of trade and transport infrastructure with a very low score of 2.88 (Arvis et al., 2014). But a sudden and commendable jump is visible in the year 2016. This can be the result of the various improvement measures taken by the government. But the road to success is still long and to get it self-considered in the global market, there is a dire need to have major breakthrough on the logistics front.

Table 3.2 India's LPI Score

Year	LPI Score	Rank
2007	3.07	39
2010	3.12	47
2012	3.08	46
2014	3.08	54
2016	3.42	35

Source: Compiled from LPI Reports

There is a strong relationship between country's LPI and its level of logistics costs (Rantasila and Ojala, 2012). 10% improvement in the index in the exporting country is associated with increased trade of 36% (Havenga, 2011). Similarly, for every 10% increase in the LPI of a typical exporter, bilateral imports increase by more than 69% on average, while for every 10% increase in the LPI of a typical importing country, bilateral imports increase by 54% on an average (Havenga, 2011). The role of the five components of LPI on logistics performance is as follows:

3.4.1 Reduction in Cost

Logistics cost is directly proportional to distance and handling incurred while transporting goods (FICCI, 2011) and inversely proportional to share of 3PL in the country (Kaur, 2011). There is immense potential in cost saving for India if it can bring down its logistics cost from the current level of 13% to 14% of GDP, to that of the USA which is 8.7% of the GDP, leading to savings of around $20 billion, resulting in a potential 4.3% cut in prices of Indian goods globally, making them more competitive (Mitra, 2008).

3.4.2 Reduction in Time

McGinnis and Kohn (1993) highlighted that emphasis on time competitiveness will improve logistics efficiency and coordination and it is a major component of logistics strategy. Wilding and Newton (1996) suggested that logistics is a time-related positioning of resources and many benefits can be obtained through it. Nordas et al. (2006) proved that time is an important competitive factor and also a barrier to trade, which affects the volume of trade and more importantly ability of the firms to enter the export markets. A 10% increase in time reduced bilateral trade volumes by between 5 to 8% (De Sousa and Findlay, 2007).

3.4.3 Improvement in Reliability

Reliability is considered to be an integral component among the nine elements of logistics identified by the Society of Logistics Engineers (SOLE) (Brimer, 1995). Reliability is the ability to perform the promised service consistently, dependably and accurately (Simons, 2004). Reliability has often been cited as the most important dimension in assessing the quality of service and is therefore a fundamental requirement for businesses to compete in the marketplace (Cook et al., 2002).

3.4.4 Improvement in Flexibility

Flexibility "reflects the ability of a system to change or react with little penalty in time, effort, cost or performance" (Naim et al., 2006). Zhang et al. (2005) define logistics flexibility as the ability of a firm to respond quickly and efficiently to changing customer needs in inbound and outbound delivery, support and services.

3.4.5 Improvement in Safety

Safety refers to the safety of stock, human resources, physical infrastructure and the overall

logistics system (Cantor, 2008). Pia (2010) concluded that flow of information, cooperation between the various parties of the chain, and the training of employees have proven to be important in improving the safety of a logistic chain and that material damage and accidents causes a lot of additional work and costs.

3.5 Case Study

To achieve the objectives and improve the LPI, case studies were conducted to study the effect of investment by LSP in the chosen areas. ABC is an Indian based logistics company established in 1985 with an annual turnover of 1200 crores. The company has a unified connectivity through air, road and rail resulting in a plethora of offerings to its customers. It is the market leader in India and has a strong presence in Asia Pacific region and SAARC countries. It has a fleet of about 7000 vehicles on road and 4000 business partners in India. For services in India, the company relies heavily on the road transport segment.

With more and more multinational logistics service providers entering Indian market, the company is facing stiff competition and is striving hard to maintain its position. For reducing logistics cost, the company is trying to optimize its logistics processes.

The company is facing huge losses through damages, high lead times and lower retention rate. After studying the various components of the process, it was found that a major reason for the increase in cost is improper handling, pilferage, redundant procedures and lack of co-ordination. Also, there is a lack of proper procedure for recruitment of logistics staff. People switch to other jobs as soon as they get one because of improper working conditions. There is a lack of focus on the development of human resources and to tap the potential savings which can be achieved through its improvement. Also, the use of information technology is limited. For improving the logistics performance, the company decided to invest Rs. 50 crores each in the next three years on improving the human resources and information technology. To study the impact of investment, models were developed using system dynamics modelling.

3.6 Data Collection for System Dynamics

To collect the information, a group of five managers were selected by the company and discussion was held among them.

3.7 Data Required for Simulation

Once the amount is earmarked and areas of improvement and performance measures are identified, the following set of information was required for simulating the system:

3.7.1 Existing and Target Values of Performance Measures

As discussed earlier, five performance measures considered for developing the LPI. 100% is considered as the target value for each of the performance measure as shown in table 3.3. For cost, it is informed by the executives that the logistics cost in their company is 63% more than the rest of the industry. Thus, logistics cost is taken as 163%. Similarly, the delivery time is 40% more than the industry and it is taken as 140%. 60% of the deliveries are consistent; therefore reliability of logistics services is 60%. Last minute changes cannot be incorporated in most of the deliveries and hence the flexibility of the system as measured by the executives is 55%. With the increase in accidents and damage to freight, safety is merely 52% in the case organization.

Table 3.3 Existing and Target Values of Performance Measures

Performance Measures	Existing (%)	Best in Industry (%)
Logistics Cost	163	100
Delivery Time	140	100
Reliability of logistics services	60	100
Flexibility of logistics services	55	100
Safety	52	100

3.7.2 Improvement in Performance Measure in the Next Interval

The improvement in performance measures in the next interval is given by equation 3.4.

$$\text{Improvement in PM (t)} = \text{PM (t-dt)} + \left(\frac{PV-TV}{TV}\right) * k \quad \text{..... 3.4}$$

where PM (t) is the value of performance measure in the next interval

PM (t-dt) is the value of performance measure at the last interval

PV = Present Value

TV = Target Value

k = improvement per lakh investment

3.7.3 Improvement in LPI

LPI is the weighted score of the five performance measures considered in this study. The weight of the each of the five inputs is arrived by using pair wise comparison technique. Inputs of PCT are taken in discussion with the executives of the company. Initially, when no investment is done, the LPI for the company is calculated using equation 3.5.

$$LPI = [(\frac{PV-TV}{TV})*w_1+(\frac{PV-TV}{TV})*w_2+(\frac{TV-PV}{TV})*w_3+(\frac{TV-PV}{TV})*w_4+(\frac{TV-PV}{TV})*w_5]*100 \quad \ldots 3.5$$

Where PV = Present value

TV = Target Value

$W_{1\text{-}5}$ = weight of each performance measure

Using equation 3.5, the LPI for the case organization is calculated as follows:

$$LPI = [(\frac{163-100}{100})*.35+(\frac{140-100}{100})*.25+(\frac{100-60}{100})*.15+(\frac{100-55}{100})*.15+(\frac{100-52}{100})*.1]*100$$

$$LPI = 0.22 + 0.1 + 0.06 + 0.07 + 0.05$$

$$LPI = 0.50 * 100$$

$$LPI = 50$$

The present value and target value are used from table 3.3 and the weight of each performance measure is taken from table 3.4. Therefore, the existing value of LPI for the case organization is 50 and the target value is 100, which is the best in industry.

With every percent improvement in the performance measure after investment, percentage improvement in LPI is given in table 3.4. For example, if cost improves by 1%, then percentage improvement in LPI will be 0.0007. Therefore, the total improvement in LPI will be the product of percentage improvement in LPI through improvement in logistics cost and weight in LPI for logistics cost i.e. total improvement will be 0.000245 for every percentage improvement in logistics cost. Similarly, improvement in LPI for every percentage improvement in delivery time will be 0.000125; improvement in LPI for every percentage

improvement in reliability and flexibility will be 0.0000525 and for safety it will be 0.000035. Therefore the total improvement in LPI, for percent improvement in performance measures is 0.0004475.

Table 3.4 Improvement and Contribution in LPI by Each Performance Measure

Performance Measures	Improvement in LPI (%)	Weight in LPI (%)
Logistics Cost	.0007	.35
Delivery Time	.0005	.25
Reliability of logistics services	.00035	.15
Flexibility of logistics services	.00035	.15
Safety	.00035	.1

3.8 Interpretive Structural Modelling

Interpretive structural modelling (ISM) is an interactive learning process. It can be used for identifying and summarizing relationships among specific variables, which define a problem or an issue (Warfield, 1974). ISM methodology supports to impose order and direction on the intricacy of associations among elements of a system (Sage, 1977). Weak and vague mental models of systems are transformed into visible and well-defined models. The model so formed portrays the structure of a complex issue or problem, a system or a field of study, in a carefully designed pattern implying graphics as well as words (Attri et al., 2013).

3.8.1 Steps in ISM Modelling

The ISM application steps are as follows and the flowchart is shown in figure 3.4.

1. Identification of elements, which are pertinent to the problem, this could be performed by literature review or any group problem solving technique.

Table 3.5 Development of SSIM

V	Variable i will help to achieve variable j
A	Variable j will help to achieve variable i
X	Variable i and j will help achieve each other
O	Variables i and j are unrelated

2. Forming a contextual connection amongst elements with respect to which pairs of

elements will be inspected.

3. Develop a SSIM, which shows pair-wise relationship between elements using the symbols shown in table 3.5.
4. Develop initial reachability matrix from SSIM by substituting V, A, X and O by 0 and 1 as per the case. The substituting of 0's and 1's are made as shown in table 3.6.

Table 3.6 Development of Initial Reachability Matrix

SSIM	**Initial Reachability Matrix**	
Entry in (i,j)	**Entry in (i,j)**	**Entry in (j,i)**
V	1	0
A	0	1
X	1	1
O	0	0

5. The final reachability matrix is obtained by incorporating the transitivity and a hierarchy level of each variable is identified sequentially by the intersection set of reachability and antecedent set. Transitivity of the contextual relation is a basic assumption in ISM which states that if element A is related to B and B is related to C, then A will be necessarily related to C.
6. Partitioning of reachability matrix into different levels.
7. Based on the relationships given above in the reachability matrix draw a directed graph (digraph), and remove transitive links.
8. Convert the resultant digraph into an ISM, by replacing element nodes with statements.
9. Review the ISM model to check for conceptual inconsistency, and make the needed modifications.
10. MICMAC analysis is done to categorize the variables into independent driving variables, linkage variables, autonomous variables and dependent variables.

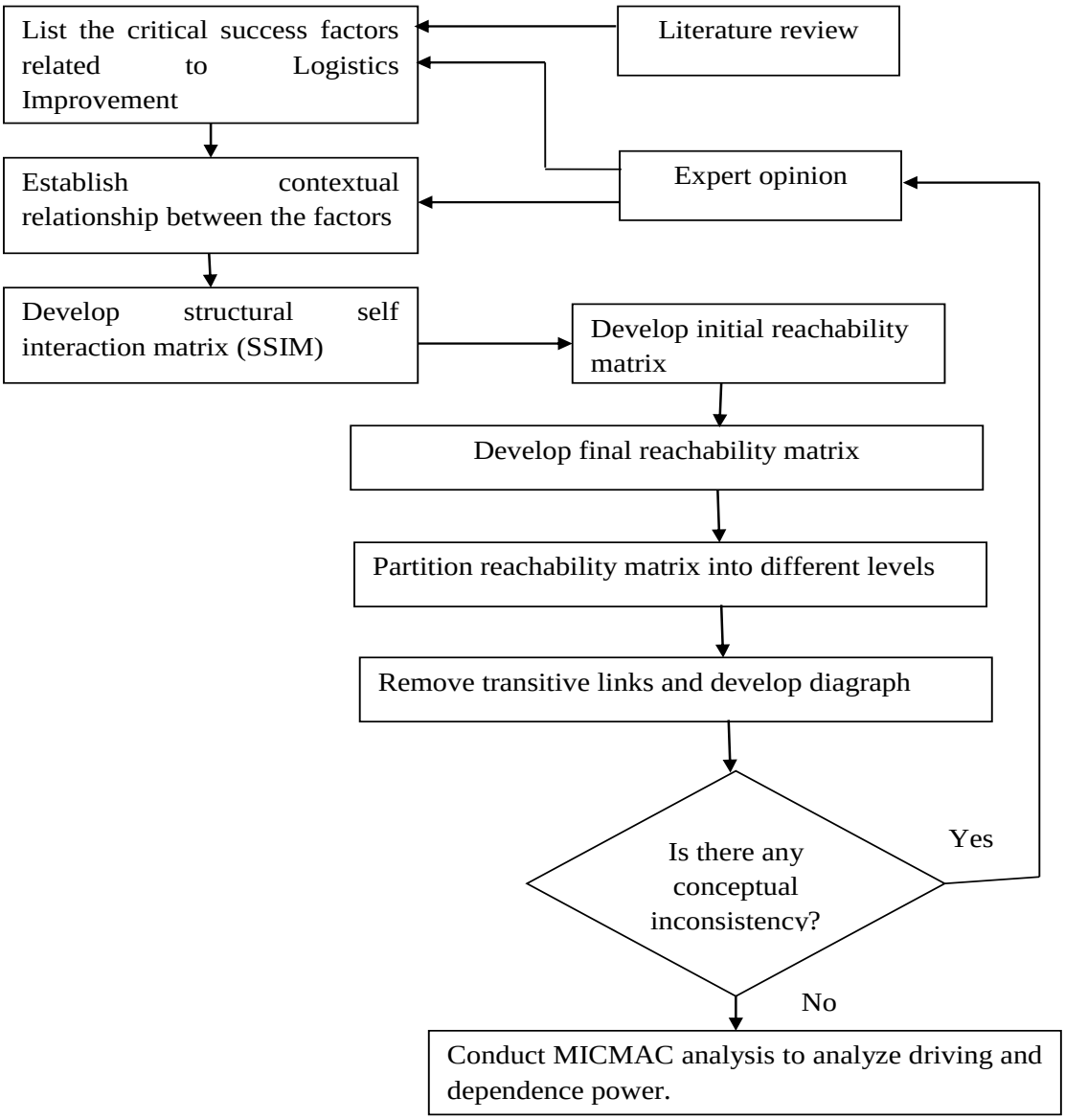


Figure 3.4 Flow Chart for Developing ISM

3.8.2 MICMAC Analysis

The MICMAC principle is based on multiplication properties of matrices (Sharma et al., 1995). The main objective is to analyse the drive power and dependence power of the variables (Mandal and Deshmukh, 1994). It is done to identify the key factors that drive the system in various categories. Based on their drive power and dependence power, the factors, have been classified into four categories i.e. autonomous factors, linkage factors, dependent and independent factors as shown in table 3.7.

Table 3.7 Categorization of Variables

Independent Driving Variables	Linkage Variables
These have strong drive power but weak dependence power. A performance measure with a very strong drive power, called the "key performance measure", falls into the classification of independent or linkage performance measures.	The drive power and the dependence, both are very strong. They are correspondingly unstable. Any action on them will have an effect on others and also a feedback effect on themselves.
Autonomous Variables	**Dependent Variables**
These performance measures have weak drive power and weak dependence. That's why they are somewhat disconnected from the system. They have few links with other elements, which may be very strong.	This category includes those performance measures which have weak drive power but strong dependence power.

3.9 Conclusion

This chapter details the research methodology adopted for conducting the research. The chapter explains the research strategy. Research techniques used for conducting the study are explained in detail. The data which will be commonly used for all the simulations has been discussed in this chapter.

Based on the discussion of this chapter, the next three chapters will deal in simulation modelling of the proposed investment plans in different areas for logistics improvement.

Chapter 4

LOGISTICS IMPROVEMENT BY INVESTMENT IN HUMAN RESOURCES

4.1 Introduction

The management of human resources holds the key to future success for companies striving to meet the competitive challenges of today and tomorrow, including globalization, technology, profitability through growth and capacity for change (Ulrich, 2013). The emerging market survey 2011 conducted by Transport Intelligence, highlights India's attractiveness as a strong growth area for logistics in future and emerging as a major logistics hub (Deloitte, 2012). According to the national skill development organization of India, transportation and logistics sector employed 7.3 million people in 2011, but the number is expected to increase to 25 million in 2022, raising a requirement of 17 million workers in the next ten years (PwC, 2012). The most severe and immediate requirement for skill development is found to be in the road freight and warehousing segments (KPMG, 2008).

As already discussed, the competitiveness of Indian organizations is getting severely hampered due to high logistics costs. The main reasons for high costs are lack of skilled manpower along with poor infrastructure and complex government regulations. According to a report by KPMG (2008), from a survey done on 80 logistics company it was found that the manpower costs forms 8-10% of overall costs in the sector (in case of road logistics it is 4%). This roughly translates to about Rs. 500 billion spent on logistics manpower annually. Of this, only 13-14% is spent on non-salary expenses such as manpower development items like welfare, training, etc., which is very less compared to global logistics countries which spend more than 20% (KPMG, 2008).

The Indian logistics sector is suffering from talent shortage in terms of both quality and quantity leading to improper handling of products, rash driving, high level of losses, damages, deterioration of stocks, separate person for each activity rather than multi-tasking, lower standard of living, etc. At management and mid-tier levels, the logistical sector in India suffers from organizational skills, lack of leadership, disjointed skills and positions and lack of process driven systems (LCL, 2011). With the reasons stated above lack of infrastructural facilities, low pay scale, lack of clearly defined career path, no suitable designations, lack of

accountability and proper training and poor or non-existent manpower policies make this sector the most unattractive sector for employment among job seekers including female workforce leading to improper and less recruitment and high attrition rates. This has widened the gap between skill set required and skill set available in the industry. To have a world class logistics system, the prerequisite is the team which can run such system. Hence, it is required to improve the human resources available, which is influenced by the investment in human resources by the government and the private sector. At international level, companies that are effective in their supply chain practices put a lot of emphasis on developing their human resource by adopting HRM practices such as training and retraining their employees and providing them with the adaptability that will help them fulfil their role in the supply chain (Anastasiou, 2012).

An early study by Ernst & Whinney (1987), in collaboration with the Council of Logistics Management, stated that the human resource is a critical factor in achieving logistics excellence (Gowen and Tallon, 2003). Possessing HR does not necessarily lead to firm's success rather poor HRM can negatively impact the employee's perception towards job satisfaction and their organizational commitment which in turn influences the firm's ability to achieve its performance goals (Ding et al., 2014). HRM practices like training, reward management, performance management, job design, staffing are considered important for making an integrated supply chain which in turn leads to improved supply chain performance in terms of cost, quality, delivery and flexibility (Shub and Stonebraker, 2009).

Government and organizations are focussing on investment and development of infrastructure and technology adoption to improve logistics performance. But simultaneously the need of the hour is to focus on the development of people who manage the logistics operations. Due to availability of cheap labour, human resource is not considered as an important asset in the Indian business environment. With 91% unorganized logistics market, it was very difficult to convince the company to invest in improvement in human resources. To improve the human resource in the logistics sector in the Indian context, investment is required in areas like imparting training, providing wages at par with other sectors of the economy keeping the job requirement in view, improving working conditions and enhancing employee welfare. The emphasis and priority of these areas can differ from organization to organization depending upon the existing level of these factors, the investment required in each area and improvement potential.

Simulation and optimisation are salient tools in the supply chain management field as a means for increasing performance (Rios Prado et al., 2014). It can be an excellent test-bed to evaluate the effects of a particular policy under a wide set of operational conditions taking into account variability and stochasticity that are unavoidable features of complex systems (Nicoletti et al., 2014). Therefore, through system dynamics modelling, this study is an attempt to identify the impact of improvement in human resources on logistics performance.

Chapter is organized as follows. Section 4.2 discusses the role of human resources in logistics and section 4.3 identifies the areas chosen for investment for improving human resources. Section 4.4 discusses the research methodology adopted in this chapter. Section 4.5 and 4.6 discusses the causal loop diagram and the stock and flow diagram respectively. Section 4.7 validates the model used in the chapter. Section 4.8 discusses the simulation results. Sensitivity analysis and scenario generation are discussed in section 4.9 and 4.10 respectively. Section 4.11 concludes the chapter and 4.12 discuss the implications for the manager.

4.2 Role of Human Resources in Logistics

A lot of studies have been conducted to understand the role of human resources in logistics management and organizational performance. Table 4.1 shows the benefits of various human resource management practices in logistics. Asthana (2012) has identified the changing trends in Indian logistics services and the growing requirement for skilled and trained human resource, intensifying the skill gap situation arising as a result of movement of Indian logistics sector from mere in house staff to complex 3PL supply chain management system. Jhawar et al. (2014) conducted a study which proved that skilled workforce has a very positive effect on the logistics performance index.

4.3 Identification of Areas of Investment

HRM has a very vast domain and thus there is a need to focus on certain areas of investment for improvement. To categorize these areas, it is first necessary to shortlist the major problems faced by the Indian logistics sector. KPMG (2008) identified following core issues as the main reasons for acute labour shortages:

1. Poor image/lack of attractiveness for new recruits arising from poor working conditions and relatively lesser attractive pay and progression incentives, in turn

arising from the fragmented and unorganized nature of the industry.

2. Rapid evolution in the logistics management processes and operations with technological change and changing customer requirements.
3. Absence of an institutionalized skill development environment.
4. Emergence of attractive alternate career options leading to attrition (especially in sectors where logistics skills come in handy like organized retail).

Table 4.1 Benefits of HRM Practices in Logistics

S.No	HRM Practices	Author/s and Remarks
1.	Recruiting, Selection and Compensation	Gibson and Cook (2001); Ding et al. (2014); Barnes and Liao (2012)
		Benchmarking hiring practices for recruiting and selecting high quality management talent; higher positioning, distribution support and agility competencies; successful strategic partnerships.
2.	Performance and Reward Management	Kam et al. (2010); Pandey et al. (2012)
		ILS, FSC; high levels of SC integration
3.	Training and Development	Ding et al. (2014); Gorane and Kant (2013); Menon (2012)
		Influences both employee and organizational performance; SCM success; higher positioning, distribution support and agility competencies; SC performance satisfaction with regard to cost and suppliers and successful supply chain integration
4.	Health and Safety of Employee	Okeudo (2012)
		Positive impact on firm performance and on logistics capabilities like FSC solution, ICT and ILS
5.	Work Motivation, Employee Commitment, Empowerment	Gorane and Kant (2013); Anastasiou (2012)
		Greater competitive advantage; supply chain success
6.	Organization Culture, Teamwork and Trust among Employees	Acar (2012); Gorane and Kant (2013); Menon (2012)
		Employee's commitment to the organization; important supply chain enablers; technological integration and coordination

To cater to the problems identified above, the four areas which were chosen for investment are:

- Training
- Improvement in wages

- Improvement in working conditions
- Welfare of the employees.

Table 4.2 Investment in Training, Welfare, Wages and Working Conditions

Author/s	Training	Welfare	Wages	Working Conditions
Kam et al. (2010); Anastasiou (2012); PwC (2012)	✓	✓	✓	✓
Okeudo (2012); Pandey et al. (2012)	✓	✓	✓	×
Huselid (1995); Wiley (1997)	✓	×	✓	✓
Delaney and Huselid (1996); Hohenstein et al. (2014)	✓	×	✓	×
Ellinger et al. (2008); Shub and Stonebraker (2009)	✓	×	✓	×
Prowse and Prowse (2010)	✓	×	×	✓
Kalliath and Kalliath (2012)	×	✓	×	✓

Table 4.2 highlights the importance of investment in training, improvement in wages, improvement in working conditions and welfare of the employees as studied by different authors. Very few authors have studied the importance of investment in all the four activities. It can be observed that importance of welfare can be seen only in studies conducted in last five years. But improvement in working conditions is still not the area of interest for many researchers and it is a topic of concern as it is one of the crucial factors for the unattractive image of the logistics sector in the Indian market.

The advantages of investment as highlighted by Huselid (1995) are lower employee turnover, greater productivity and corporate financial performance. Delaney and Huselid (1996) and

Prowse and Prowse (2010) asserts that it has a positive effect on organizational performance, whereas Kalliath and Kalliath (2012) states that is has a positive effect on employability of employees. HR strategies have a very positive effect on supply chain integration and performance was concluded by Shub and Stonebraker (2009).

Hohenstein et al. (2014) conducted a literature review on issues of HRM in SCM and concluded that the authors are concentrating more on skills, training, impact on performance and very less on wages, recruitment procedures and global mind-set which are very important to tackle talent shortage. Wiley (1997) suggests that the most important factor for employee motivation is wages. From these studies, it can be understood that HRM issues play a very important role in logistics and organizational performance and investment in it will reap positive outcomes.

4.4 Research Methodology

To study the investment plans, the objectives, scope, performance measures, policies etc. are discussed below.

4.4.1 Chapter Aims

The aims of this chapter are

1. To identify the investment area/s, which will maximize logistics performance?
2. To develop a dynamic model using system dynamics modelling for the investments in human resources
3. To evaluate the various investment plans for the decision maker to formulate the investment strategy which best meets the requirements of the business.
4. To quantify the relationship between performances measures like logistics cost, delivery time, reliability, flexibility and safety and logistics performance.
5. To study the effect of improvement in logistics performance, if any, on the profit of the firm.

4.4.2 Model Assumptions

The following assumptions are made for carrying out the simulations:

1. The activities are not interrelated to each other i.e. improvement in working condition does not affect training or wages etc.
2. The effect of improvement in activities is instantaneous and there is no time lag between investment and improvement.

3. After 12 quarters, if the profit increases by 3%, then the company will invest 1% of the investment amount every quarter.The existing profit percentage of the company is 10%. With every percentage improvement in LPI, profit will improve by 0.002.

4.4.3 Investment Plans

The investment plans need to be developed with respect to two aspects:

1. Proportion of investment in different HR improvement areas. These plans are given in table 4.3.
2. Time phasing of the investment. Plans on this aspect are given in table 4.4.

In the equal focus plan (PA1), as shown in table 4.3, 25% of total budgets are earmarked for training, 25% of welfare, 25% for improvement in wages and 25% to improve the working conditions is done in equal percentage in each activity to study the improvement in each activity for the period of time. Improvement area like wages and welfare are considered as direct areas of improvement as they directly influence to the manpower worker in the organization. On the other hand, training and working conditions are taken as indirect areas since their impact is not directly and may take some time to be visible. In partial indirect focus plan (PA2), 30% and 40% investment is done in indirect focus areas i.e. training and working conditions respectively and 15% investment is done in welfare and wages each.

Table 4.3 Investment Plans for Different Activities

Investment Plans		**Investment in Activity (%)**			
Code	**Description**	**Training**	**Welfare**	**Wages**	**Working Conditions**
PA1	**Equal Focus Plan**	25	25	25	25
PA2	**Partial Indirect Focus Plan**	30	15	15	40
PA3	**Semi Focus Plan**	30	0	30	40
PA4	**Indirect Focus Plan**	50	0	0	50
PA5	**Partial Direct Focus Plan**	40	15	15	30
PA6	**Direct Focus Plan**	0	50	50	0

In the semi focus plan (PA3), 30% investment is done in improving the wages which will directly benefit the employees and 40% and 30% investment is done in improving the working conditions and training respectively which will improve their morale and job satisfaction. In indirect focus plan (PA4), 50% investment is done in working conditions and

50% investment is done in training for the betterment of the employees and no investment is done in wages and welfare.

In partial direct focus plan (PA5), 40% investment is done in training, 30% in working conditions and 15% in increasing wages and 15% in welfare which will focus on improving the skills of the worker which will help them in the long run in their career. Direct focus plan (PA6), will benefit the workers directly as it is completely focussed on equal percentage i.e. 50% investments is done in improving the wages and welfare with no investment in training and working conditions.

Table 4.4 QAP as Percentage of Activity

QAP	Quarter wise Allocation of Funds (%)												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
QAP1	10	10	10	10	10	10	10	10	5	5	5	5	100
QAP2	5	5	5	5	5	5	5	5	10	10	20	20	100
QAP3	25	0	0	25	0	0	25	0	0	25	0	0	100
QAP4	15	15	15	10	10	5	5	5	5	5	5	5	100
QAP5	20	20	15	15	15	15	0	0	0	0	0	0	100

To achieve the maximum benefits, the investment in an area is further broken quarter wise. Since the present plan is for 3 years, the investment is divided into 12 quarterly periods. Based on it, five plans are prepared and analysed as given in table 4.4. In QAP1, 10% of the investment is done in first eight quarters and it was reduced to half in the last four quarters. Exactly opposite to this, in QAP2, 5% investment was done in first eight quarters and it was doubled in the last four quarters. In QAP3, 25% of the investment amount was invested every third quarter. More than 50% of the investment was done in QAP4, in the initial four quarters and 5% of the investment was done in every quarter afterwards. In QAP5, whole investment was done in the initial six quarters.

4.4.4 Research Framework

As shown in figure 4.1, through investment in the four areas of human resources, considerable improvement can be achieved in the performance measures which will improve the logistics performance leading to improvement in profit. Improved profit will lead to more investment.

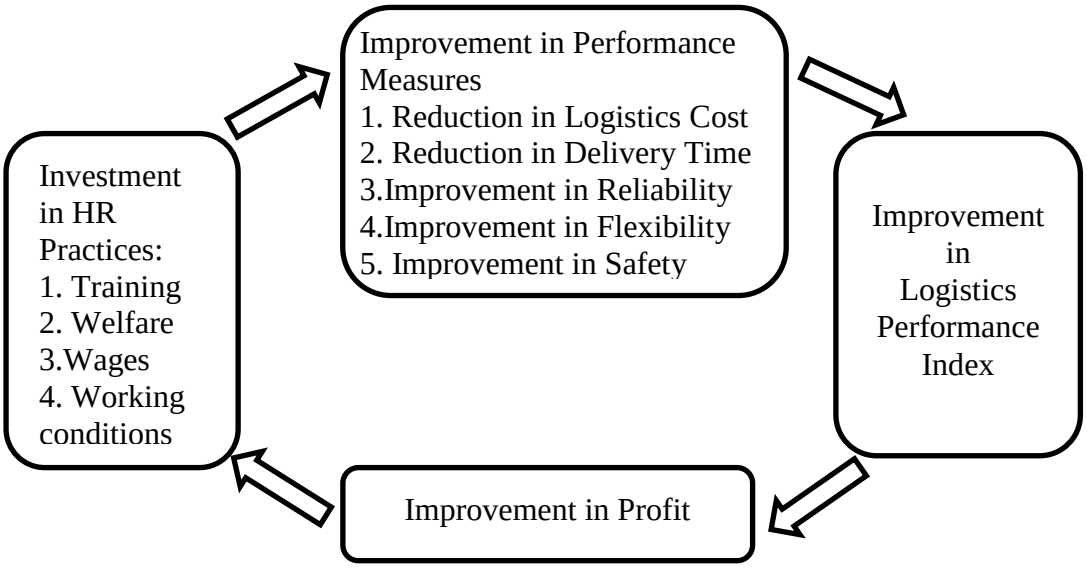


Figure 4.1 Research Framework

4.5 Causal Loop Diagram

Success of transportation and logistics operators depend decisively on the quality, competence and knowledge of human assets that deliver outstanding service and customer satisfaction (Wong and Karia, 2010).

Table 4.5 Distribution of Human Resources by Education Level

Education Qualification	Road Transport	Warehousing	3PL Providers	Rail Transport	Ship Transport
Graduate	0-5%	5-10%	50-60%	20-30%	40-50%
Matriculate	10-15%	35-40%	20-25%	50-60%	30-35%
Literate but not matriculate	50-55%	25-30%	10-15%	10-15%	10-15%
Very minimally educated	20-25%	15-20%	-		-

Source: NSDC, 2011

Training and development plays a very important role to boost the morale of an employee. Training seems to develop a positive orientation to the employees and uplifting organisations performance (Inn et al., 2010). In India employees at managerial and strategic level might have some background through education, and experience, but, the real problem is at the operational level. No formal training is provided to a truck driver, loading supervisor, warehouse staff etc. If people loading trucks are not good enough, the system breaks down (Kam et al., 2010).

Table 4.6 Level-Wise Distribution of Human Resources in the Road Transportation and Warehousing Segment

Functions	Distribution	
	Road Transportation Segment	**Warehousing Segment**
Senior Management	1-2%	1-2%
Middle Management	3-5%	5-8%
Supervisory Staff	10-13%	Not Applicable
Worker level (truck drivers, loaders, good handlers)	70-80%	
Operational - front line staff	Not Applicable	85-90%

Source: NSDC, 2011

As seen from table 4.5 and table 4.6, people with lowest education qualification consist of 85-90% of the workforce in the road and warehouse segment. Therefore there is an urgent need to develop training and development institutions to provide formal training to them. If the LSP increases their human capital investment by both on and off the job training, they should be able to improve their performance.

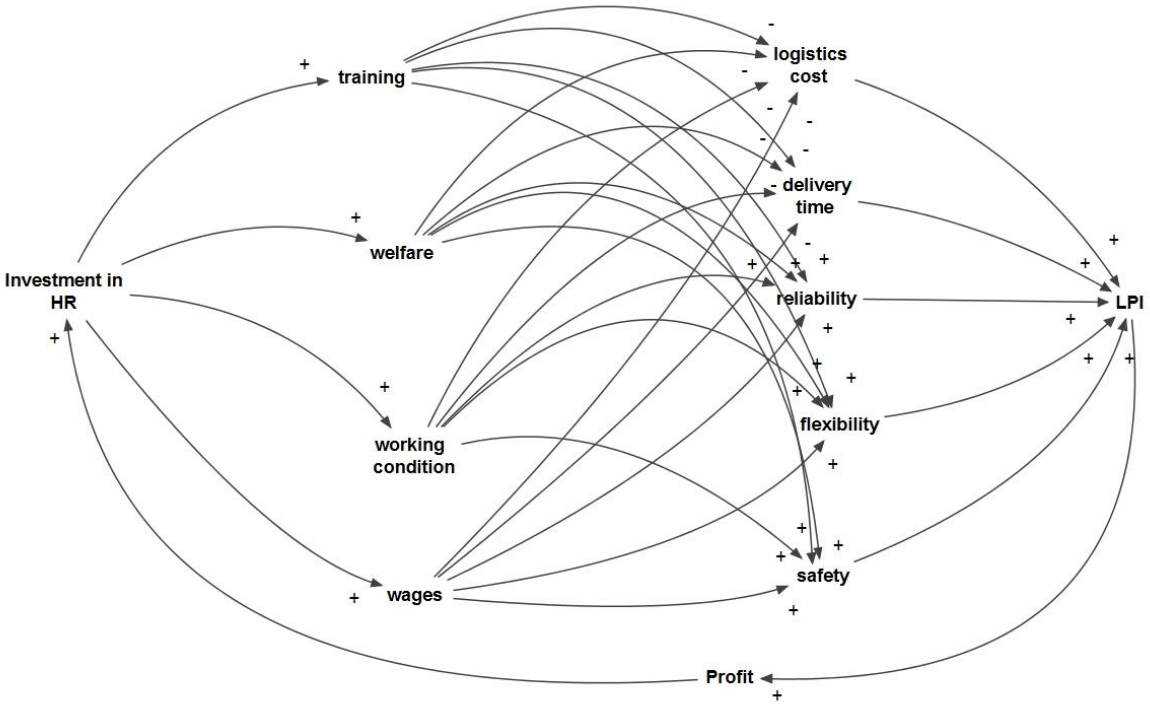


Figure 4.2 Causal Loop Diagram for Investment in HR and its Effect on LPI

Also, poor working conditions, misappropriate salary structures and poor or non-existent manpower policies have added to industry's woes creating a poor image of the sector that holds few attractions for those seeking employment. Due to this, female workforce also does not get attracted. Logistics companies in emerging countries need to invest in training and development, enhancing opportunity for advancement and improving working condition, improving recruitment efforts and making current workers satisfied to improve their employer brand (PwC, 2012). Reward management strategies like competitive salaries and attractive benefits are a popular HRM approach to attract, retain and motivate best talent (Kam et al., 2010). Attention to reward management, performance management and training and development programme is likely to result in reduced staff turnover and strengthen LSC capabilities.

The LSP will invest in training and improvement in human resources. Through training, the skilled labour work force will improve. Due to skilled work force, the cost will decrease. Decrease in cost will lead to improvement in LPI. Improvement in LPI will generate revenue for LSP which will invest more in human resources. Therefore in figure 4.2, the loop between investments in HR, training, cost, LPI and profit is balancing loop. Skilled workforce will reduce the time for doing logistics activities, which will improve the LPI. So, the loop between investments in HR, training, delivery time, LPI and profit is also balancing loop. Skilled labour will improve the reliability, flexibility and safety of the system. So the loop between investments in HR, training, skilled labour, reliability/flexibility/safety, LPI and profit is a reinforcing loop.

The investment in improving the welfare, wages and working conditions will improve the worker's performance and will indirectly reduce the logistics cost and delivery time. Therefore in figure 4.2, the loop between investments in HR, welfare/wages/working conditions, cost/time, LPI and profit is balancing loop. The reliability, flexibility and safety of the system will also get affected in a positive manner through a motivated workforce. So the loop between investments in HR, welfare/wages/working condition, reliability/flexibility/ safety, LPI and profit is reinforcing loop.

4.6 Stock and Flow diagram

The stock and flow diagram shown in figure 4.3, has been developed using STELLA 9.1.3 software. After developing the stock and flow diagram, the model has been simulated for 12

quarters, taking the value of DT as 1. Delta time controls how frequently calculations are applied each unit of time and as they process will not change every unit of time, it is taken as 1 in this case.

4.6.1 Data Required for Simulation

Once the amount is earmarked and areas of improvement and performance measures are identified, the company needs to have an implementation plan which will provide the quarter wise investment in each of the improvement area for the next 3 years. To achieve this dynamic model as given in figure 4.3 is developed and simulated using Stella 9.1.3. The following set of information was required for simulating the system:

a. The present level and the target level of the performance measures in the case organization (table 3.3).
b. The improvement in the performance measures (improvement rate) with every one lakh investment (table 4.7).
c. The improvement in LPI with one percent improvement in the performance measure (table 3.4).
d. The weightage of each performance measure on the LPI (table 3.4).

To collect the above information, discussion was held with the executives of the company and the following information was collected for use in the study.

4.6.2 Improvement in Performance Measure for Every One Lakh Investment

Improvement in the values of the performance measures is achieved by making investment in HR areas. Table 4.7 gives the percentage improvement in the performance measures for every one lakh investment in the improvement area. For example, the present value of logistics cost in the company is 163. With an investment of one lakh in training, the logistics cost will reduce by 0.009 i.e. it will become 162.99. Similarly, an investment of one lakh in welfare will reduce the logistics cost by 0.006. If investment of one lakh each is made in all the four areas, then the logistics cost will reduce by (.009+.006+.007+.006) = 0.028. With first one lakh investment in each area, logistics cost will reduce to 162.97 from the existing level of 163. This one lakh in each of the four areas will reduce the logistics time from 140 to 139.97, reliability will improve to 60.0095 from 60, flexibility will improve to 55.008 from 55 and safety will improve to 52.007 from 52.

Table 4.7 Percentage Change in Performance Measure by Per Lakh Investment in Activity

Activity	Percentage change in Performance Measures by per lakh investment in activity				
	Reduction in Cost	**Reduction in Time**	**Improvement in Reliability**	**Improvement in Flexibility**	**Improvement in Safety**
Training	0.009	0.007	0.0025	0.0015	0.0015
Welfare	0.006	0.005	0.0015	0.002	0.0015
Wages	0.007	0.006	0.0025	0.0015	0.002
Working Conditions	0.006	0.007	0.003	0.003	0.002

4.7 Model Validation

Validation of system dynamics model is necessitated to establish sufficient confidence in the model (Sahay et al., 1996). Forrester (1961), Coyle (1979) and Wright (1971), suggests that the significance of the model depends on how well it serves its purpose and thirteen subjective criteria have been suggested by them for model validation. Generally, there is a serious criticism for the popular validation techniques due to their overemphasis on quantitative validation rather than the usefulness of the model and paying insufficient attention to underlying assumptions (Khanna et. al, 2008).

Table 4.8 Model Validation Results

Performance Measures	Percentage Change based on calculations	Results based on SD model	Percent deviation from system dynamics prediction
Logistics Cost	162.52	161.24	-0.48
Delivery Time	138.75	139	-0.089
Reliability of Services	60.48	64.37	6
Flexibility of Services	55.40	59.17	6.3
Safety	52.35	55.92	6.3

Data was collected for the organization through a group of managers to assess the percentage change in the performance measures. The average score was then compared to the system dynamics model results for equal focus plan, as shown in table 4.8.

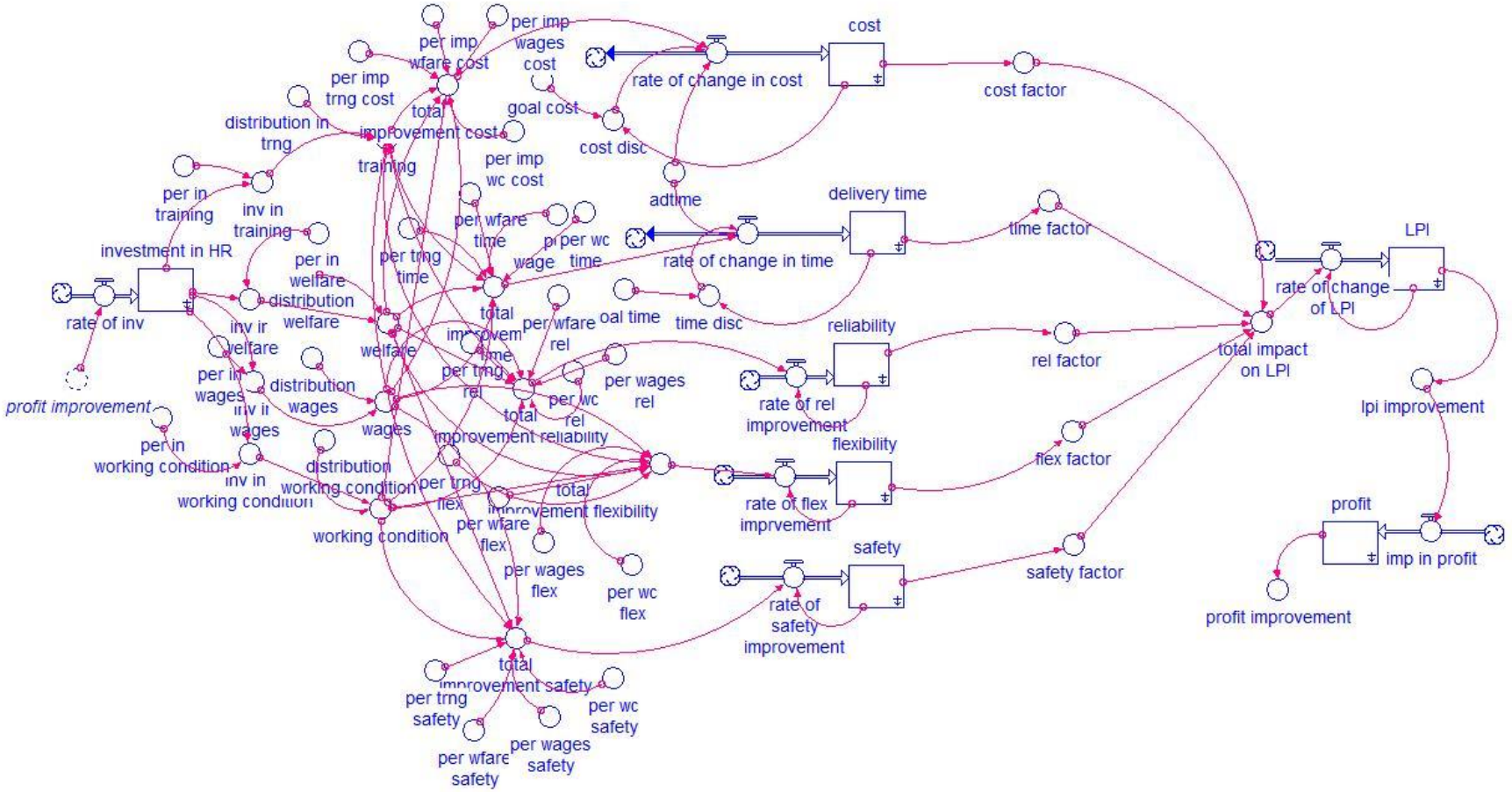


Figure 4.3 Stock and Flow Diagram for Investment in HR

Khanna et al. (2008) accepted the model at a percent deviation of 10%. Since maximum variation has been observed to be around 6 percent, the SD model fairly replicates the dynamic behaviour and thus validates the interrelationships.

4.8 Results and Discussion

The LPI results are shown in figure 4.4. LPI reached the highest value in the indirect focus plan (PA4), with a value of 51.27. The second highest value of 51.23 was for semi focus plan (PA3), which is slightly less than PA4 followed by PA2, PA5, PA1 and PA6. Further simulations will be carried out with base as PA3 and PA4.

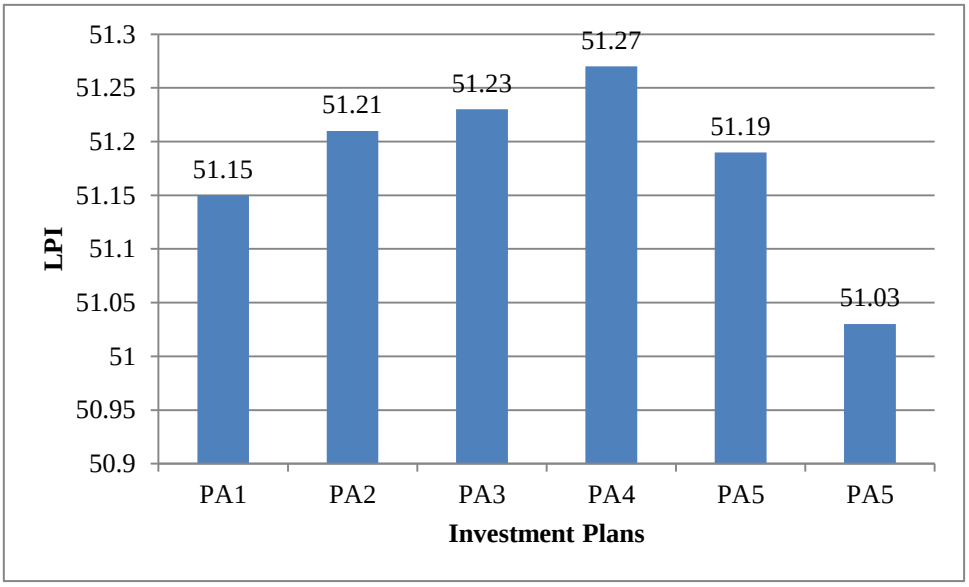


Figure 4.4 Results for LPI for Alternative Investment Plans in Activities

In phase 2, the quarter-wise allocation of funds as a percentage of total investment in the activity is shown in table 4.4. Simulations runs were carried out by taking base PA3 as selected above and quarter wise investment as the percentage of total investment in an activity.

4.8.1 Quarter-Wise Investment in Semi Focus Plan (PA3)

The results for quarter wise investment for PA3 is shown in figure 4.5. LPI reached highest with a value of 51.58 in QAP4, where 10 to 15% investment is done more in initial quarters and 5% investment is done 6th quarter onwards. The second highest value of LPI is 51.41 through QAP1, in which 10% investment is done in initial quarters and 5% investment is done in last four quarters.

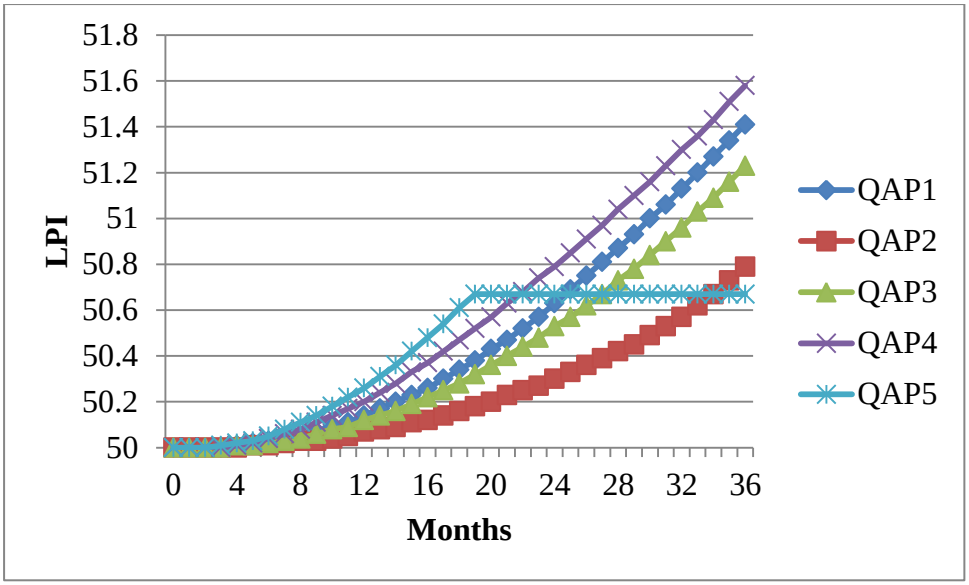


Figure 4.5 Results for LPI for Quarter Wise Investment in PA3

Table 4.9 Results for Performance Measures with Quarter Wise Investment in PA3

QAP	Logistics Cost	Delivery Time	Reliability of services	Flexibility of services	Safety	LPI
QAP1	161.17	138.96	64.98	59.42	56.18	51.41
QAP2	161.26	139.02	64.75	59.21	55.98	50.79
QAP3	161.19	138.98	64.93	59.37	56.13	51.23
QAP4	161.17	138.96	64.98	59.42	56.18	51.58
QAP5	161.14	138.95	65.07	59.50	56.25	50.67

After evaluating, the results for QAP1 to QAP5 with base as PA3, the result of performance measures is shown in table 4.9. As seen from table 4.9, the lowest value for logistics cost and delivery time and highest value for reliability of services, value for flexibility of services, safety and LPI is highest for QAP5. But as the investment is done in only initial 6 quarters, LPI reached a maximum value of 50.67 only. Therefore, the best plan with base as PA3 is to follow QAP4 where LPI reaches the value of 51.58. Logistics cost decreased by 1.12%, delivery time decreased by 0.74%, reliability of services increased by 8.3%, flexibility of services improved by 8.03% and safety improved by 8.03%. LPI improved by 3.16% through 30% investment in training, 30% investment in wages and 40% investment in working conditions. Figure 4.6 and figure 4.7 are software generated graphs indicating that initially the improvement is slow, but it starts improving suddenly after 16 months.

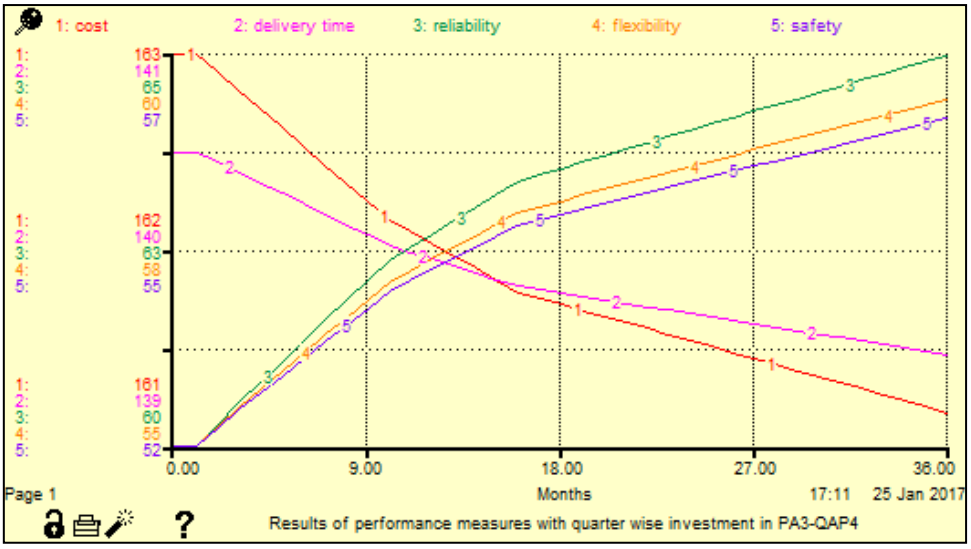


Figure 4.6 Results for Performance Measures for Quarter Wise Investment in PA3-QAP4

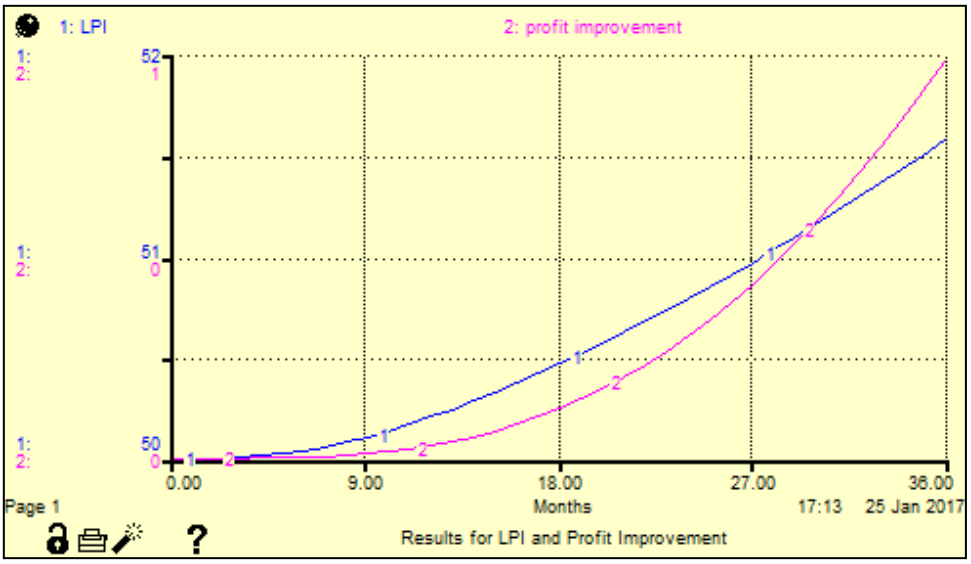


Figure 4.7 Results for LPI and Profit Improvement with Quarter Wise Investment in PA3-QAP4

4.8.2 Quarter Wise Investment in Indirect Focus Plan (PA4)

Now, using the base as PA4, quarter wise distribution was done as shown in table 4.4. The results for quarter wise investment in indirect focus plan (PA4) is shown in figure 4.8. LPI reached highest with a value of 51.63 in QAP4. The second highest value of LPI is 51.45 through QAP1. After evaluating, the results for QAP1 to QAP5 with base as PA4, the result of performance measures is shown in table 4.10. As seen from table 4.10, the lowest value for

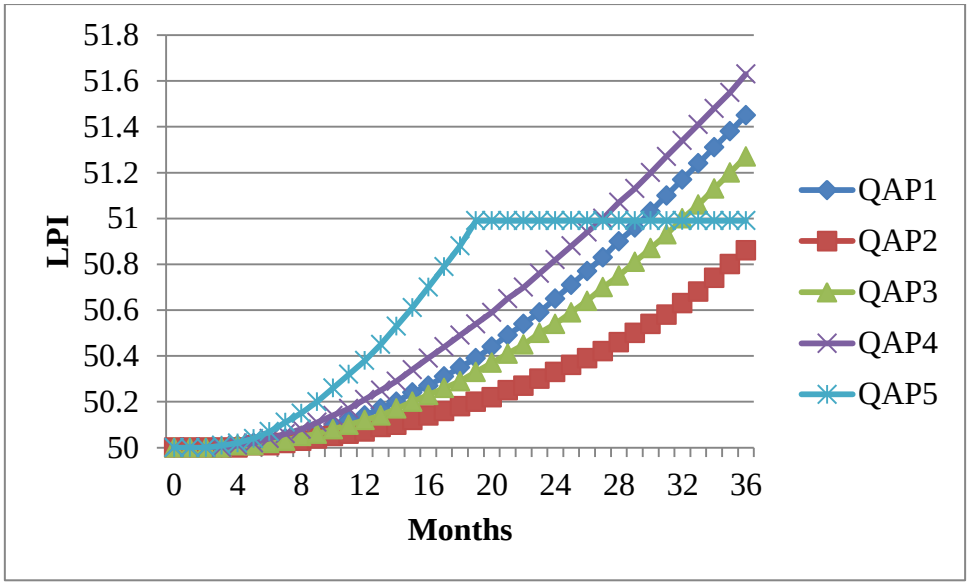


Figure 4.8 Results for LPI for Quarter Wise Investment in PA4

logistics cost and delivery time and highest value for reliability of services, value for flexibility of services, safety and LPI is highest for QAP5. But the growth becomes stagnant and LPI reached a maximum value of 50.99 only. Therefore, the best plan with base as PA4 is to follow QAP4 where LPI reaches the value of 51.63. Logistics cost decreased by 1.17%, delivery time decreased by 0.8%, reliability of services increased by 8.45%, flexibility of services improved by 8.58% and safety improved by 7.61%. LPI improved by 3.26% through 50% investment in training and 50% investment in working conditions. Figure 4.9 and figure 4.10 are software generated graphs indicating that initially the improvement is slow, but it starts improving suddenly after 16 months.

Table 4.10 Results for Performance Measures with Quarter Wise Investment in PA4

QAP	Logistics Cost	Delivery Time	Reliability of services	Flexibility of services	Safety	LPI
QAP1	160.09	138.87	65.07	59.72	55.96	51.45
QAP2	161.19	138.93	64.83	59.49	55.77	50.86
QAP3	161.11	138.88	65.01	59.67	55.92	51.27
QAP4	161.09	138.87	65.07	59.72	55.96	51.63
QAP5	160.17	138.45	67.29	61.29	58.19	50.99

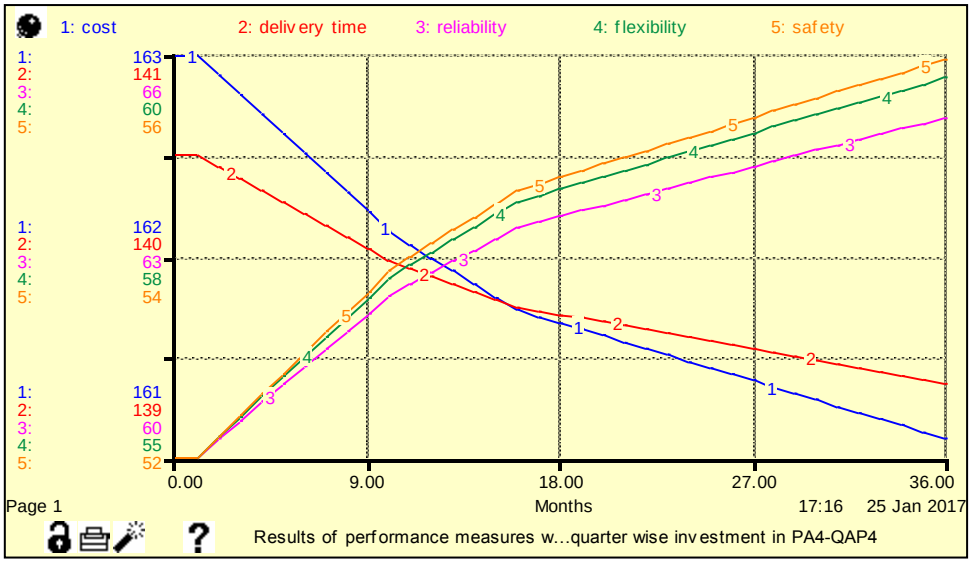


Figure 4.9 Results for Performance Measure for Quarter Wise Investment in PA4-QAP4

Figure 4.10 Results for LPI and Profit Improvement with Quarter Wise Investment in PA4-QAP4

4.8.3 Year Wise Improvement in PA4-QAP4

To understand the exact amount of investment and time required by the company to achieve significant results, PA4-QAP4 was further simulated by increasing the investment amount by 10%, when profit improvement will be more that 3% as it was decided by the company initially. The results are shown in table 4.11.

From figure 4.11, it can be observed that improvement in performance measures is seen around 18 months. From figure 4.12, profit improvement reaches 3% between 54 months to 60 months, indicating that 10% of the initial amount invested must have started getting added to the investment amount.

Table 4.11 Year Wise Improvement in Performance Measures

Months	Logistics Cost	Delivery Time	Reliability of services	Flexibility of services	Safety	LPI	PI
36	161.09	138.87	65.07	59.72	55.96	51.63	0.82
48	160.71	138.64	66.02	60.62	56.73	52.63	1.81
60	160.33	138.42	66.94	61.50	53.83	57.48	3.33

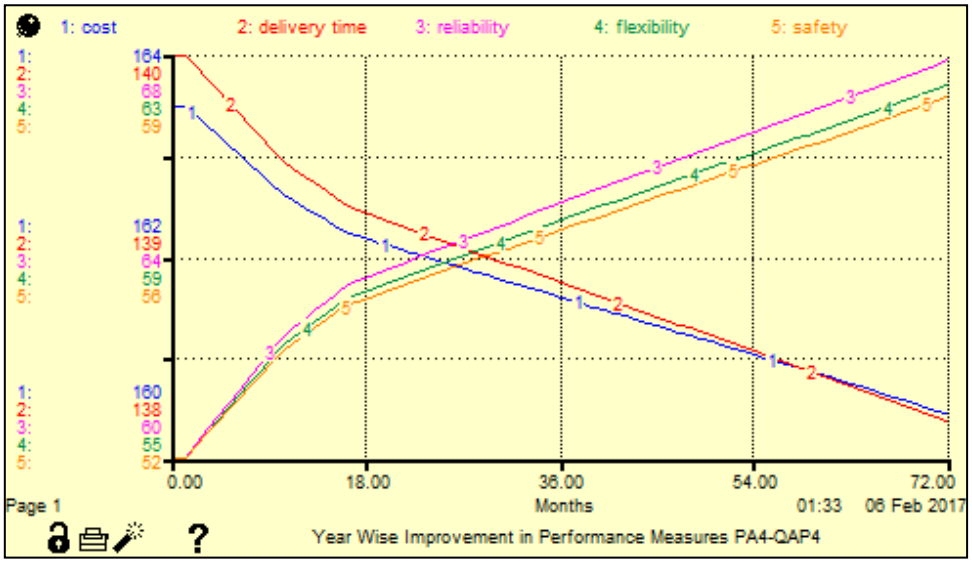


Figure 4.11 Results for Performance Measures for Year Wise Investment in PA4-QAP4

Figure 4.12 Results for LPI and Profit Improvement for Year Wise Investment in PA4-QAP4

4.9 Sensitivity Analysis

Sensitivity analysis is carried out for developing faith in the model and to check the sturdiness of the model. If the model appears to be too sensitive to reasonable changes in the model, the model based conclusions are difficult to be relied on because sensitive models are not much help as a policy tool (Sushil, 1993). Sensitivity analysis was performed by taking investment as decision variable from Rs. 50 crores to Rs. 5000 crores.

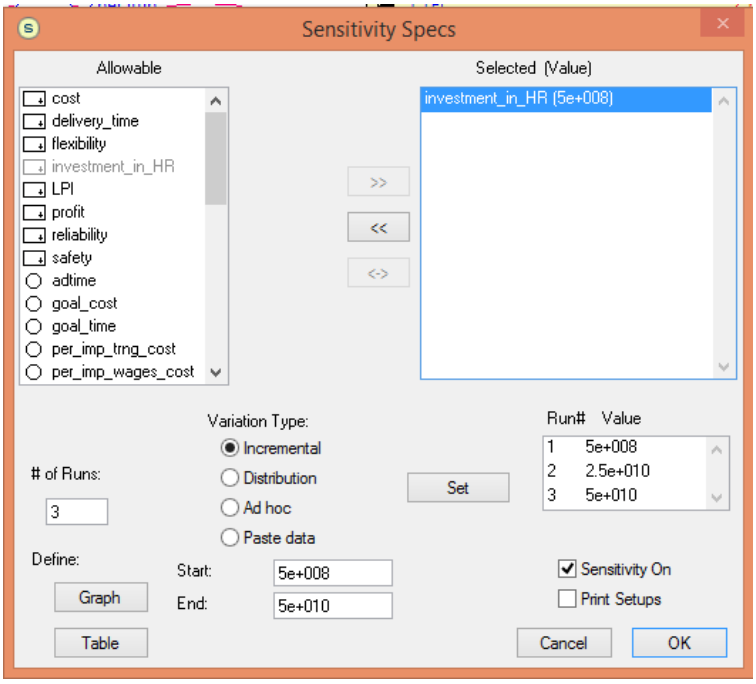


Figure 4.13 Input window for Sensitivity Analysis in Stella Software

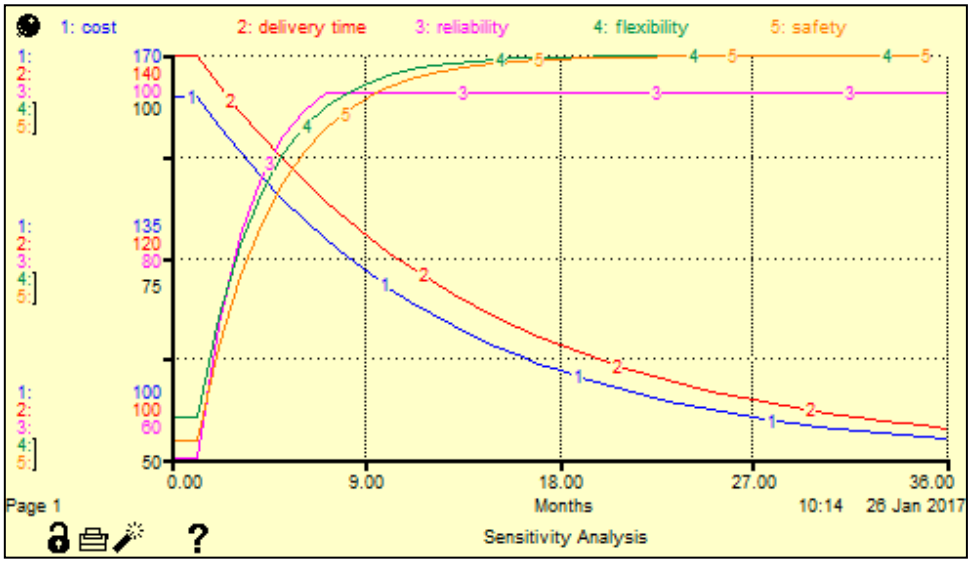


Figure 4.14 Results for Performance Measure for Sensitivity Analysis

Figure 4.13 displays the input with for sensitivity analysis in the Stella software. The decision variable is the input to the selected (value) window. In the start and end tab, the initial and final value for the decision variable is entered. The user can select the number of runs for the simulation. After selecting and inputting all required data, the set button chooses different values for the decision variables according to the number of runs selected.

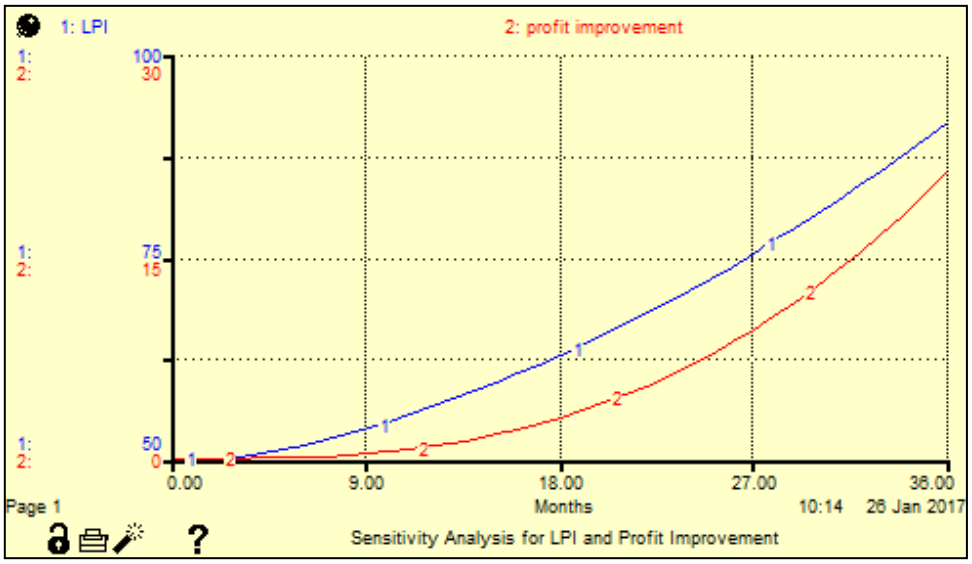


Figure 4.15 Results for LPI and Profit Improvement for Sensitivity Analysis

Figure 4.14 and figure 4.15 depict the result of sensitivity analysis. As the maximum value for the decision variable is too large the performance measures have reached the target values very fast. From figure 4.14, it can be seen that reliability reaches 100 in around 9 months, flexibility and safety reaches its target values in around 15-16 months. Reduction in cost and time requires around 36 months reaching its target values. From figure 4.15, it can be seen that LPI reaches its target value in 36 months and profit is about 30% in 36 months. From the results, it can be seen that the model does not display any abnormal behaviour and it is found suitable for scenario generation or policy formulation.

4.10 Scenario Generation

Once a valid model with improved policy structure is obtained after sensitivity analysis, it can be used to create generate different types of scenario for future. Various managerial options regarding different policy and system parameters can be considered and their impact on the dynamic response of the model can be taken as a future scenario (Sushil, 1993). The four scenarios considered for further evaluation are shown in table 4.12.

The two best plans combinations, PA3-QAP4 and PA4-QAP4 are simulated further. The two criteria considered for scenario generation are percentage investment after improvement in profit and the time gap between investment and improvement in performance measures. As the company has decided that it will invest 1% of the initial investment every quarter if the profit increases by 3%, therefore investment percentage is divided into four slots namely 0-25%, 25%-50%, 50%-75% and 75%-100%. The other criterion is the time gap between the amount invested and the actual improvement in the performance measures. It is also divided into four slots namely 0-3 months, 3-6 months, 6-9 months and 9-12 months.

Table 4.12 Scenario Generation

Scenario	**Percentage investment after improvement in profit**	**Time gap between investment and improvement in performance measures (months)**
Highly Pessimistic	0-25	9-12
Pessimistic	25-50	6-9
Optimistic	50-75	3-6
Highly Optimistic	75-100	0-3

a. Highly Pessimistic Scenario

In this scenario, the maximum time delay and minimum profit percentage are considered. In the base model, no time delay is taken into consideration. But in real environment, delays are natural and a lot many factors influence them. Delays may be caused due to human errors, people reluctant to change or taking the initiative of the company in a negative manner, strike, improper training method used lack of motivation among workers, etc. Therefore, a maximum delay of 12 months and minimum delay of 9 months is considered in this case.

Delay duration will be generated randomly for every run between the maximum and minimum duration. Also, what if the company does not invest the decided amount back even if the profit is achieved. Therefore, a minimum of zero percentage and a maximum of 25% are considered of the invested amount. The percentage investment will be generated randomly for every run. Results are compiled in table 4.13.

b. Pessimistic Scenario

In this scenario, a delay of six to nine months is considered and profit percentage of 25% to 50% is considered. Results are compiled in table 4.14.

c. Optimistic Scenario

Assuming that the investments in the areas chosen are yielding the desired results, in this scenario, a delay of three to six months is considered and profit percentage of 50% to 75% is considered. Results are compiled in table 4.15.

d. Highly Optimistic Scenario

In this scenario, a delay of zero to three months is considered and profit percentage of 75% to 100% is considered. Results are compiled in table 4.16.

Table 4.13 Highly Pessimistic Scenario Result

Performance Measure	PA3-QAP4		PA4-QAP4	
	Minimum Value	Maximum Value	Minimum Value	Maximum Value
Logistics Cost	161.44	161.54	161.38	161.48
Logistics Time	139.12	139.17	139.06	139.1
Reliability of services	64.02	64.27	64.10	64.34
Flexibility of services	58.56	58.78	58.80	59.04
Safety	55.36	55.57	55.19	55.94
LPI	50.79	50.97	50.82	51
PI	0.24	0.35	0.25	0.36

Table 4.14 Pessimistic Scenario Result

Performance Measure	PA3-QAP4		PA4-QAP4	
	Minimum Value	Maximum Value	Minimum Value	Maximum Value
Logistics Cost	161.38	161.44	161.28	161.35
Logistics Time	139.07	139.12	138.98	139.04
Reliability of services	64.27	64.51	64.34	64.59
Flexibility of services	58.78	58.99	59.04	59.27
Safety	55.57	55.77	55.38	55.58
LPI	50.97	51.10	51	51.20
PI	0.35	0.47	0.36	0.49

Table 4.15 Optimistic Scenario Result

Performance Measure	PA3-QAP4		PA4-QAP4	
	Minimum Value	Maximum Value	Minimum Value	Maximum Value
Logistics Cost	161.26	161.35	161.19	161.28
Logistics Time	139.02	139.07	138.93	138.96
Reliability of services	64.51	64.75	64.59	64.83
Flexibility of services	58.99	59.21	59.27	59.49
Safety	55.77	55.98	55.58	55.77
LPI	51.16	51.36	51.20	51.41
PI	0.47	0.62	0.49	0.64

Table 4.16 Highly Optimistic Scenario Result

Performance Measure	PA3-QAP4		PA4-QAP4	
	Minimum Value	Maximum Value	Minimum Value	Maximum Value
Logistics Cost	161.17	161.26	161.09	161.19
Logistics Time	138.98	139.02	138.87	138.93
Reliability of services	64.75	64.98	64.07	64.99
Flexibility of services	58.21	59.42	59.49	59.72
Safety	55.98	56.18	55.77	55.90
LPI	51.36	51.58	51.41	51.63
PI	0.62	0.79	0.64	0.82

Figure 4.16 depicts the improvement in profit in PA3-QAP4 under all the four scenarios. Profit improvement is slowest in highly pessimistic scenario, which will start around 69 months. It is the fastest in the highly optimistic scenario, which will start around 59 months.

Similarly, profit improvement in PA4-QAP4 is slowest in highly pessimistic scenario (figure 4.17), which will start around 67 months. It is the lowest in the highly optimistic scenario, which will start around 58 months. Circumstances differ from time to time and businesses get affected by many exogenous factors which are beyond the control of the company. So, managers need to implement the investment strategies keeping in mind the repercussions of any delay.

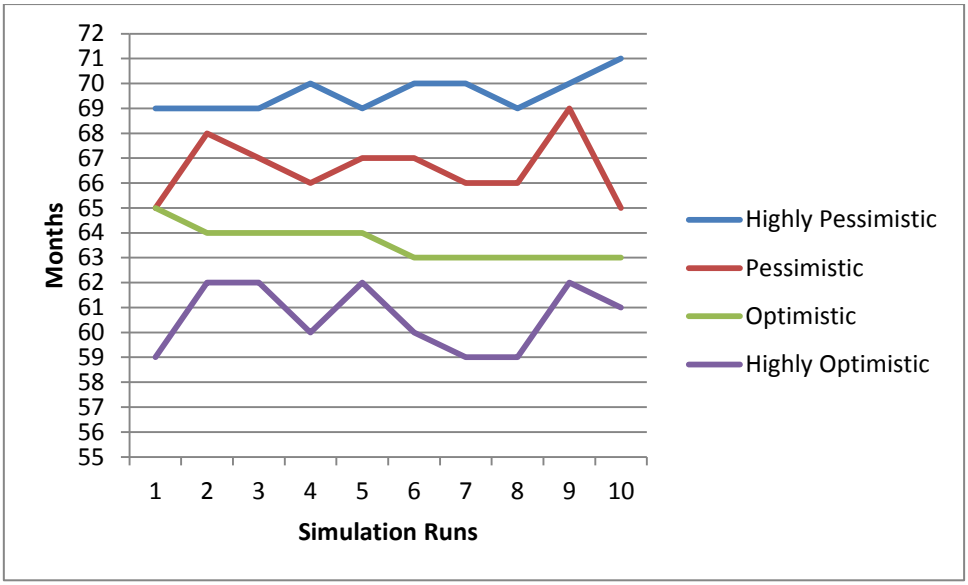


Figure 4.16 Improvement in Profit in PA3-QAP4

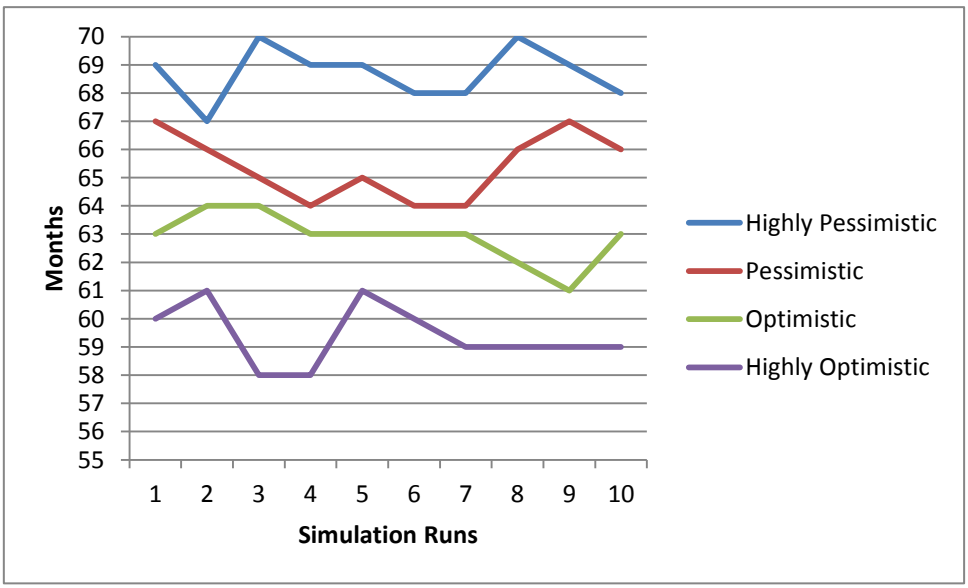


Figure 4.17 Improvement in Profit in PA4-QAP4

4.11 Conclusion

In this chapter, the improvement in logistics performance is studied by making investments in human resources, which is generally a neglected area in the corporate world in general and logistics in particular. System dynamics is used as tool to demonstrate the impact of investment in human resources on the logistics performance index. The developed model will allow companies to simulate the investment environment and to understand the impact of investment on performance measures like cost, time, reliability, flexibility and safety and also the time frame and the investment area in which the investment will reap maximum benefits.

Out of the five plans proposed, two plans which reaped maximum benefits were semi focus plan (PA3) and indirect focus plan (PA4). The plans were further simulated by doing investment quarter wise. The best quarter wise investment plan is QAP4, where 65% investment is one in initial 5 quarters and rest in remaining 7 quarters.

In semi focus plan, 30% investment was done in training, 0% investment was done in welfare, 30% investment in wage improvement and 40% investment in improving the working conditions. After following QAP4, cost reduced by 1.14%, time reduced by 0.75%, reliability improved by 8.45%, flexibility improved by 8.18% and safety by 8.17%. LPI improved by 1.34%.

In the indirect focus plan, 50% investment in done in training and 50% investment in improving the working conditions. After following QAP4, cost reduced by 1.73%, time reduced by 1.1%, reliability improved by 12.15%, flexibility improved by 11.14% and safety by 11.9%. LPI improved by 1.98%.

By comparing both the plans, it can be observed that in both the plans investment is done in training and working conditions. If the company is interested in improving only training and working conditions then it can opt for PA4 and if interested in improving the wages too, then it can opt for PA3. It can be observed that the value of LPI and other performance measures have not increased considerably by investment in improving activities related to human resources. LPI is governed by various several other factors like infrastructure, government regulations and use of information technology. Improvement in these factors also is a must to study the impact of LPI improvement at the organization and country level.

Profit improvement will start after approximately 5 years under highly optimistic scenario where time gap between investment and improvement in performance measures is only up to 3 months and percentage investment after improvement in profit is 75% to 100%.

From the simulations it can be concluded the organization should focus on investment in imparting training and improving the working conditions of the employees. Superior performance of firms depends upon work outcomes of their employees that are strongly committed to their organization. For gaining this commitment wages and welfare can be improved after the results of improvement in training and working conditions are visible.

4.12 Managerial Implications

The role of supervisors is very important for creating a learning environment in the organization. Even if it is strategically decided to invest in human resources, without managerial support it becomes very difficult for the employees to reap maximum benefits from the training programs and other employee benefit programs. Also, to take maximum utilization of a learned employee and keeping him motivated is also in the hands of the manager. Also, utilizing the full knowledge of a trained employee is also in the hands of the manager. As indicated in the study, improvement in training and working condition can improve the profit by 25% along with improvement in performance measures, therefore the managers should focus on reaping the maximum benefits so that the organizations see investment in human resources as an opportunity rather than a burden.

Also, what factors are to be considered for improving the working conditions have to be decided by the manager. The manager needs to build a right rapport with the employees so that they can give their suggestions freely and the investment amount is invested in the needed areas, so that a better working place will be provided to the employees.

After the improvement in human resources, retaining and attracting the right pool of employees becomes very necessary. At present, the recruitment and selection process is very weak in the Indian logistics sector. Therefore, following the correct recruitment process and hiring and retaining the right staff will be the ultimate answer to the above investments because it will indicate that the attractiveness of the logistics industry is improving.

Chapter 5

LOGISTICS IMPROVEMENT BY INVESTMENT IN INFORMATION TECHNOLOGY

5.1 Introduction

Information is a valuable logistics resource and IT plays a very important role to enhance logistics competitiveness. Many studies since the 1990s suggest the important role information technology plays in enhancing the effectiveness and efficiency of logistics management (Introna (1991); Schary (1991); Hammant (1995); Closs (1997); Loebbeck (1998)). Timely, accurate and well-managed information improves decision making and enhances effectiveness, efficiency and flexibility. Functional role of IT is transaction execution, collaboration and coordination and decision support (Nair et al., 2009). Bowersox et al. (2002) separated the functionality of ICT systems for logistics into four categories: strategic planning, decision analysis, management control and transaction systems. The various activities performed under the above functions and the benefits obtained through them are shown in table 5.1.

Table 5.1 Role of IT in Logistics Management

Author	Benefits
Closs et al. (1997)	Accuracy, information sharing, timeliness, availability, internal connectivity, operating timeliness, usage driven formatting and flexibility
Lai et al. (2006)	Improving delivery speed and reliability, customer relations and order accuracy, higher cost advantage
Pokharel (2005)	Higher efficiency, cost savings, reduced data entry error and increased customer service level
Auramo et al. (2005)	Customer service, efficiency, information quality, planning collaboration for improving agility
Tseng et al. (2011)	Robust, seamless and resilient supply chain, enormous economic benefits, reduction in cost and time wastage, enhancing competitive advantage
Savitskie (2007)	logistic costs, inventory turnover, order fill capacity, product and order flexibility, delivery time, flexibility, customer satisfaction

For a consistent and superior logistics performance, organizations should invest heavily in information technology and make it an integral part of the logistics process. The Indian

logistics industry spends hardly 0.3% of its revenues on ICT as compared to 2-3% in developed countries and the need of the hour is 4-5% of revenues need to be ploughed back in ICT to advance quickly and generate competitive advantage (Srivastava and Chandra, 2013). Figure 5.1 shows the overall trend of investment in information technology by the Indian logistics players in the year 2010. As shown in figure 5.1, almost 50% of the players are investing less than ten lakh rupees and only 2.58% are investing more than 1 crore rupees. Hammant (1995) suggests that the pressure to invest in information technology is high and will increase with an increase in profits and the penalties of under investment or of poorly-thought-through investment is also very high.

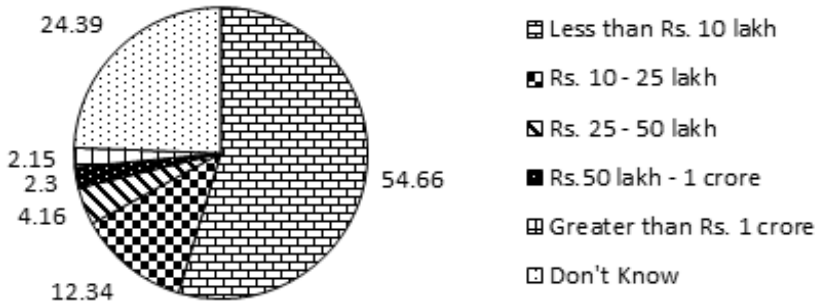


Figure 5.1 Investments in IT by Indian Logistics Players in 2009

Source: Softlink, 2009

Chapter is organized as follows. Section 5.2 identifies the technologies for investment. Section 5.3 discusses the research methodology adopted in this chapter. Section 5.4 and 5.5 discusses the causal loop diagram and the stock and flow diagram respectively. Section 5.6 validates the model used in the chapter. Section 5.7 discusses the simulation results. Sensitivity analysis and scenario generation are discussed in section 5.8 and 5.9 respectively. Section 5.10 concludes the chapter and 5.11 discuss the implications for the manager.

5.2 Identification of Technologies for Investment

One of the utmost critical factors of effective logistics service is adequate information technology systems support, which changes the nature of operations performed by logistics organizations. Table 5.2 identified various technologies being used by logistics professionals.

Table 5.2 Various Technologies Used in Logistics Management

Author	Technologies Identified
Closs (2007)	ERP; WMS; TMS; SCEM; RFID; CPFR; CRM
LQ (2007)	RFID; EDI; GPS;ERP;CPFR
Nair et al. (2009)	EDI; Material Resource Planning; ERP; WMS; TMS; IMS; RFID
Vashisht (2013)	EDI;ERP;GPS; GIS
PwC (2013)	ERP; WMS;RFID; FMS;SS
Bhandari (2014)	RFID; EDI; GPS; GIS; ERP

EDI and RFID emerged as the two technologies that were addressed most often in SCM literature accounting 32% of all the articles in which IT is the primary focus (Hazen and Byrd, 2012). Also, logistics require a high level of organizational and inter-organizational communication systems such as RFID, EDI and ERP at various levels of the logistics chain for better coordination, planning and decision optimization. Coordination is the management of dependencies between activities and use of IT enhances it by reducing uncertainty in the

Table 5.3 Technologies Identified

Technology	Observations
RFID	**Concept**
	1. It is a term used for technologies utilizing radio waves for identifying individual items automatically and is designed to track items in the supply chain without requiring a line of sight (Mehrjerdi, 2010). 2. It is a technology that enables radio frequencies to send and receive data and from one or many RFID tags and an enabler system including antennas (Stefansson and Lumsden, 2009).
	Purpose
	1. It is an automatic identification method to keep track and trace of moving objects within the logistics network (Lee et al., 2011) 2. It is used in the logistical planning and operation of supply chain processes in the manufacturing, distribution and retail industries, and has helped move its adoption into services such as security and access control, tracking, monitoring, and management (Cheung et al., 2008). 3. RFID has the potential to increase the level of visibility and communication, which can be used in decision making to eliminate non-value-adding activities, strengthening the competitiveness of the supply chain (Kumar et al., 2015). 4. It helps in transport network design by helping in making decisions on transportation modes, location, routes for shipping, type of mode to be used etc. (Jones and Chung, 2007).

	Benefits
	1. Walmart believes RFID system can help in reducing labour costs, reduce inventory costs, reduce human errors, increasing revenues by limiting shortages, increasing overall efficiency and productivity of the supply chain (Mehrjerdi, 2013). 2. It is a data acquisition and storage method, which promises numerous supply chain benefits such as improved speed, accuracy, efficiency and security of information sharing (Kumar et al., 2015).
	Application/Empirical Evidence
	1. P&G Company expects to cut its costs by $400 million a year by using RFID (Bhandari, 2014).
EDI	**Concept**
	1. EDI is defined as computer to computer exchange of structured data for automatic processing (Nair et. al., 2009). 2. It is the electronic transfer of structured data by agreed message standards from one computer application, with a minimum of human intervention, connecting all parties in a supply chain (Adebambo and Toyin, 2011).
	Purpose
	1. It enhances efficient coordination of logistics systems and facilitates logistical integration (Larson and Kulchitsky, 1998).
	Benefits
	The main advantages of using EDI are to enter only informative needs on the computer system once, and then it is able to speed of transaction and to reduce cost and error rates, better customer service, reduced paper work, increased productivity, improved tracing and expediting, cost efficiency and improved billing (Nair et. al., 2009).
	Application/Empirical Evidence
	1. Singapore has been noted as a leader in Paperless Trading, with its Trade Net System, a nationwide EDI System focused on the submission of regulatory documents (Toh et al., 2009).
GPS/GIS	**Concept**
	1. GIS is the software tool for visualization of spatial location of any entity on earth, in terms of physical maps of the surface of the earth, layout of the inner surface of the earth or a layout of streets or roads, which is stored in databases (Bhandari, 2014). 2. GPS provides the service of vehicles positioning. It could help the control centres to monitor and dispatch trucks. GIS provides the basic geographic database for the deliverers to enable to organise their routes easier and faster (Tseng et al., 2011).
	Purpose
	1. GIS in integration with GPS is used in logistical operation for tracking and tracing of the consignment location to the extent of road or street in a particular city (Bhandari, 2014). 2. GPS technology has provided major breakthroughs in transportation management by vehicle tracking, determination of speed and waiting time (Prasanna and Hemalatha, 2012).

	Benefits
	1. It increases service quality, relevance of information, traceability of products and also improves productivity (Saidi and Hammami, 2011). 2. The benefits of integrating GPS and GIS with advanced information systems are better service quality, reduced unnecessary trips, and increased loading rate (Tseng et al., 2011).
	Application/Empirical Evidence
	1. A decision support system using GPS and GIS reduced the ELR, which measures the efficiency and wastage of a route, by 20% in China (Hu and Sheng, 2014). 2. Use of IT in vehicles leads to fuel savings of 5%, reduction in accident damage by 50%, security, better maintenance and utilization of vehicle (Hammant, 1995).
ERP	**Concept**
	1. ERP systems have been touted to streamline organizational functions and processes by integrating enterprise-wide data and business processes **(**Katerattanakul et al., 2014**).** 2. ERP systems are software packages that integrate a number of business processes, such as manufacturing, supply chain, sales, finance, human resources, budgeting and customer service activities (Schniederjans and Yadav, 2013).
	Purpose
	1. ERP is generally referred to as a cutting edge information technology that helps the firm coordinate and integrate company-wide business processes, including sales, marketing, manufacturing, logistics, purchasing, accounting, and human resources management using a common database and shared management reporting tools **(**Hwang and Min, 2013**).** 2. If successfully implemented, ERP can create value in a number of different ways of integrating the firm's multifarious business activities into a single system, facilitating organizational standardization, increasing access to online and real time information, improving intra- and inter-organizational communication and collaboration, and enhancing decision-making capabilities **(**Hwang and Min, 2013**).**
	Benefits
	1. The most significant benefits are cycle time reduction, faster information transactions, better financial management, laying the groundwork for electronic commerce, making tacit process knowledge explicit (transferring knowledge from an aging workforce into the enterprise system) (Adebambo and Toyin, 2011). 2. ERP systems are transaction based enterprise-wide information systems used for automating and integrating all activities and functions of a business **(**Hwang and Min, 2013**).**
	Application/Empirical Evidence
	1. Companies such as Honeywell, Caterpillar, Procter and Gamble, GlaxoSmithKline, and others have made decisions to implement ERP systems across their end-to-end supply chains, from customer order management to supplier collaboration **(**Hwang and Min, 2013**).** 2. Hunton et al., (2003) conducted a longitudinal study of ERP system

	deployment effects on financial performance based on a sample of 63 companies. Results suggest that return on assets, ROI, and asset turnover of ERP adopters were significantly better than non-adopters. 3. The companies like Hindustan Lever, Colgate and Nestle have implemented ERP in their supply chain system, resulting in minimum inventory of raw material and finished goods and benefit in terms of cost reduction (Bhandari, 2014).

supply chain, enhancing decision making and communication (Lewis and Talalayevsky, 2004). For automatic tracking of vehicles, freight, containers, etc., including location, speed and time can be measured with the help of GPS. Tracking and tracing concerns a process of determining the current and past locations (and other information) of a unique item or property. This information can be appropriately used by GIS for corrective actions. Although, there are innumerable technologies being used, the authors have considered the above mentioned five technologies to be studied further in this study. Table 5.3 explains the concept, purpose, benefits and application/empirical evidence of the five technologies identified in this chapter.

The five technologies shortlisted for the study will impact logistics processes like tracking and tracing, planning and forecasting, transportation and automation, coordination with suppliers and customers and decision optimization. These processes in turn will help to reduce the cost, reduce the delivery time, improve the reliability of logistics services, and improve the flexibility of logistics services and safety which will affect the logistics performance index.

5.3 Research Methodology

The research methodology adopted in this chapter is as follows:

5.3.1 Chapter Aims

The aims of this chapter are

1. To identify the technologies, which will maximize logistics performance?
2. To develop a dynamic model using system dynamics modelling for the investments in IT
3. To evaluate the various investment plans and scenarios for the decision maker to formulate the investment strategy which best meets the requirements of the business.

4. To quantify the relationship between performances measures like logistics cost, delivery time, reliability, flexibility and safety and logistics performance.
5. To study the effect of improvement in logistics performance, if any, on the profit of the firm.

5.3.2 Model Assumptions

The following assumptions are made for carrying out the simulations

a. The activities are not interrelated to each other i.e. improvement in RFID does not affect EDI etc.
b. The effect of improvement in logistics processes is instantaneous and there is no time lag between investment and improvement.
c. After 12 quarters, if the profit increases by 3%, then the company will invest 1% of the investment amount every quarter.The existing profit percentage of the company is 10%. With every percentage improvement in LPI, profit will improve by 0.005.

5.3.3 Investment Plans

The investment plans need to be developed with respect to two aspects:

1. Proportion of investment in different technologies (table 5.4).
2. Time phasing of the investment (table 5.5).

More than fifteen combinations of different investment plans and quarter wise allocation of funds were proposed and simulated. The plans with maximum improvement were considered for further simulation.

Table 5.4 Investment Plans for Different Activities

Investment Plans		Investment in Activity (%)			
Code	**Description**	**RFID**	**EDI**	**GPS**	**ERP**
PA1	**Equal Focus Plan**	25	25	25	25
PA2	**Customized Plan I**	30	15	15	40
PA3	**Customized Plan II**	15	30	15	40
PA4	**External Focus Plan**	0	50	0	50
PA5	**TT Focus Plan**	25	0	25	50

In the equal focus plan (PA1), as shown in table 5.4, 25% of total budgets are earmarked for RFID, 25% of EDI, 25% for GPS and 25% for ERP. Technologies like RFID and GPS directly impacts the automation of the transportation network like vehicle routing, fleet

management, location of the product identification, etc. On the other hand, ERP and EDI will help more in improving in planning and forecasting, coordination and decision optimization. PA2 and PA3 are customized plans where investment combinations are done to test the effect of improvement in different technologies.

In the external focus plan (PA4), 50% investment is done EDI and ERP each to focus on better coordination between suppliers and customers which will lead to better planning and decision making. For better tracking and tracing, 25% investment in RFID, 25% investment in GPS and 50% investment in ERP is done in TT focus plan (PA5).

To achieve the maximum benefits, the investment in an area is further broken quarter wise. Since the present plan is for 3 years, the investment is divided into 12 quarterly periods.

Table 5.5 QAP as Percentage of Activity

QAP	Quarter wise Allocation of Funds (%)												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total**
QAP1	10	10	10	10	10	10	10	10	5	5	5	5	100
QAP2	5	5	5	5	5	5	5	5	10	10	20	20	100
QAP3	25	0	0	25	0	0	25	0	0	25	0	0	100
QAP4	15	15	15	10	10	5	5	5	5	5	5	5	100

Based on it, five plans are prepared and analysed as given in table 5.5. In QAP1, 10% of the investment is done in first eight quarters and it was reduced to half in the last four quarters. Exactly opposite to this, in QAP2, 5% investment was done in first eight quarters and it was doubled in the last four quarters. In QAP3, 25% of the investment amount was invested every third quarter. More than 50% of the investment was done in QAP4, in the initial five quarters and 5% of the investment was made in every quarter afterwards.

5.3.4 Research Framework

As shown in figure 5.2, investment in the five technologies will lead to improvement in logistics processes like tracking and tracing, planning and forecasting, transportation automation, coordination with suppliers and customers and decision optimization. This will lead to improvement in the performance measures like reduction in cost, reduction in delivery time, improvement in reliability, improvement in flexibility and improvement in safety. This

will improve the logistics performance leading to improvement in profit. Improved profit will lead to more investment.

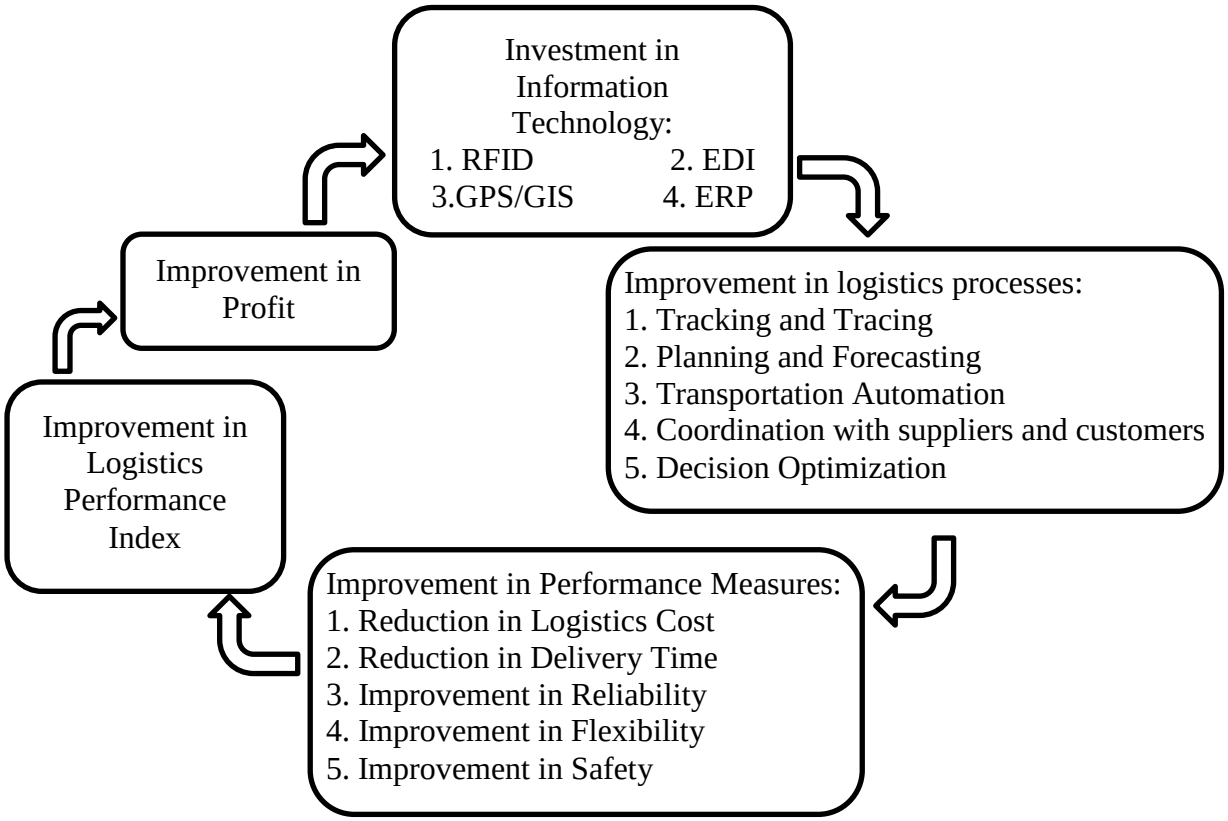


Figure 5.2 Research Framework

5.4 Causal Loop Diagram

5.4.1 RFID

RFID was classified as one of the ten major innovation technologies in 2004 by CNN and one of the ten major IT technologies in 2005 by ZDNet (Lin, 2009). It possesses multiple advantages such as high storage capacity, remote and repeated reading, writing better data security and ability to read numerous tags simultaneously (Lin, 2009). It will help in tracking and tracing of pallets and shipments (Cheung et al., 2008); reduce amount of potential error and diminishes losses (Ginters and Martin-Gutierrez, 2013); enhances speed and accuracy (Bhandari, 2014); improvement in responsiveness, lean and agile logistics workflow (Lee et al., 2011); helps in order fulfilment and efficient WMS (Garcia et al., 2006) leading to reduction in cost, reduction in time and improvement in safety (Mehrjerdi, 2010). Error in warehouse can create several million in damages, even if component costs a few euros

(Ginters and Martin-Gutierrez, 2013). Although RFID implementations incur additional costs, it can make the supply chain continuously visible, thus reducing the production lead times to zero or almost negligible (Bhadrachalam et al., 2011). Therefore in figure 5.3, the loop between investment in IT by LSP, RFID, tracking and tracing, logistics cost/logistics time, LPI and profit are balancing loops and the loop between investment in IT by LSP, RFID, tracking and tracing, safety/reliability/flexibility, LPI and profit are reinforcing loop.

By integrating RFID with ERP, efficient fleet management system can be created (PwC, 2013) leading to transportation automation. It is a key factor in good customer service affecting delivery, punctuality, timeliness accuracy and tracking (Ngai et al., 2008b). As synonyms to the word "reliability" is dependability, accuracy, constancy, fidelity and security, transportation automation improves reliability of the system. Thus, the loop between investment in IT by LSP, RFID and ERP, transportation automation, logistics time, LPI and profit is a balancing loop and the loop between investment in IT by LSP, RFID and ERP, transportation automation, reliability, LPI and profit is a reinforcing loop.

5.4.2 EDI

EDI can be defined as the computer to computer exchange of business information electronically in a structured format between business trading partners (Murphy and Daley, 1998). It helps companies to exchange commercial documents without human intervention (Ngai et al., 2008a). It enhances efficient coordination (Larson and Kulchitsky, 1998), which enhances decision making and communication facilitating better planning and forecasting leading to reduction in cost (Lewis and Talalayevsky, 2004), reduction in error, improvement in transaction, speed, better customer service and achieving cost efficiency (Nair et al., 2009); improvement in accuracy (Mulligan, 1996) and flexibility (Hazen and Byrd, 2012). Therefore in figure 5.3, the loop between investments in IT, EDI, coordination with suppliers and customers/decision optimization, logistics cost/logistics time, LPI and profit are balancing loops. Also, the loop between investment in IT, EDI, coordination with suppliers and customers/decision optimization, reliability/flexibility/safety, LPI and profit is reinforcing loop.

5.4.3 GPS/GIS

The next important technology to be adopted by organization is GPS and GIS. It helps in supporting route scheduling and visualization (Hu and Sheng, 2014) leading to transportation

automation and tracking and tracing. GPS tracking and IT enabling of vehicles no doubt will help in tracking, but tracking the welfare of human being who do this arduous work is undoubted more critical (Sethi, 2013). GPS and GIS combined with RFID will provide safety and better utilization of fleet. Also, it will reduce the ELR, which measures efficiency and wastage of a route. Use of IT in vehicles leads to fuel savings of 5%, reduction in accident damage by 50%, security, better maintenance and utilization of vehicle (Hammant, 1995). Therefore, huge cost and time savings, reduction in uncertainty and improvement in reliability, safety and flexibility cab be achieved through GPS and GIS.

Therefore in figure 5.3, the loop between investment in IT, GPS/GIS, tracking and tracing/ transportation automation, logistics cost/logistics time, LPI and profit are balancing loops. Also, the loop between investment in IT, GPS/GIS, tracking and tracing/transportation automation, reliability/flexibility/safety, LPI and profit are reinforcing loops.

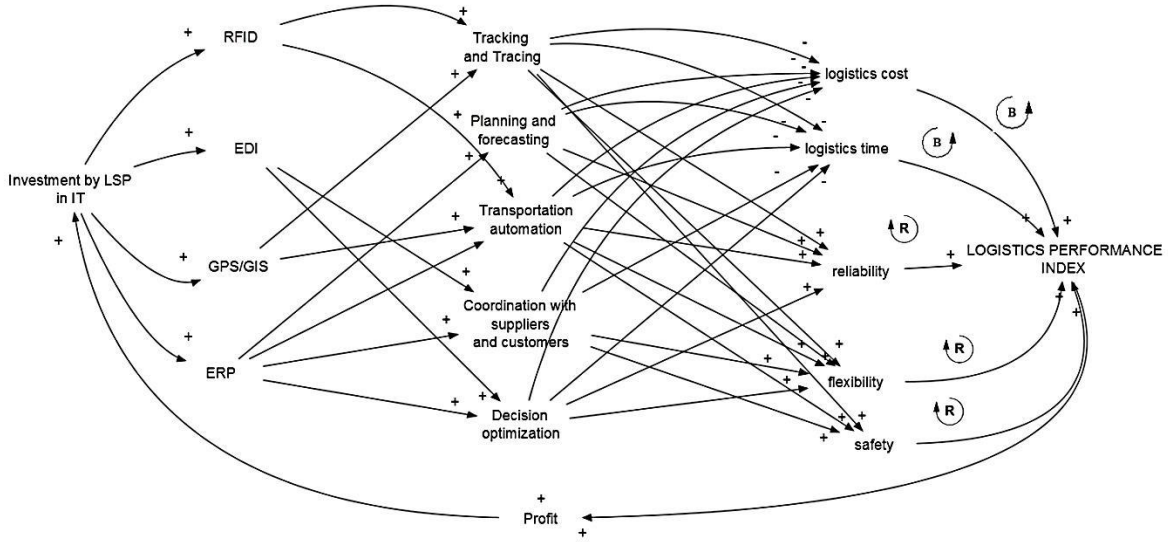


Figure 5.3 Causal Loop Diagram for Investment in IT and its Effect on LPI

5.4.4 ERP

ERP is business management software which integrates core business processes of an organization and facilitates information flow between all business functions and manages connections to outside stakeholders. It collects, store, manage and interpret data from many business activities like product planning, cost and development, manufacturing or service delivery, marketing and sales, inventory management and shipping and payment. ERP integrates all the business processes in order to improve efficiency of the organisation and enhanced supply chain performance (Koh et al., 2014). It improves operational decision

making (Reddy, 2012), coordination, better planning and forecasting (Razi and Tarn, 2003) leading to reduction in cost (Burca et al., 2005), reduction in cycle time (Yang and Su, 2009), reduction in uncertainty (Lewis and Talalayevsky, 2004) leading to improvement in reliability and improvement in responsiveness (Closs and Savitskie, 2003) leading to improvement in flexibility (Daughtery and Pittman, 1995). Also, other systems like WMS, TMS, IMS, FMS and SS can be combined together with ERP to get a customized solution leading to accuracy, consistency, economies of scale and efficiency (LQ, 2007). Therefore in figure 5.3, the loop between investment in IT, ERP, planning and forecasting/coordination with suppliers and customers/decision optimization, logistics cost/logistics time, LPI and profit are balancing loops. Also, the loop between investment in IT, ERP, planning and forecasting/coordination with suppliers and customers/decision optimization, reliability/ flexibility, LPI and profit are reinforcing loops.

As shown in figure 5.3, investment in RFID, GPS/GIS, EDI and ERP will lead to reduction in cost and time and improvement in reliability, flexibility and safety leading to improvement in LPI. LPI will improve the profit, as high logistics performance is associated with reliable operation, high asset productivity (Essays, 2013) and high profitability (Coyle et al., 2008) leading to more investments in IT.

5.5 Stock and Flow Diagram

The stock and flow diagram shown in figure 5.4, has been developed using STELLA 9.1.3 software. After developing the stock and flow diagram, the model has been simulated for 12 quarters, taking the value of DT as 1.

5.5.1 Data Required for Simulation

Once the amount is earmarked and technologies and performance measures are identified, the company needs to have an implementation plan which will provide the quarter wise investment in each of the improvement area for the next 3 years. The following set of information was required for simulating the system:

1. The present level and the target level of the logistics processes in the case organization (table 5.6).
2. The present level and the target level of the performance measures in the case organization (table 3.3).
3. The improvement in the logistics processes with every one lakh investment (table 5.7)

4. The improvement in the performance measures with percent improvement in the logistics processes (table 5.8).
5. The improvement in LPI with one percent improvement in the performance measure (table 3.4).
6. The weightage of each performance measure on the LPI (table 3.4)

To collect the above information, discussion was held with the executives of the company and the following information was collected for use in the study.

5.5.2 Existing and Target Values of Logistics Processes

The existing level of the logistics processes in given in table 5.6. The target is taken as cent percent. Although, at present, IT is not used in the company at a very large extent, the above logistics processes are carried out with the help of mobile phones, internet, etc. as most of the Indian organizations from the unorganized sector works in this manner.

Table 5.6 Existing and Target Levels of Processes Achieved from IT Adoption

Processes	Existing (%)	Target (%)
Tracking and tracing	30	100
Planning and forecasting	60	100
Transportation automation	25	100
Coordination with suppliers and customers	55	100
Decision optimization	55	100

5.5.3 Improvement in Processes for Every One Lakh Investment

The improvement in processes is measured through per lakh investment in the technology. For example, as shown in table 5.7, per lakh investment in RFID and GPS/GIS will improve tracking and tracing by (.006+.006) = 0.012. Therefore, tracking and tracing will become 30.012 with every one lakh investment. Similarly, planning and forecasting will become 60.016, transportation automation will become 25.016, coordination with suppliers and customers will become 55.016 and decision optimization will become 55.014 with every one lakh investment respectively.

5.5.4 Improvement in Performance Measures

With every one percent improvement in logistics processes, the percentage improvement in performance measures is given in table 5.8. For example, with percent improvement in

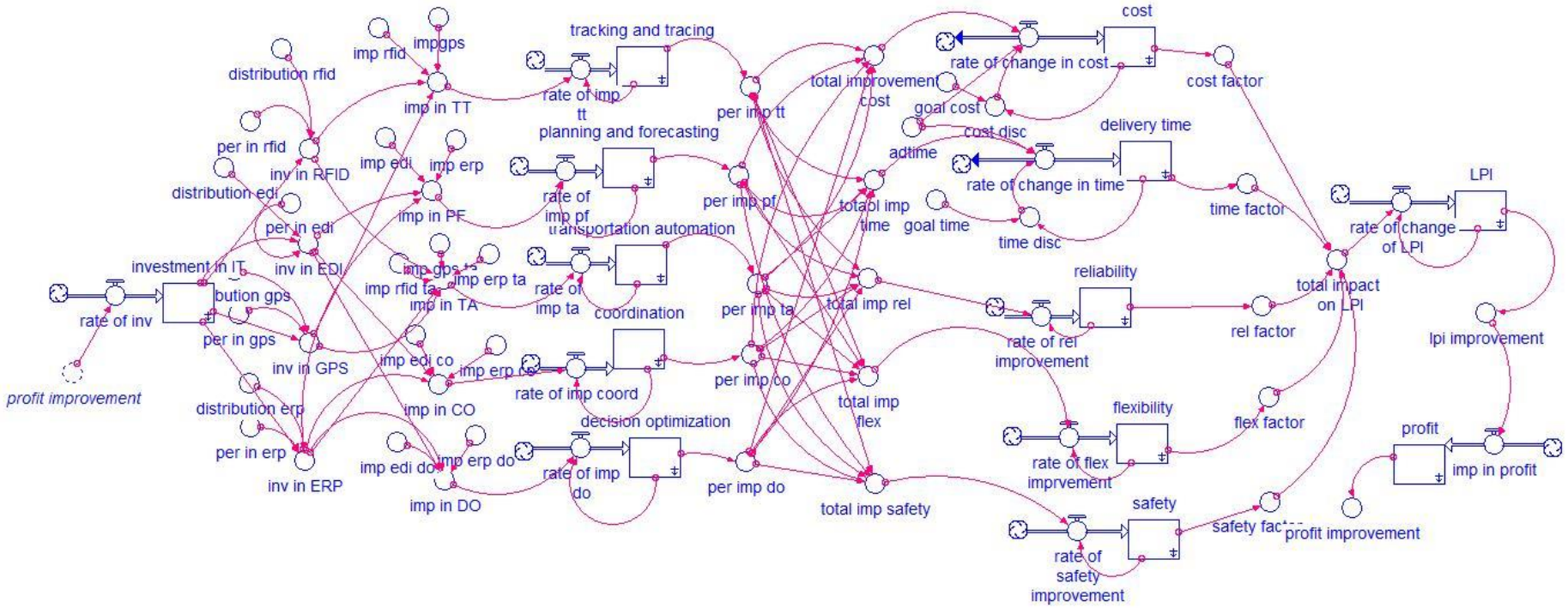


Figure 5.4 Stock and Flow Diagram for Investment in Information Technology

processes, the logistics cost will be reduced by (.005+.009+.007+.006+.0065) = 0.0335. Therefore, the logistics cost will be 162.9665 with every percent improvement in logistics processes. Similarly, delivery time will be 139.962, improvement in reliability will be 60.038, improvement in flexibility will be 55.0375 and improvement in safety will be 52.035.

Table 5.7 Percentage Improvement in Processes by Investing (Rs in Lakh) in Technologies

Technology	Percentage change in benefits by per lakh investment in technology				
	TT	PF	TA	CO	DO
RFID	.006	-	.004	-	-
EDI	-	.007	-	.009	.008
GPS/GIS	.006	-	.007	-	-
ERP	-	.009	.005	.007	.006

Table 5.8 Percentage Change in Performance Measure by Percentage Improvement in Processes

Processes	Improvement in Performance measure (in %) by improvement (in %) in Processes				
	Reduction in Cost	Reduction in Time	Improvement in Reliability	Improvement in Flexibility	Improvement in Safety
TT	.005	.007	.009	.0095	.008
PF	.009	.0095	.009	.008	.006
TA	.007	.008	.008	.007	.009
CO	.006	.0075	.007	.006	.007
DO	.0065	.006	.005	.007	.005

The total improvement in performance measures is calculated using table 5.8. The value obtained is used in equation 3.4 as a percentage improvement in performance measure (k). The rate of improvement in performance measures is given by equation 3.4.

5.6 Model Validation

The validation results are shown in table 5.9. The ultimate aim of a system dynamics models is to test different management policies, it is necessary to generate confidence in the model so that it can be used for policy recommendations. Khanna et al. (2008) accepted the model at a

percent deviation of 10%. Since maximum variation has been observed to be around 6 percent, the SD model fairly replicates the dynamic behaviour and thus validates the interrelationships.

Table 5.9 Validation Results

Performance Measures	Percentage Change based on calculations	Results based on SD model	Percent deviation from system dynamics prediction
Logistics Cost	162.9	162.42	-0.29
Delivery Time	138.9	139.59	-0.49
Reliability of Services	61.3	64.64	5.16
Flexibility of Services	56.7	60.09	5.64
Safety	53.5	57.16	6.4

5.6 Results and Discussion

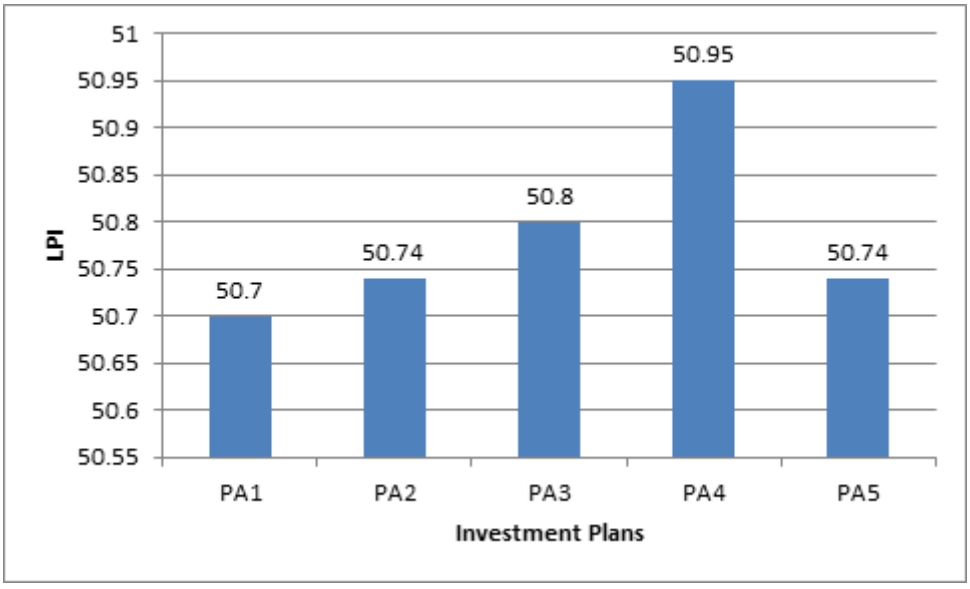


Figure 5.5 Results for LPI for Alternative Investment Plans in Activities

The LPI results are shown in figure 5.5. LPI reached the highest value in the external focus plan (PA4), with a value of 50.95. The second highest value of 50.8 was for customized plan II (PA3), followed by PA2, PA5 and PA1. Further simulations will be carried out with base as PA3 and PA4. In phase 2, the quarter-wise allocation of funds as a percentage of total investment in the activity is shown in table 5.5

5.7.1 Quarter Wise Allocation with Base as Semi Focus Plan (PA3)

Simulations runs were carried out by taking base PA3 as selected above and quarter wise investment as the percentage of total investment from table 5.5.

The results for quarter wise investment for PA3 is shown in figure 5.6. LPI reached highest with a value of 51.58 in QAP4, where 10% to 15% investment is done more in initial quarters and 5% investment is done 6th quarter onwards. The second highest value of LPI is 50.96 through QAP1, in which 10% investment is done in initial quarters and 5% investment is done in last four quarters.

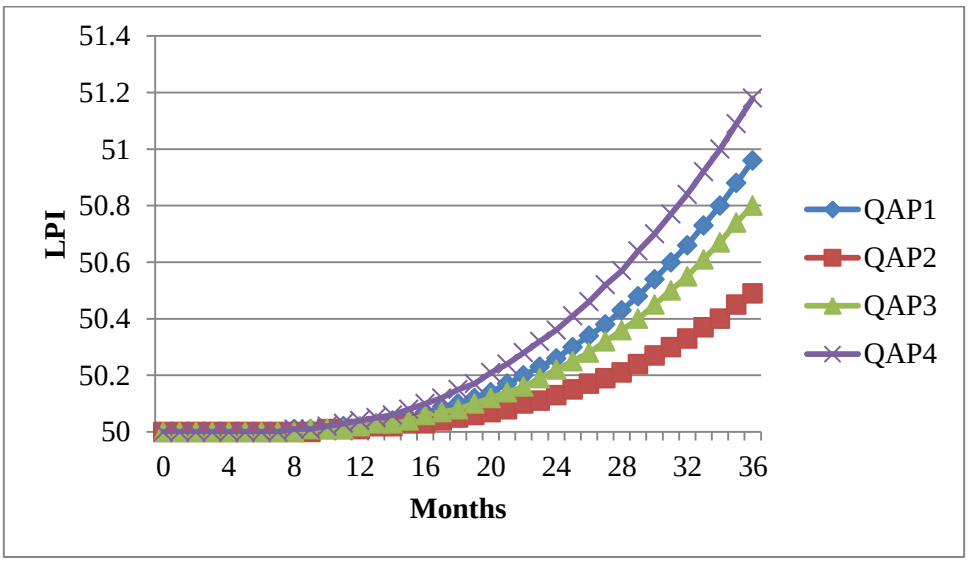


Figure 5.6 Results for LPI for Quarter Wise Investment in PA3

Table 5.10 Results for Performance Measures with Quarter Wise Investment in PA3

QAP	Logistics Cost	Delivery Time	Reliability of services	Flexibility of services	Safety	LPI
QAP1	162.19	139.43	66.05	61.63	58.60	50.96
QAP2	162.54	139.67	63.59	58.93	55.91	50.49
QAP3	162.30	139.51	65.30	60.80	57.58	50.80
QAP4	162.10	139.37	66.71	62.36	59.33	51.18

After evaluating, the results for QAP1 to QAP4 with base as PA3, the result of performance measures is shown in table 5.10. As seen from table 5.10, the lowest value for logistics cost and delivery time and highest value for reliability of services, value for flexibility of services, safety and LPI is highest for QAP4. The best plan with base as PA3 is to follow QAP4 where

LPI reaches the value of 51.18. Logistics cost decreased by 0.55%, delivery time decreased by 0.45%, reliability of services increased by 11.18%, flexibility of services improved by 13.38% and safety improved by 14.09%. LPI improved by 2.36% through 15% investment each is done with RFID and GPS, 30% investment in EDI and 40% investment in ERP.

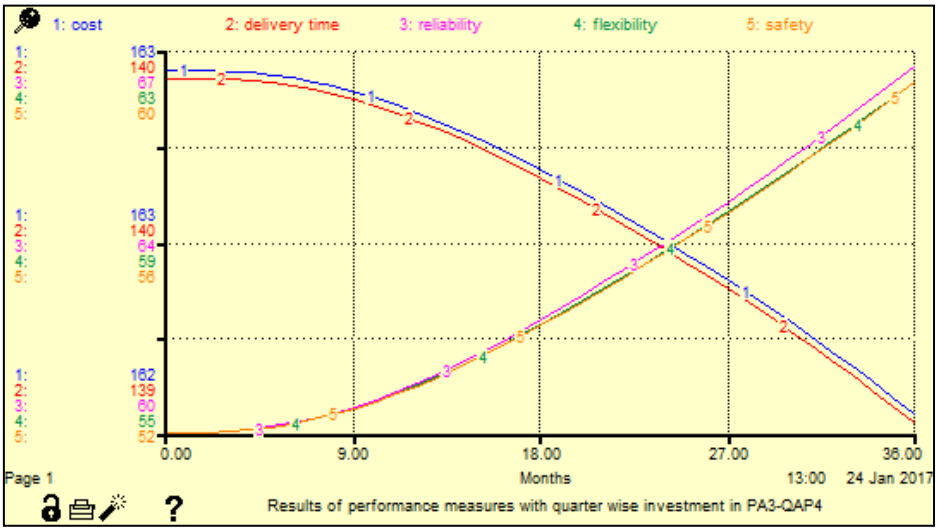


Figure 5.7 Results for Performance Measure for Quarter Wise Investment in PA3-QAP4

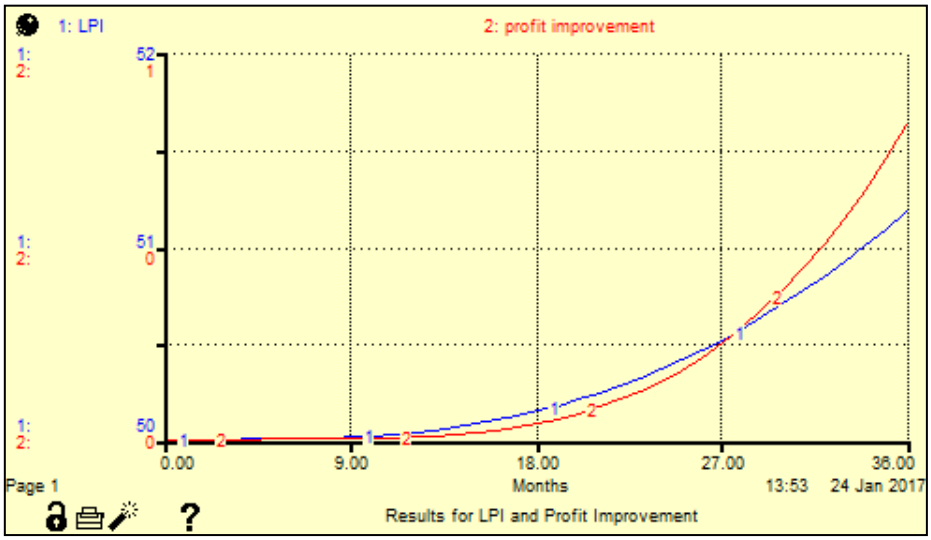


Figure 5.8 Results for LPI and Profit Improvement for Quarter Wise Investment in PA3-QAP4

Figure 5.7 and figure 5.8 are software generated graphs. Figure 5.7 indicates that improvement in performance measures is steady. It can be seen that flexibility and safety are improving at the same rate. Also, for initial 12 months reliability is also improving at the same rate with flexibility and safety but after that improvement in reliability is slightly faster than flexibility and safety. Figure 5.8 depicts the improvement in LPI and profit.

5.7.2 Quarter Wise Investment in Indirect Focus Plan (PA4)

Now, using the base as PA4, quarter wise distribution was done as shown in table 5.5. The results for quarter wise investment in external focus plan (PA4) is shown in figure 5.9. LPI reached highest with a value of 51.40 in QAP4. The second highest value of LPI is 51.13 through QAP1.

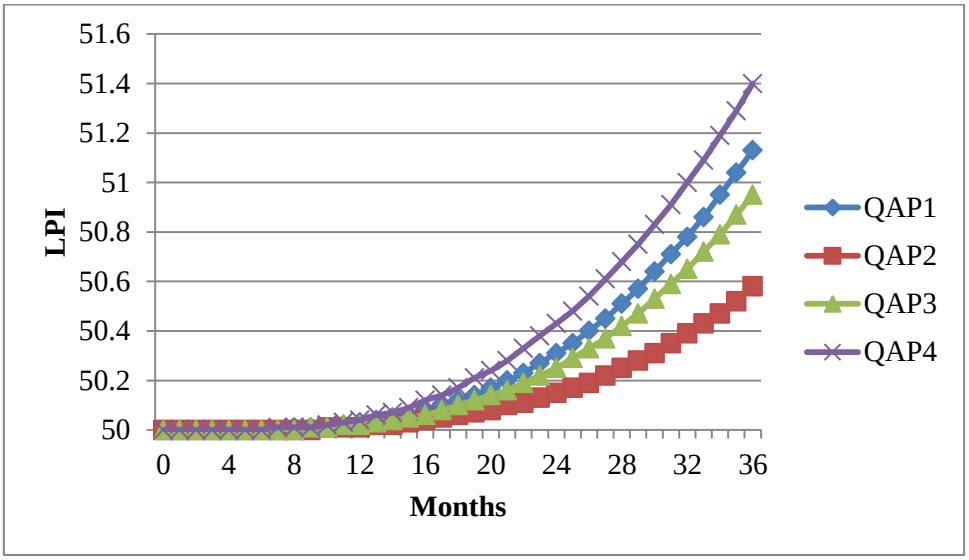


Figure 5.9 Results for LPI for Quarter Wise Investment in PA4

Table 5.11 Results for Performance Measures with Quarter Wise Investment in PA4

QAP	Logistics Cost	Delivery Time	Reliability of services	Flexibility of services	Safety	LPI
QAP1	161.98	139.30	67.15	62.86	59.63	51.13
QAP2	162.42	139.60	64.22	59.64	56.49	50.58
QAP3	162.12	139.39	66.25	61.87	58.67	50.95
QAP4	161.85	139.21	67.93	63.72	60.47	51.40

After evaluating, the results for QAP1 to QAP5 with base as PA4, the result of performance measures is shown in table 5.11. As seen from table 5.11, the lowest value for logistics cost and delivery time and highest value for reliability of services, value for flexibility of services, safety and LPI is highest for QAP4. The best plan with base as PA4 is to follow QAP4 where LPI reaches the value of 51.40. Logistics cost decreased by 0.7%, delivery time decreased by 0.56%, reliability of services increased by 13.21%, flexibility of services improved by 15.85% and safety improved by 16.28%. LPI improved by 2.8% through 50% investment in EDI and 50% investment in ERP respectively.

Figure 5.10 and figure 5.11 are software generated graphs. Figure 5.10 indicates that improvement in performance measures is steady. Also, for initial 12 months reliability is improving at the same rate with flexibility and safety but after that improvement in reliability is slightly faster than flexibility and safety. Unlike figure 5.7, flexibility is improving at a faster rate than safety. Also, improvement in LPI and profit is better than figure 5.8, indicating that PA4 is a better plan than PA3.

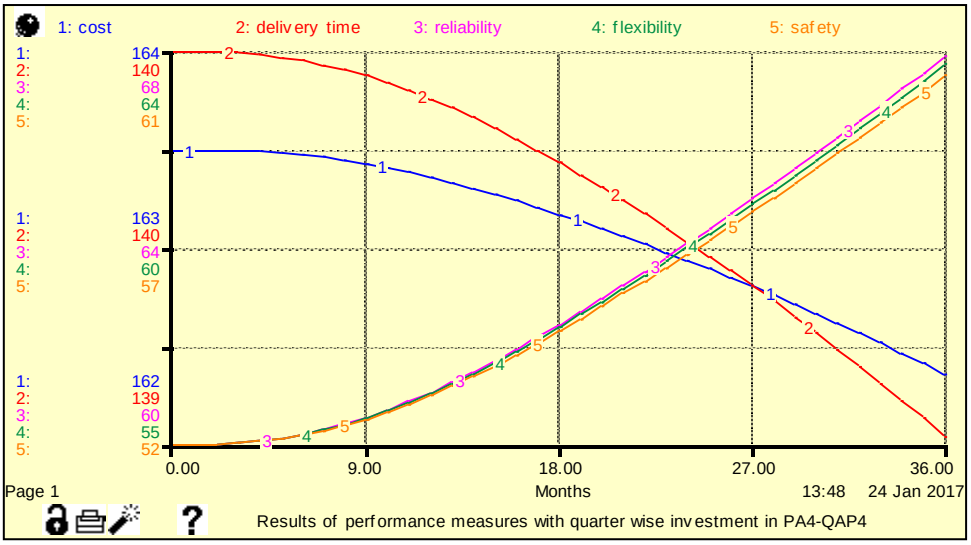


Figure 5.10 Results for Performance Measure for Quarter Wise Investment in PA4-QAP4

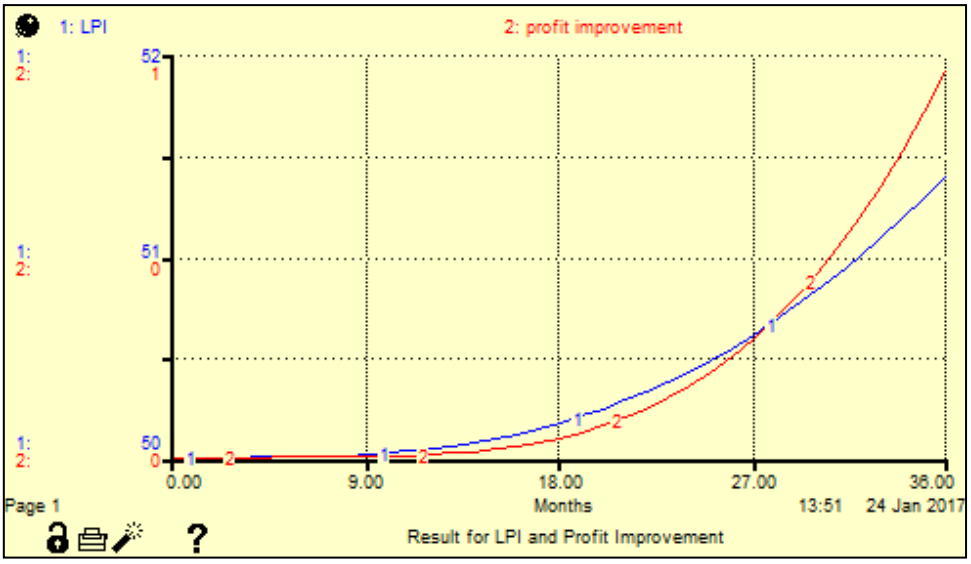


Figure 5.11 Results of LPI and Profit Improvement with Quarter Wise Investment in PA4-QAP4

5.7.3 Year Wise Improvement in Performance Measures in PA4-QAP4

To understand the exact amount of investment and time required by the company to achieve significant results, PA4-QAP4 was further simulated by increasing the investment amount by 10%, when profit improvement will be more than 3% as it was decided by the company initially. The results are shown in table 5.12.

From figure 5.12, it can be observed that improvement in reliability is the slowest but after 25 months, its starts improving and exceeds improvement in flexibility and safety. Improvement in flexibility and safety is steady, but improvement in flexibility is more than improvement in safety. Reduction is cost and reduction in time is almost simultaneous. From figure 5.13, profit improvement reaches 3% between 58 months to 60 months, indicating that 10% of the initial amount invested must have started getting added to the investment amount.

Table 5.12 Year Wise Improvement in Performance Measures

Months	Logistics Cost	Delivery Time	Reliability of services	Flexibility of services	Safety	LPI	PI
36	161.85	139.21	67.93	63.72	60.47	51.40	0.48
48	161.12	138.71	72.24	68.48	65.17	53.10	1.49
60	160.22	138.10	76.77	73.50	70.21	55.69	3.51

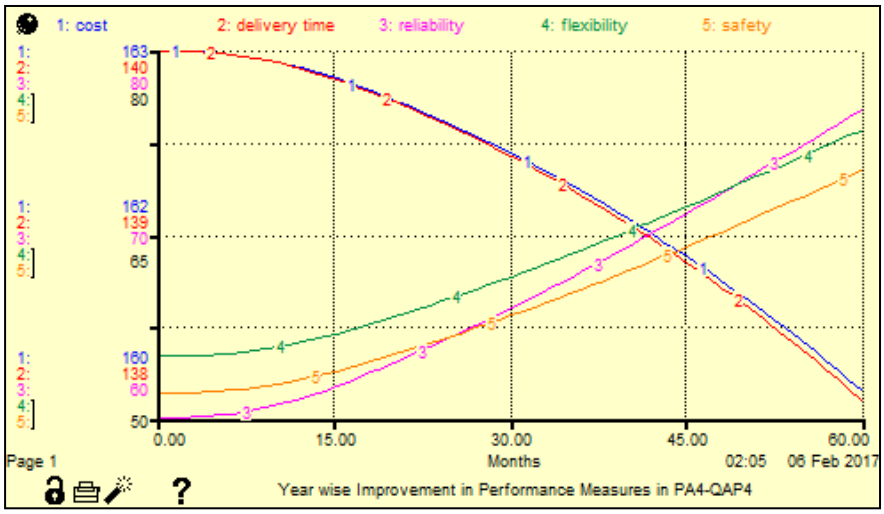


Figure 5.12 Results for Performance Measures for Year Wise Investment in PA4-QAP4

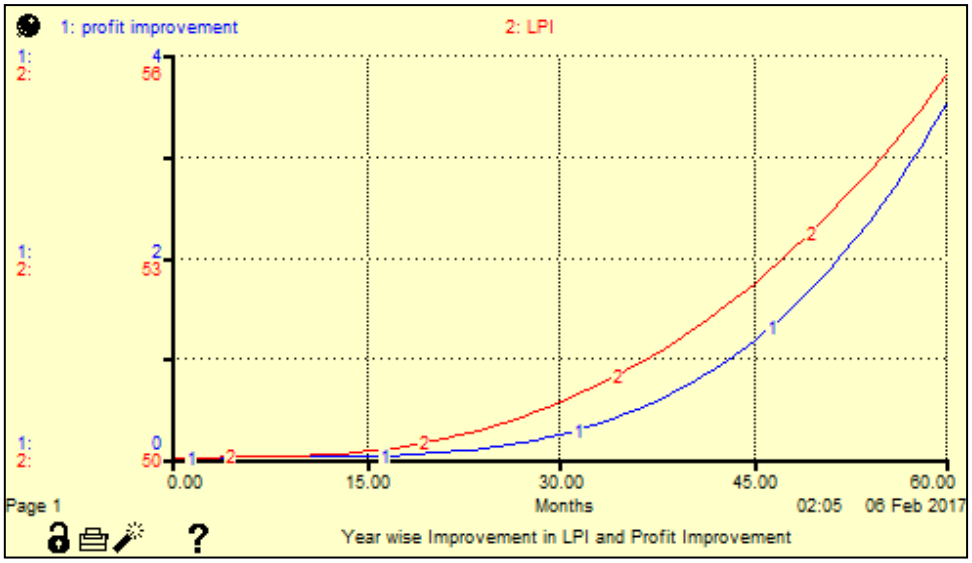


Figure 5.13 Results for LPI and Profit Improvement for Year Wise Investment in PA4-QAP4

5.8 Sensitivity Analysis

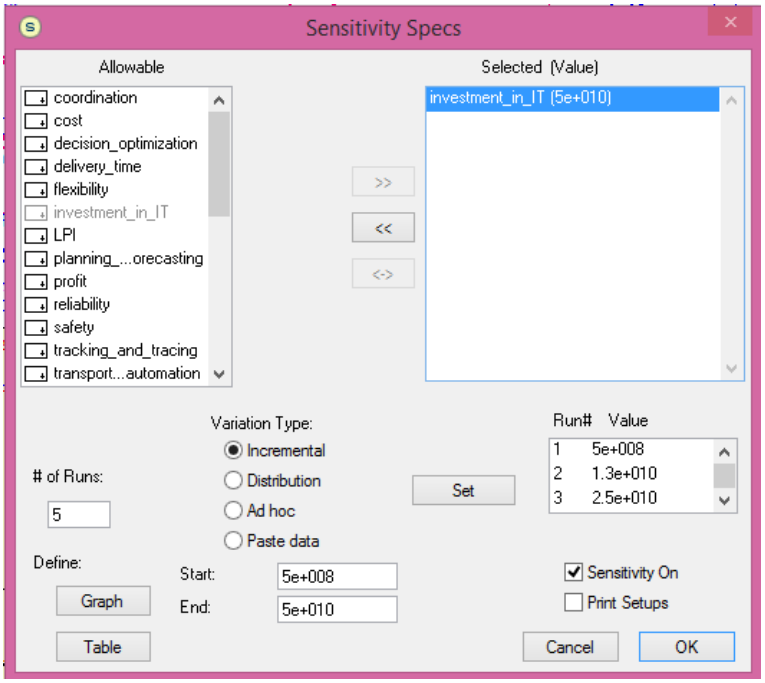


Figure 5.14 Input Window for Sensitivity Analysis in Stella Software

Sensitivity analysis is carried out for developing faith in the model and to check the sturdiness of the model. If the model appears to be too sensitive to reasonable changes in the model, the model based conclusions are difficult to be relied on because sensitive models are not much help as a policy tool (Sushil, 1993). Sensitivity analysis was performed by taking investment as decision variable from Rs. 50 crores to Rs. 5000 crores.

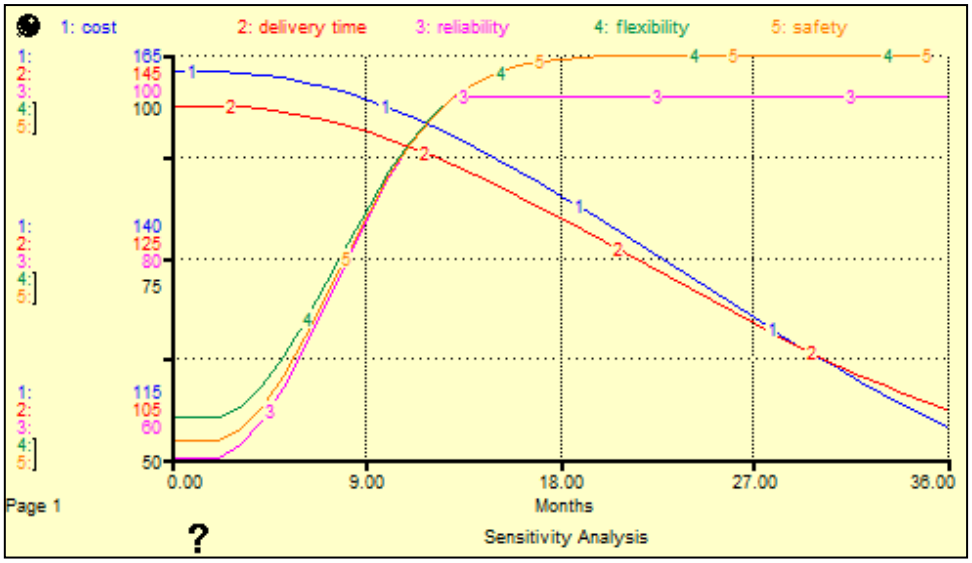


Figure 5.15 Results for Performance Measures for Sensitivity Analysis

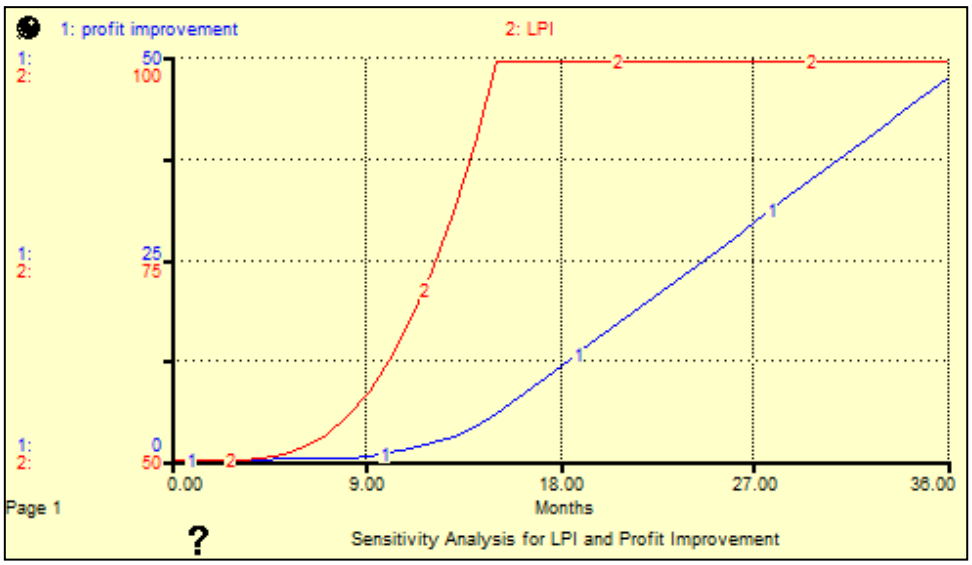


Figure 5.16 Results for LPI and Profit Improvement for Sensitivity Analysis

Figure 5.14 displays the input with for sensitivity analysis in the Stella software. The decision variable is the input to the selected (value) window. In the start and end tab, the initial and final value for the decision variable is entered. The user can select the number of runs for the simulation. After selecting and inputting all required data, the set button chooses different values for the decision variables according to the number of runs selected.

Figure 5.15 and figure 5.16 depict the result of sensitivity analysis. As the maximum value for the decision variable is too large the performance measures have reached the target values in a short period of time. From figure 5.15, it can be seen that reliability reaches 100 in

around 15 months, flexibility and safety reaches its target values in around 18 months. Reduction in cost and time reached a minimum value of 115 and 105 respectively. From figure 5.16, it can be seen that LPI reaches its target value in 15 months and profit is about 50% in 36 months. From the results, it can be seen that the model does not display any abnormal behaviour and it is found suitable for scenario generation or policy formulation.

5.9 Scenario Generation

Once a valid model with improved policy structure is obtained after sensitivity analysis, it can be used to create generate different types of scenario for future. Various managerial options regarding different policy and system parameters can be considered and their impact on the dynamic response of the model can be taken as a future scenario (Sushil, 1993). The four scenarios considered for further evaluation are shown in table 5.13.

Table 5.13 Scenario Generation

Scenario	Percentage investment after improvement in profit	Time gap between investment and improvement in performance measures (months)
Highly Pessimistic	0-25	9-12
Pessimistic	25-50	6-9
Optimistic	50-75	3-6
Highly Optimistic	75-100	0-3

The two best plans combinations, PA3-QAP4 and PA4-QAP4 are simulated further. The two criteria considered for scenario generation are percentage investment after improvement in profit and the time gap between investment and improvement in performance measures. As the company has decided that it will invest 1% of the initial investment every quarter if the profit increases by 3%, therefore investment percentage is divided into four slots namely 0-25%, 25%-50%, 50%-75% and 75%-100%. The other criterion is the time gap between the amount invested and the actual improvement in the performance measures. It is also divided into four slots namely 0-3 months, 3-6 months, 6-9 months and 9-12 months.

a. Highly Pessimistic Scenario

In this scenario, the maximum time delay and minimum profit percentage are considered. In the base model, no time delay is taken into consideration. But in real environment, delays are natural and a lot many factors influence them. Delays may be caused due to human errors, people reluctant to change or taking the initiative of the company in a negative manner,

improper installation, improper use of technology etc. Therefore, a maximum delay of 12 months and minimum delay of 9 months is considered in this case. Delay duration will be generated randomly for every run between the maximum and minimum duration. Also, what if the company does not invest the decided amount back even if the profit is achieved. Therefore, a minimum of zero percentage and a maximum of 25% are considered of the invested amount. The percentage investment will be generated randomly for every run. Results are compiled in table 5.14.

b. Pessimistic Scenario

In this scenario, a delay of six to nine months is considered and profit percentage of 25% to 50% is considered. Results are compiled in table 5.15.

c. Optimistic Scenario

Assuming that the investments in the areas chosen are yielding the desired results, in this scenario, a delay of three to six months is considered and profit percentage of 50% to 75% is considered. Results are compiled in table 5.16.

d. Highly Optimistic scenario

In this scenario, a delay of zero to three months is considered and profit percentage of 75% to 100% is considered. Results are compiled in table 5.17.

Table 5.14 Highly Pessimistic Scenario Result

Performance Measure	PA3-QAP4		PA4-QAP4	
	Minimum Value	Maximum Value	Minimum Value	Maximum Value
Logistics Cost	162.45	162.55	162.30	162.44
Logistics Time	139.61	139.69	139.52	139.61
Reliability of services	63.47	64.23	64.10	65
Flexibility of services	58.50	59.64	59.50	60.49
Safety	55.78	56.61	56.36	57.32
LPI	50.36	50.52	50.43	50.61
PI	0.08	0.12	0.09	0.15

Table 5.15 Pessimistic Scenario Result

Performance Measure	PA3-QAP4		PA4-QAP4	
	Minimum Value	Maximum Value	Minimum Value	Maximum Value
Logistics Cost	162.34	162.45	162.16	162.30
Logistics Time	139.54	139.61	139.43	139.52
Reliability of services	64.23	65.03	65	65.94
Flexibility of services	59.64	60.51	60.83	61.53
Safety	56.61	57.48	57.32	59.33
LPI	50.52	50.70	50.61	50.83
PI	0.12	0.19	0.15	0.23

Table 5.16 Optimistic Scenario Result

Performance Measure	PA3-QAP4		PA4-QAP4	
	Minimum Value	Maximum Value	Minimum Value	Maximum Value
Logistics Cost	162.22	162.34	162.01	162.16
Logistics Time	139.48	139.54	139.32	139.43
Reliability of services	65.03	65.86	65.94	66.92
Flexibility of services	60.51	61.42	61.53	62.60
Safety	57.48	58.39	58.33	59.38
LPI	50.70	50.92	50.83	51.09
PI	0.19	0.29	0.23	0.34

Table 5.17 Highly Optimistic Scenario Result

Performance Measure	PA3-QAP4		PA4-QAP4	
	Minimum Value	Maximum Value	Minimum Value	Maximum Value
Logistics Cost	162.10	162.22	161.85	162.01
Logistics Time	139.37	139.45	139.21	139.32
Reliability of services	65.86	66.71	66.92	67.93
Flexibility of services	61.42	62.36	62.60	63.72
Safety	58.39	59.33	59.38	60.47

LPI	50.92	51.18	51.09	51.40
PI	0.29	0.41	0.34	0.48

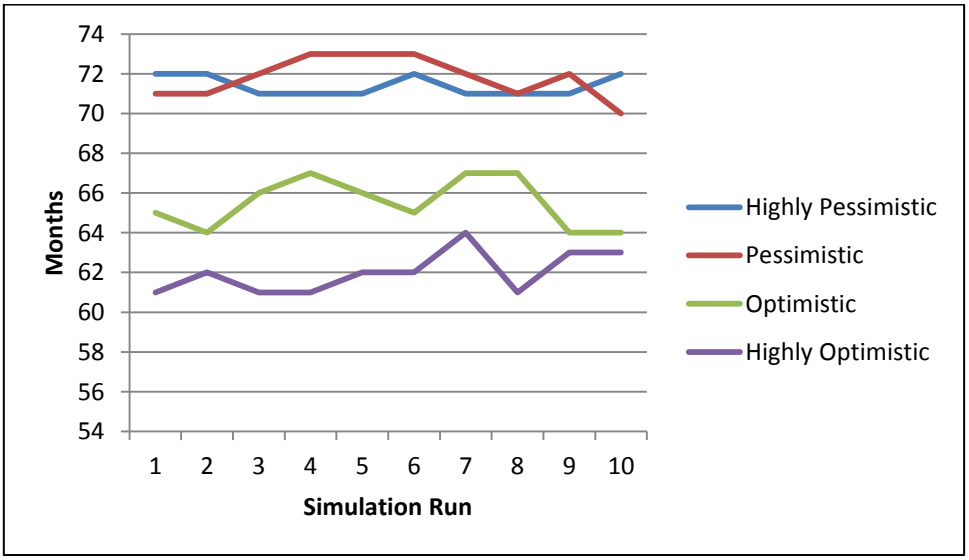


Figure 5.17 Improvement in Profit in PA3-QAP4

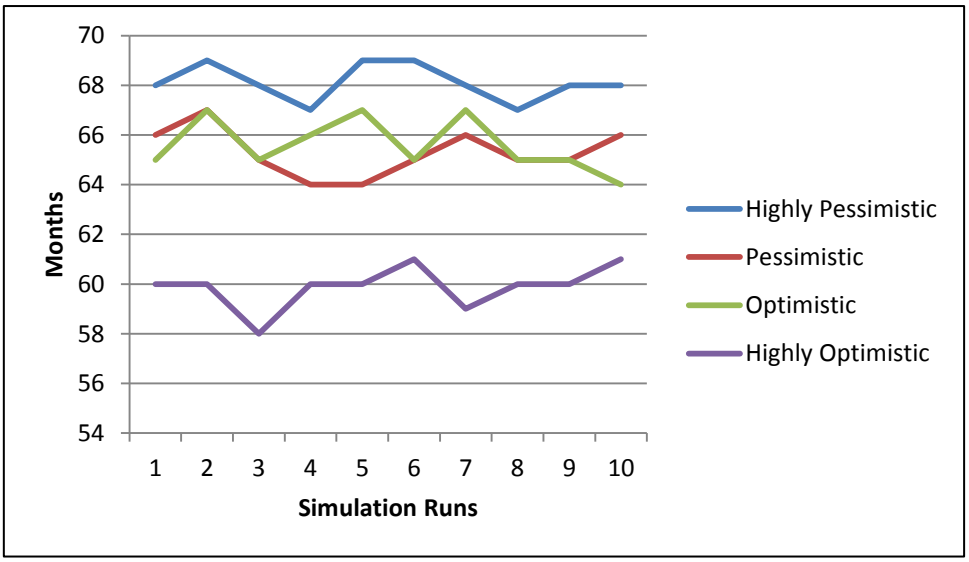


Figure 5.18 Improvement in Profit in PA4-QAP4

Figure 5.17 depicts the improvement in profit in PA3-QAP4 under all the four scenarios. Profit improvement is slowest in highly pessimistic scenario, which will start around 71 months. It is the fastest in the highly optimistic scenario, which will start around 59 months.

Similarly, profit improvement in PA4-QAP4 is slowest in highly pessimistic scenario (figure 5.18), which will start around 67 months. It is the fastest in the highly optimistic scenario,

which will start around 58 months. Circumstances differ from time to time and businesses get affected by many exogenous factors which are beyond the control of the company. So, managers need to implement the investment strategies keeping in mind the repercussions of any delay.

5.10 Conclusion

In this chapter, the improvement in logistics performance is studied by making investments in information technology, which has become a necessity in today's business arena. System dynamics are used as a tool to demonstrate the impact of investment in information technology on the logistics performance index. The developed model will allow companies to simulate the investment environment and to understand the impact of investment on performance measures like cost, time, reliability, flexibility and safety and also the time frame and the technology in which the investment will reap maximum benefits.

Out of the five plans proposed, two plans which reaped maximum benefits were external focus plan (PA4) and customized plan II (PA3). The plans were further simulated by doing investment quarter wise. The best quarter wise investment plan is QAP4, where 65% investment is one in initial 5 quarters and rest in remaining 7 quarters.

In the external focus plan, 50% investment in done in EDI and 50% investment in ERP. After following QAP4, cost reduced by 0.70%, time reduced by 0.56%, reliability improved by 13.21%, flexibility improved by 15.85% and safety by 16.28%. LPI improved by 2.8%.

In the customized plan II, 15% investment was done in RFID, 30% investment was done in EDI, 15% investment in GPS and 40% investment in ERP. After following QAP4, cost reduced by 0.55%, time reduced by 0.45%, reliability improved by 11.18%, flexibility improved by 13.38% and safety by 14.09%. LPI improved by 2.36%.

Profit improvement will start after approximately after 5 years under highly optimistic scenario where time gap between investment and improvement in performance measures is only up to 3 months and percentage investment after improvement in profit is 75% to 100%.

By comparing both the plans, it can be observed that highest investment is done in ERP. Therefore, companies should focus on maximizing investment in ERP. Also, Indian companies need to invest heavily in IT to achieve competitive advantage and to face the fierce competition posed by foreign competitors. Also, the maximum improvement is observed in flexibility and safety. It can be observed that the value of LPI and other performance measures have not

increased considerably by investment in IT. LPI is governed by various several other factors like infrastructure, government regulations and skilled work force. Improvement in these factors also is a must to study the impact of LPI improvement at the organization and country level.

5.11 Managerial Implications

The biggest role of the manager is to identify the right technology for the organization. As implementation of the technology requires huge investment, adopting the right technology will be the key to ease logistics processes. Also, the company will have to bear huge losses if a wrong technology is chosen or the implementation is faulty.

Any technology chosen comes with many features and upgradations. It becomes the duty of manager to ensure that completely utilization of technology is happening. Return on investment on IT is a slow process and before implementation all the steps of business process reengineering should be carried out.

After the successful implementation of the technology identified, the employees should be trained for the same. Proper training program may assist acceptance of the technology by the users. It will also build employee's confidence to use particular technology and lead to employee satisfaction. Employees should be informed and explained why a particular technology is being implemented and how it will affect their work and the company goals. Without such knowledge, unfamiliarity and uncertainty will lead to opposition, lack of involvement and eventual disassociation by the employee. Therefore, training programs should not only provide exposure to technical aspect of the system, but also resolve whatever concerns and question users might have about proposed implementation

A technology offers hundreds of services, so there are innumerable ways to misuse it. Managers have to keep constant attention to avoid misuse of the technology. Vast information is available with employee and can be used against company's interests. Many times fear of being replaced or removed due to automation affects the work of employee. To keep the employee motivated after implementation of the technology and to clear doubts regarding the same becomes the role of the manager. If necessary, retraining can be arranged for employees who are either reluctant or not able to properly use the technology. So the role of manager is very important to successfully choose, implement, train/retrain and upgrade the technology.

Chapter 6

LOGISTICS IMPROVEMENT BY SIMPLIFYING GOVERNMENT REGULATIONS AND INVESTMENT IN INFRASTRUCTURE

6.1 Introduction

Governments around the world are becoming increasingly aware of the importance of an efficient and effective logistics sector in promoting and sustaining regional and national economic performance. Many countries in Asia (China, Hong Kong, Singapore and Malaysia) and the Middle East (UAE, Kuwait, Saudi Arabia) are positioning themselves to be logistic hubs by strengthening transport; connectivity and collaboration among players in the logistics chain (Fernandes and Rodrigues, 2009).

In comparison to other developed and developing countries, Indian logistics competitiveness has been low primarily due to poor infrastructure, low technology penetration, low regulatory effectiveness and fragmented industry (PwC, 2013). Greater productivity, cost efficiency and competitiveness are the rewards of a well-developed logistics sector and a driving force for sustainable development (Colona, 2012). It's high time for India to realize it else the waste caused by poor logistics infrastructure will increase from current 4.3% of GDP to 5% of GDP in 2020 (Mckinsey, 2010). In order to improve the Indian logistics competitiveness, initiatives taken by different countries to improve the logistics performance were studied as shown in table 6.1.

Characteristics of a world class logistics city are quality of road and rail infrastructure, skilled workforce, depth and strength of regional distribution industry, sustainability, world class information and communications technology, collaboration between government and private industry and government legislation (Toh et al., 2009). Chapter 4 and chapter 5 studied the improvement in logistics performance through investment in human resources and information technology respectively. This chapter will study the role and investment by government to improve the logistics performance.

A focus on time, cost, and reliability from a supply chain point of view can be seen as a 'new generation' trade facilitation initiative, which moves beyond traditional concerns such as streamlining border processes and lowering trade costs, to deal with factors that promote the development of global and regional value chains (Shepherd and Hamanka, 2015).

Table 6.1 Initiatives Taken by Different Countries for Logistics Improvement

S.No	Country and Author/s	Initiatives and Findings
1.	China: Goh and Ling (2003); Hongmei (2013)	The government is investing RMB 4.7 trillion on roadways RMB 350 billion on railways, RMB 110 billion on airways, RMB 1.25 trillion on the telecom sector. Also, they are simplifying custom procedures and developing IT to facilitate trade.
		Investment in infrastructure, development of IT and simplification of government procedures
2.	Singapore: Siew (2002)	Attracting leading transport and logistics, finance and insurance, maritime legal and arbitration services companies by creating an internationally competitive and flexible, global integrated logistics hub. To achieve this, multimodal connectivity will be enhanced and Singapore will be developed as and IT and SCM nerve centre.
		Creating an integrated logistics hub; multimodal connectivity; Use of information technology
3.	Thailand: Termpittayapais-ith (2010)	The government targeted to reduce logistics cost by business logistics improvement, transport and logistics network optimization, logistics services internationalization, trade facilitation enhancement and capacity building.
		Optimization of network; internationalization of logistics services; capacity building enhancement
4.	Dubai: Fernandes and Rodrigues (2009)	Government is concentrating on massive infrastructural development, developing financial markets, improving corporate governance system and to enhance logistics related education and research.
		Infrastructure development; enhancement of logistics related education and research; Corporate governance
5.	United States of America (USA): Xiong (2010)	In the 1980s, US opted for deregulation of transportation policy, use of 3PL providers, and use of IT and just in time manufacturing. It has a very strong infrastructure with largest highway and railway network in the world. Logistics cost to GDP ratio has decreased in the 80s' from 16.2% in 1981 to 10.1% in 1992 and has remained at a stable level.
		A strong transportation infrastructure; use of IT; good governance
6.	Australia: Bureau of Transport Economics (2001)	Development of a seamless logistics system, integration of the best available technologies to link management systems with transport infrastructure, codification, promotion of professional and accredited logistics specialist.
		Smooth logistics system, Use of IT, development of skilled workforce

By reducing time and cost involved in administrative procedures, businesses stand to gain very significantly in terms of their ability to trade competitively in national and international markets (Korinek and Sourdin, 2011). Therefore, priority of government agencies should be on development of a strong infrastructure network and to introduce logistics conducive government regulations

The role of government and its agencies is to develop road infrastructure, railway infrastructure, airports, seaports, upgrade existing warehouses and to develop various taxation and fiscal policies to boost the trade by way of efficient logistics system. India ranks 86th in quality of infrastructure by World Economic Forum 2012, 85th in quality of roads, among 142 countries and the Indian business community continues to cite infrastructure as the single biggest hindrance to doing business in the country (Schwab, 2012). In India, freight movement is dominated by the roadways. India has the third largest road network in the world. But still faces major difficulty in connectivity as out of 65,590 km of national highways constitutes of only 2% of the network and carries 40% of the total road freight (Deloitte, 2009).

A large part of India's freight traffic comprises bulk material and moves over long distances that can be more economically served by rail and waterways leading to unbalanced modal mix. A balanced modal mix can be achieved by thorough planning by government for improvement of roadways, railways, ports and airports and also on the connecting links between them. Therefore, there is a need to increase and integrate the infrastructure capacity and further to maintain it properly.

Development of policies, introduction of taxes, subsidies is also in the hands of the government. One of the barriers to the Indian logistics system is the tax infrastructure. With state owned tax structure, along with other taxes, movement of goods become costly and inflexible. Also, the movement is hauled by police check posts, tolls etc. which increases the cost, wastes time and fuel. Cost of delay due to stoppages to the Indian economy is 5.5 billion USD (TCIL, 2010).

To overcome the problems stated above, the aims of the chapter are as follows:

1. To identify the areas of improvement, which will maximize logistics performance?
2. To develop a dynamic model using system dynamics modelling.
3. To evaluate the various investment plans and scenarios for the decision maker to

formulate the investment strategy.

4. To quantify the relationship between performance measures like logistics cost, delivery time, reliability, flexibility and safety and logistics performance.
5. To study the effect of improvement in logistics performance, if any, on the GDP.

Chapter is organized as follows. Section 6.2 discusses the causal loop diagram for investment by government. Section 6.3 depicts the stock and flow diagram. Chapter is concluded in section 6.4.

6.2 Causal Loop Diagram

Logistics infrastructure is a critical enabler for economic development of any country and also a critical factor in the logistics performance. As logistics deal with the movement of goods, well developed roads, railways, ports, logistics parks and warehouses can make movement easy, quick, flexible and cost saving. India's need for infrastructure creation in logistics sector is striking. In just a decade, India has seen its economic size more than double to $1.37 trillion (2012) and total foreign merchandize trade multiply from 20% of GDP (2000) to 42% of GDP (2012) (Deloitte, 2009).

Table 6.2 Growth in GDP/ Freight/Vehicle/Road during 1950-51 to 2011-12

GDP/ Freight/Vehicle/Road	Unit	1950-51	2011-12	CAGR *** (%)
GDP**	USD	20 Billion	1710.9 Billion	7.7
Road freight volume*	BTKM	6	1212.4	9.25
Vehicles (All types)*	Million	0.306	141.8	10.77
Vehicles (Goods)*	Million	0.082	7.064	7.71
Road Length*	Million Km	0.4	4.6	4.02

Source: * www. data.gov.in;
** http://www.tradingeconomics.com/india/gdp
***http://www.investinganswers.com/calculators/return/compound-annual-growth-rate-cagr-calculator-1262

As seen from table 6.2, it can be observed that during 1950-51 to 2011-12, the GDP grew at a CAGR of 7.7% whereas the road freight volume and goods vehicle increased at a CAGR of 9.25% and 7.71% respectively. The total length of road increased at a CAGR of only 4.02%, implying that growth in roads is not able to keep pace with growth in freight volume and number of vehicles which grew at a CAGR of 10.77% during the same period. Inefficiency in

logistics infrastructure cost the Indian economy an extra $45 billion, about 4.3% of GDP every year, which will rise to around USD 14 billion in 2020 (Mckinsey, 2010).

There is clear link between quality of infrastructure and transport costs and thus concludes that infrastructure investments are important for export lead economic growth (Hausman, 2005). An inadequate transportation infrastructure leads to:

a. slow movement of goods
b. high unit cost of freight
c. high cost of operation and maintenance
d. delayed deliveries
e. increase in damages and accidents
f. increase in inventories (unreliable delivery systems leads to high inventories)
g. High ordering and overhead costs.

6.2.1 Development of Infrastructure

The role of government and its agencies is to develop roadways, railways, ports, logistics parks through investment in infrastructure which will build the capacity, integrate the network and to maintain it in the long run. This can be entirely financed by public sector or through PPP. Logistics parks provide economies of scale and sharing of resources, reducing per unit service cost with amenities for drivers, vehicles and ancillary services.

With the investment and well-connected infrastructure, there will be considerable reduction in cost and time. Reduction in logistics cost and time will lead to improvement in LPI. LPI will increase the revenue to the government in terms of tax collection leading to improvement in government budgets and ultimately the government will think more about investing in the logistics sector. Therefore, the loop between investment by government in infrastructure in capacity building/network integration/maintenance, logistics cost/logistics time, LPI, revenue to government/economic growth and investment by government is a balancing loop. Flexibility is the ability to adapt information processes and capabilities to meet requirements of specific customer segments (Closs et al., 1997). Also, poor infrastructure leads to slow speed, equipment breakdown and accidents. Therefore, with good infrastructure the system will become more reliable and safe. Therefore the loop between investments by

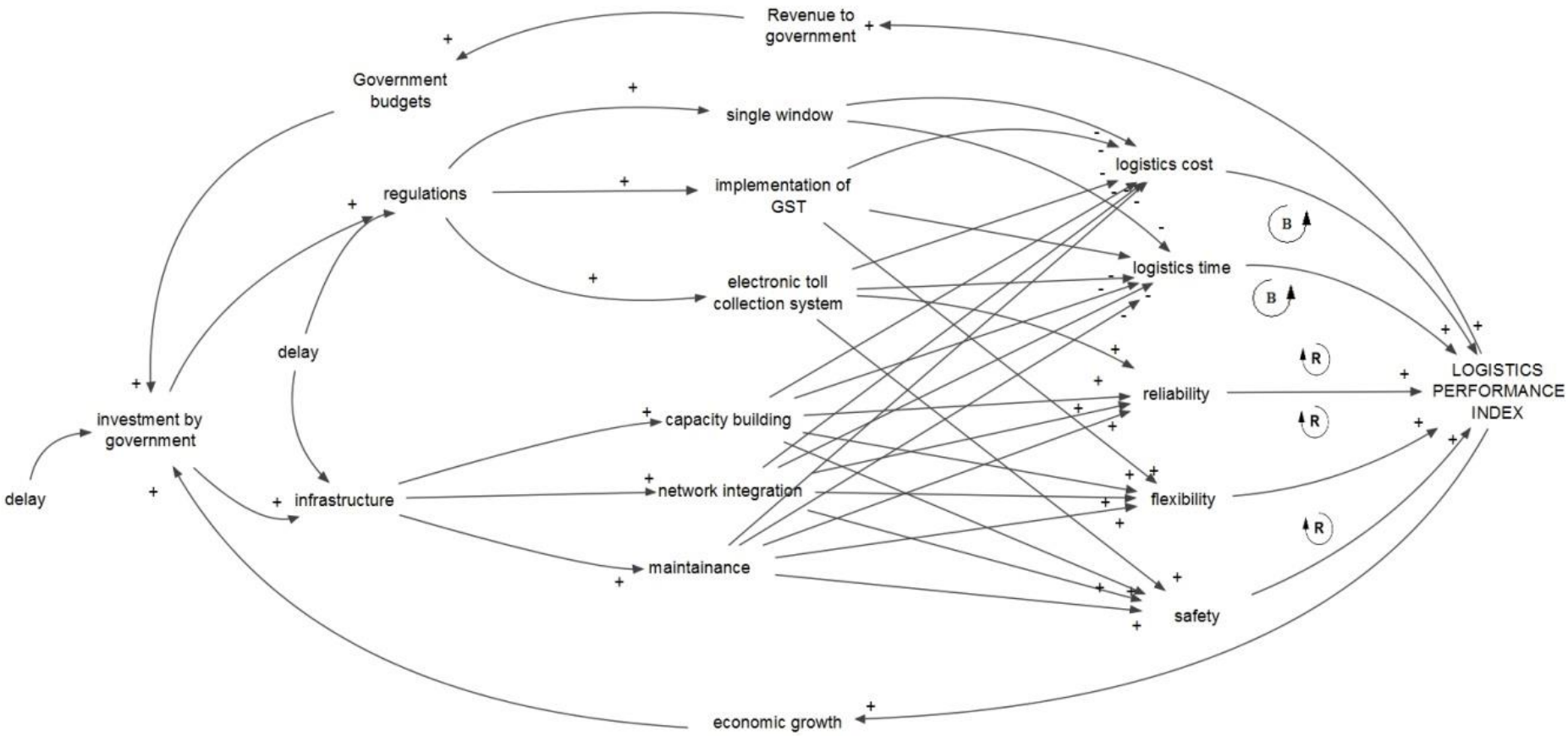


Figure 6.1 Causal Loop Diagram for Investment by Government and its Effect on LPI

government in infrastructure, capacity building/network integration/maintenance, reliability /flexibility/safety, LPI, revenue to government/economic growth and investment by government is a reinforcing loop.

Figure 6.1, is indicating delay at investment by government, regulations and infrastructure. Because in investments, clearances, construction, planning all are handled by different ministries in India and this will cause delay in the development of logistics supported infrastructure.

6.2.2 Improvement in Government Regulations

Government also plays a very important role in developing various taxation and fiscal policies. The existing complex and multi-layered indirect tax structure has fragmented India market into twenty nine state markets by tax barrier which adversely affects India's competitiveness (Kothari, 2011). Administration of these indirect taxes requires the erection of check posts and physical barriers (Kothari, 2011), resulting in annual cost of delay due to stoppages of USD 5.5 billion and impact of additional fuel consumption due to delay and slow speed of USD 12 billion per annum to the Indian economy (TCIL, 2010). It requires a lot of documentation and approvals of various bodies leading to wastage of time and increased cost. Introduction to uniform documentation and electronic check posts will reduce paperwork and delays. Singapore has been noted as a leader in paperless trading with its TRADENET system which is focused on the submission of regulatory documents (Toh et al., 2009).

Introduction to single window environment for documentation. Korean firms were able to save US$ 2.1 billion due to introduction of single window for trade transactions (Korinek and Sourdin, 2011). India can also create a national level single window system through which all the paperwork and taxes are paid online and a paperless smooth flow of freight is achieved nationally and internationally leading to considerable reduction in cost and time. Therefore, investment by government in regulations, single window, and logistics cost/logistics time, LPI, economic growth/revenue to government and investment by government are balancing loops.

One of the most important pending decisions by the government of India is implementation of GST. GST has the ability to turn India as a "complex tax destination" to a "competitive

destination" for which there is a need considerable improvement in tax structure and administration (Kothari, 2011). Introduction of GST as a uniform tax will help in promoting interstate trade, exports, raising employment opportunities and boosting overall economic growth. It will reduce average cost to manufacture by10–15%, increasing the GDP by 1.4% to 1.6% and reduce overall production cost by 10-15% (Kothari, 2011). Along with national level single window and GST, a national common market leading to economies of scale and efficient and effective supply chain can be achieved. As there will be no barrier in interstate goods the distribution cost will be reduced and trade within the state will increase. Therefore, implementation of GST will lead to reduction in cost and time and improvement in flexibility of the logistics system. Therefore, investment by government in regulations, implementation of GST, logistics cost/logistics time, LPI, economic growth/revenue to government and investment by government are balancing loops and investment by government in regulations, implementation of GST, flexibility, LPI, economic growth/revenue to government and investment by government is reinforcing loop.

Electronic toll collection system will lead to reduction in cost. Time and improvement in reliability and safety of the logistics system as the trucks will not have to wait for hours at the tolls. Therefore, investment by government in regulations, electronic toll collection system, logistics cost/logistics time, LPI, economic growth/revenue to government and investment by government are balancing loops and investment by government in regulations, electronic toll collection system, reliability and safety, LPI, economic growth/revenue to government and investment by government are reinforcing loops.

With electronic toll collection system, implementation of GST and national single window, India will have a logistics conducive government regulation. Also, the revenue to the government will increase as unorganized players will not be able to evade tax. This will also increase the share of organized market in India. Reduction in logistics cost and time will lead to improvement in LPI. LPI will increase the revenue to the government in terms of tax collection leading to improvement in government budgets and ultimately the government will think more about investing in the logistics sector.

6.3 Stock and Flow diagram

The stock and flow diagram shown in figure 6.2, has been developed using STELLA 9.1.3 software.

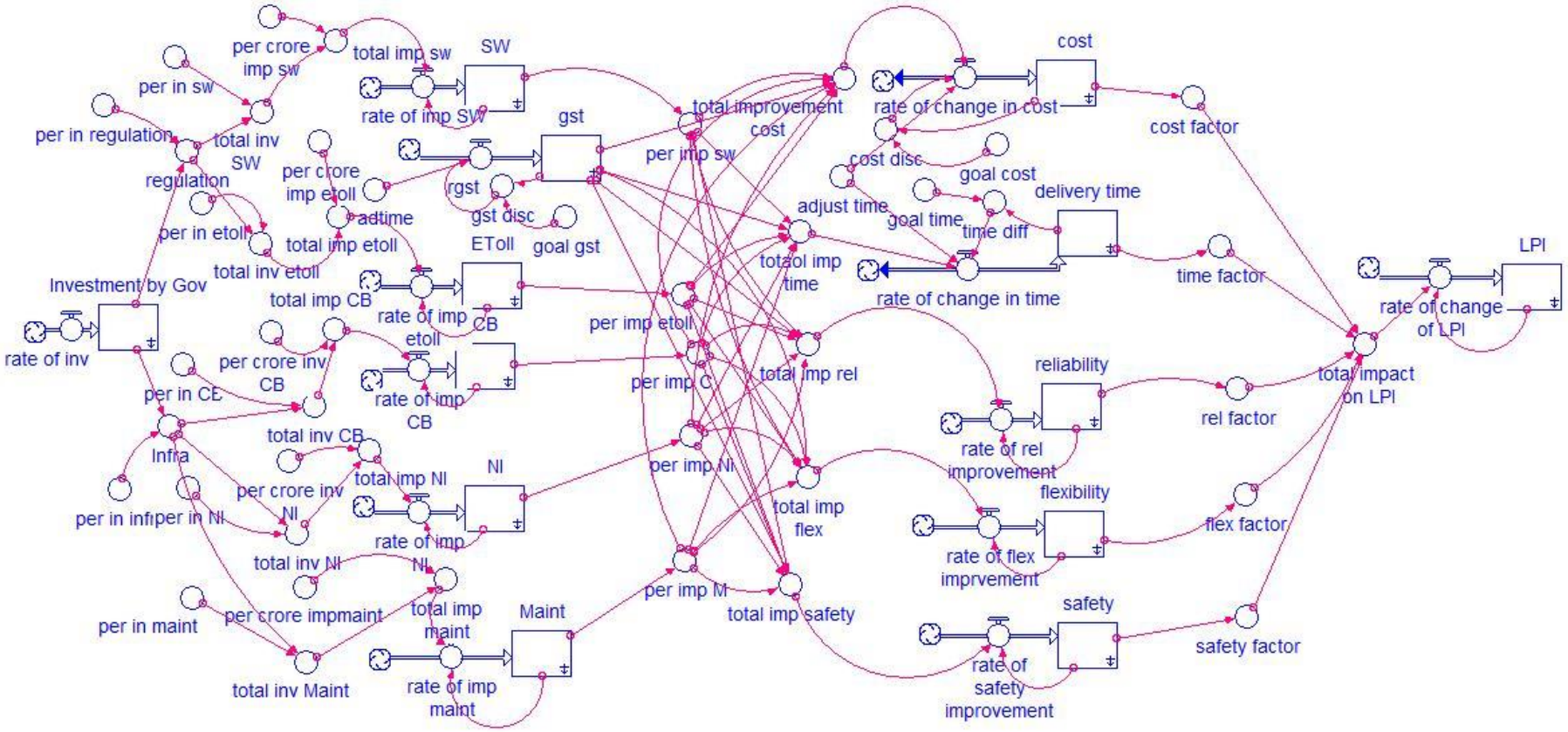


Figure 6.2 Stock and Flow Diagram for Investment by Government for Development of Infrastructure and Simplifying Government Regulations

6.4 Conclusion

The contribution of this chapter lies in development of a causal loop diagram and stock and flow diagram to study the role of government for improving the government regulations and development of infrastructure for logistics improvement. Using the stock and flow diagram, simulations can be carried out to develop various policies and investigate different investment strategies which will optimize the logistics performance index. Also, it can be found out that which investment area will yield maximum result and can be considered on top priority for improving the logistics performance.

Chapter 7
ISM OF CRITICAL FACTORS FOR IMPROVEMENT IN LOGISTICS PERFORMANCE

7.1 Introduction

Interpretive Structural Modelling (ISM) assists individuals or groups to develop a map of the numerous relationships between several factors involved in a complex situation for taking effective decisions. Generally, ISM is a combination of three modelling languages – words, digraphs, and discrete mathematics – to ensure solution to a structure of complex issues (Jia et al., 2015). In this approach, a methodical application of some factorary notions of graph theory is applied in such a way that theoretical, conceptual and computational leverage are exploited to explain the complex arrangement of contextual relationship among a set of variables (Attri et al., 2013).

The researchers selected this approach because of its benefits; direct and indirect relationships between variables based on situations are revealed far more accurately than single factors taken in isolation (Cagno et al., 2014). Therefore, in this chapter, the enablers for improvement in logistics performance have been analysed using the ISM methodology, which shows the interrelationships of the enablers and their levels. Sixteen critical success factors were identified from literature review for improving the logistics performance (table 7.1).

These factors are also classified depending on their driving power and dependence power using MICMAC analysis. Assessment of logistics improvement will be done through the LPI, which is considered as the weighted average of logistics cost, delivery time, reliability of services, flexibility of services and safety of the logistics system. The main objectives of this chapter are:

1. To identify and rank the factors for improvement in logistics performance.
2. To find out the interaction among identified factors using ISM.
3. To find out the consequences of improvement in logistics performance at organization and country level.
4. To discuss the implications of this research for policy makers and managers.

Chapter is organized as follows. Section 7.2 identifies the critical success factors for logistics

improvement. Section 7.3 explains the data collection method adopted and section 7.4 describes the application of ISM methodology respectively. Formation of digraph is explained in section 7.5. MICMAC analysis is explained in section 7.6. Section 7.7 is labelled for result and discussion. The chapter concludes in section 7.8.

7.2 Identification of Critical Success Factors

Table 7.1 introduces the sixteen factors chosen in the chapter for logistics improvement using ISM modelling.

Table 7.1 Critical Success Factors

S.No	Factor and Author/s	Remark/s
1.	Investment by Government : Havenga (2011); Shepherd and Hamanka (2015)	A successful logistics trade cycle depends on the magnitude and speed of government measures to liberalise the supply chain of logistics including appropriate infrastructure investments. Transport is a single most expensive component of trade logistics and adequate infrastructure is required to facilitate transportation and it is an important factor in determining the country's trade logistics services (Korinek and Sourdin, 2011). Therefore, priority of government agencies should be on development of a strong infrastructure network and to introduce logistics conducive government regulations.
2.	Investment by Logistics Service Provider : Shepherd and Hamanka (2015)	As private sector requires an efficient environment like high quality infrastructure and economically rational regulations to operate, public sector depends on the information flows from the private sector and a relationship of trust and confidence with operators to build a strong regulatory environment. An additional aspect of internal logistics performance relates to the development of private sector capacity, including through improvements in human resources.
3.	Development of Infrastructure: Dobbs et al. (2013); Mckinsey (2010)	An increase in infrastructure investment equivalent to 1% of GDP would translate into an additional 3.4 million direct and indirect jobs in India. Infrastructure development is the backbone of the nation which helps in effective flow of goods and facilitation of trade.
4.	Improvement in Government Regulations: Vasavi(2009); Kothari (2011)	India needs better infrastructure and less bureaucracy. There is a strong need to turn India as a "complex tax destination" to "competitive destination" for which there is a need for considerable improvement in tax structure and administration.
5.	Development of Skilled Work Force: Jurcevic et al. (2009); Pandey et al. (2012)	Companies that consider their human capital as their most important asset are successful. Training, collaborative performance systems and reward alignment achieves high levels of supply chain integration.

6.	Development of IT enabled Logistics system: Pokharel (2005); Lai et al. (2006)	Use of IT leads to efficiency, cost savings, reduced data entry error and increased customer service level. Also, it helps in improving delivery speed and reliability, customer relations and order accuracy, higher cost advantage.
7.	Logistics Performance Index: Rantasila and Ojala (2012); Havenga (2011)	There is a strong relationship between country's LPI and its level of logistics costs. 10% improvement in the index in the exporting country is associated with increased trade of 36%. Similarly, for every 10% increase in the LPI of a typical exporter, bilateral imports increase by more than 69% on average, while for every 10% increase in the LPI of a typical importing country, bilateral imports increase by 54% on average.
8.	Reduction in Cost : FICCI (2011); Kaur (2011);	Logistics cost is directly proportional to distance and handling incurred while transporting goods and inversely proportional to share of 3PL in the country.
9.	Reduction in Time: Nordas et al. (2006); De Sousa and Findlay (2007)	Time is an important competitive factor and also a barrier to trade, which affects the volume of trade and more importantly ability of the firms to enter the export markets. A ten percent increase in time reduced bilateral trade volumes by between 5% to 8%.
10.	Improvement in Reliability: Simons (2004); Cook et al. (2002)	Reliability is the ability to perform the promised service consistently, dependably and accurately. It is the most important dimension in assessing the quality of service and is therefore a fundamental requirement for businesses to compete in the marketplace
11.	Improvement in Flexibility: Novich (1990)	Flexibility in meeting a particular customer delivery requirement at an agreed place, agreed mode of delivery and with agreed upon customised packaging. This type of flexibility can influence the decision of customers to place orders, and thus can be regarded as important in enchanting and retaining customers.
12.	Improvement in Safety: Cantor (2008); Pia (2010)	Safety refers to the safety of stock, human resources, physical infrastructure and the overall logistics system. Flow of information, co-operation between the various parties of the chain, and the training of employees have proven to be important in improving the safety of a logistic chain and that material damage and accidents causes a lot of additional work and costs.
13.	Improved Profit: Randall and Farris (2009); Anderson (2011)	Improvement of logistics performance will lead to savings, leading to more profits. Outstanding logistics performance is associated with high financial performance through low costs, high revenues and efficient and effective asset utilization.
14.	Competitiveness of Organizations: Hausman et al. (2005)	Inefficiencies in logistics have been highlighted as an important constraint on firms; productivity and competitiveness in developing countries.
15.	Improvement in FDI: Saidi and Hammami (2011)	Firms with better investment climate and better logistics have higher probability of exporting to international markets and attracting FDI. Transportation and logistics are two factors which have an important role to enhance the FDI attractiveness

		for developing countries.
16.	Economic Growth: Liu (2009)	Logistics industry's value added, total employment of logistics industry, new fixed assets investment, freight volume and freight turnover have huge impact on economic growth. There is a clear link between quality of infrastructure and transport costs and thus concludes that infrastructure investments are important for export led economic growth.

7.3 Data Collection for ISM

For identifying the contextual relationship among the enabler's two experts from academia with research interests in the area and three managers working for a 3PL firm were consulted for the same. Management techniques such as brain storming and nominal technique were used in developing the contextual relationship among the variables.

7.4 Application of Proposed Methodology

ISM is a methodology which facilitates the understanding of complex situations which deal with a large of number of interactive variables. It is identifying and understanding the interrelationships between these variables and bringing out the key driving and dependent variables. In ISM, a set of different but directly related factors are structured in a comprehensive and systematic model (Warfield, 1974).

The methodology is known as interpretive because relation between the variables is based on the judgment of the group. It is structural too because an overall structure is extracted from the complex set of variables on the basis of the relationship. The ISM steps are discussed in section 3.7 in chapter 3. The application of the steps is as follows:

7.4.1 Structural Self- Interaction Matrix (SSIM)

The development of SSIM requires depicting dependence among all possible pairs of enablers by choosing a contextual relationship showing which enablers lead to which others. For analysing the factors, a contextual relationship of 'leads to' or 'influences' type must be chosen. This means that one factor influences another factor. On the basis of this, contextual relationship between the identified factors is developed. For expressing the relationship between different critical factors, four symbols have been used as denoted in table 3.5. On the basis of the expert opinions, SSIM as shown in table 7.2 was developed.

The following statements explain the use of V, A, O and X in SSIM:

1. According to the expert's opinion, skilled work force (11) will help in achieving reduction in cost (1). Hence, V is assigned to the cell at the intersection of skilled workforce row and column of reduction in cost. Similarly, infrastructure development (13) will help in reduction in time (2). Therefore, V is assigned to the cell at the intersection of infrastructure development row and column of reduction in time.

Table 7.2 Structural Self- Interaction Matrix

S.No	Critical Success Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Reduction in cost	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2	Reduction in time	O	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3	Improvement in reliability	O	O	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	Improvement in flexibility	O	O	O	*	*	*	*	*	*	*	*	*	*	*	*	*
5	Improvement in safety	O	O	O	O	*	*	*	*	*	*	*	*	*	*	*	*
6	Improved Profit	A	O	O	O	O	*	*	*	*	*	*	*	*	*	*	*
7	Competitiveness of organizations	A	A	A	A	A	X	*	*	*	*	*	*	*	*	*	*
8	Logistics Performance Index	A	A	A	A	A	V	V	*	*	*	*	*	*	*	*	*
9	Improved FDI	O	O	O	O	O	A	A	A	*	*	*	*	*	*	*	*
10	Economic Growth	O	O	O	O	O	A	A	A	X	*	*	*	*	*	*	*
11	Skilled work Force	V	V	V	V	V	O	O	O	O	O	*	*	*	*	*	*
12	IT enabled logistics system	V	V	V	V	V	O	O	O	O	O	O	*	*	*	*	*
13	Infrastructure development	V	V	V	V	V	O	O	O	O	O	O	O	*	*	*	*
14	Government regulations	V	V	V	V	V	V	O	O	O	O	O	O	O	*	*	*
15	Investment by government	O	O	O	O	O	O	O	O	O	O	O	O	V	V	*	*
16	Investment by LSP	O	O	O	O	O	O	O	O	O	O	V	V	O	O	O	*

2. According to the expert's opinion, reduction in cost (1) will lead to improved profit (6). Hence, A is assigned to the intersection at the row of improved profit and column of reduction in cost. Similarly, improvement in reliability (3) will lead to improve competitiveness of organization (7). Therefore, A is assigned at the intersection of row of competitiveness of organizations and column of improvement in reliability.

3. According to the discussion held among experts, competitiveness of organization (7) and improved profit (6) will help in achieving each other. Hence, X is assigned to the intersection at the row of competitiveness of organization and column of improved profit.

Similarly, economic growth (10) and improved FDI (9) will help in achieving each other. Therefore, X is assigned at the intersection of row of economic growth and column of improved FDI.

4. According to the discussion held among experts, reduction in time (2) and improvement in flexibility (4) do not help in achieving each other. Hence, O is assigned to the intersection at the row of reduction in time and column of improvement in flexibility. Similarly, there is no direct relationship between IT enabled logistics system (12) and logistics performance index (8). Therefore, O is assigned at the intersection of row of IT enabled logistics system and column logistics performance index

7.4.2 Reachability Matrix

Table 7.3 Initial Reachability Matrix

CSF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0
2	0	1	0	0	0	0	1	1	0	0	0	0	1	0	0	0
3	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0
4	0	0	0	1	0	0	1	1	0	0	0	0	0	0	1	0
5	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	1
6	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0
7	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0
8	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
11	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	1
12	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1
13	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1
14	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

The initial reachability matrix is formed by converting the SSIM into a binary matrix, following the rules depicted in table 3.6. SSIM matrix was the input to the program in MATLAB version 7.0.1 to get the initial reachability matrix (table 7.3) and then the final reachability matrix (table 7.4).

The final reachability matrix is obtained by incorporating the transitivity as described in step 4 of ISM methodology as shown in table 7.4. Here, the driving power and dependence of each factor are also shown. The driving power of a particular factor is the total number of factors (including itself), which it may help achieve while dependence is the total number of factors which may help in achieving it. On basis of driving power and dependence power, these factors will be classified into four groups of autonomous, dependent, linkage and independent (driver) factors.

Table 7.4 Final Reachability Matrix

CSF	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Driving Power
1	1	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	6
2	0	1	0	0	0	1	1	1	1	1	0	0	0	0	0	0	6
3	0	0	1	0	0	1	1	1	1	1	0	0	0	0	0	0	6
4	0	0	0	1	0	1	1	1	1	1	0	0	0	0	0	0	6
5	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	6
6	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	4
7	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	4
8	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	5
9	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2
10	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	2
11	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	11
12	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	11
13	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	11
14	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	0	11
15	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0	13
16	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	13
Dependence Power	7	7	7	7	7	14	14	12	16	16	2	2	2	2	1	1	

7.4.3 Level Partitions

From the final reachability matrix, the reachability and antecedent set for each factor are found. The reachability set consists of the factor itself and other factors to which it may help achieve, whereas the antecedent set consists of the factor itself and the other factors which may help achieving it. Then the intersection of these sets is derived for all factors. The factor for which the reachability and intersection sets are same is the top-level factor in the ISM

hierarchy. The top-level factor of the hierarchy would not help achieve any other factor above their own hierarchy. Once the top-level factor is identified, it is separated out from the other factors. Then by the same process, the next level of factors is found. These identified levels help in building the digraph and final model. The iteration is repeated till the levels of each enabler are found out.

Table 7.5 Iteration I

CSF	Reachability Set	Antecedent Set	Intersection	Level
1	1,6,7,8,9,10	1,11,12,13,14,15,16	1	
2	2,6,7,8,9,10	2 ,11,12,13,14,15,16	2	
3	3,6,7,8,9,10	3,11,12,13,14,15,16	3	
4	4,6,7,8,9,10	4,11,12,13,14,15,16	4	
5	5,6,7,8,9,10	5,11,12,13,14,15,16	5	
6	6,7,9,10	1,2,3,4,5,6,7,8,11,12,13,14,15,16	6,7	
7	6,7,9,10	1,2,3,4,5,6,7,8,11,12,13,14,15,16	6,7	
8	6,7,8,9,10	1,2,3,4,5,8,11,12,13,14,15,16	8	
9	9,10	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	9,10	I
10	9,10	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	9,10	I
11	1,2,3,4,5,6,7,8,9,10,11	11,16	11	
12	1,2,3,4,5,6,7,8,9,10,12	12,16	12	
13	1,2,3,4,5,6,7,8,9,10,13	13,15	13	
14	1,2,3,4,5,6,7,8,9,10,14	14,15	14	
15	1,2,3,4,5,6,7,8,9,10,13,14,15	15	15	
16	1,2,3,4,5,6,7,8,9,10,11,12,16	16	16	

For the present research, the process is completed in six iterations (tables 7.5-7.10). In table 7.5, the factor 9 (improved FDI) and factor 10 (economic growth) is found at level I. Thus, it will be positioned at the top of hierarchy of the ISM model. After removing factor 9 and factor 10 from table 7.5, we get table 7.6.

Table 7.6 Iteration II

CSF	Reachability Set	Antecedent Set	Intersection	Level
1	1,6,7,8	1,11,12,13,14,15,16	1	
2	2,6,7,8	2, 11,12,13,14,15,16	2	
3	3,6,7,8,	3, 11,12,13,14,15,16	3	
4	4,6,7,8	4,11,12,13,14,15,16	4	
5	5,6,7,8	5,11,12,13,14,15,16	5	
6	6,7	1,2,3,4,5,6,7,8,11,12,13,14,15,16	6,7	II
7	6,7	1,2,3,4,5,6,7,8,11,12,13,14,15,16	6,7	II
8	6,7,8	1,2,3,4,5,8,11,12,13,14,15,16	8	
11	1,2,3,4,5,6,7,8,11	11,16	11	
12	1,2,3,4,5,6,7,8,12	12,16	12	

13	1,2,3,4,5,6,7,8,13	13,15	13	
14	1,2,3,4,5,6,7,8,14	14,15	14	
15	1,2,3,4,5,6,7,8,13,14,15	15	15	
16	1,2,3,4,5,6,7,8,11,12,16	16	16	

In table 7.6, factor 6 (improved profit) and factor 7 (competitiveness of organization) are put at level II. Thus, these factors will be positioned at the level II in the ISM model. In table 7.7, factor 8 (logistics performance index) is at level III. Therefore, it will be positioned at level III in the ISM model. In table 7.8, factor 1 (reduction in cost), factor 2 (reduction in time), factor 3 (improvement in reliability), factor 4 (improvement in flexibility) and factor 5 (improvement in safety) is at level IV. Therefore, it will be positioned at level IV in the ISM model.

Table 7.7 Iteration III

CSF	Reachability Set	Antecedent Set	Intersection	Level
1	1,8	1, 11,12,13,14,15,16	1	
2	2,8	2,11,12,13,14,15,16	2	
3	3,8	3,11,12,13,14,15,16	3	
4	4,8	4,11,12,13,14,15,16	4	
5	5,8	5,11,12,13,14,15,16	5	
8	8	1,2,3,4,5,8,11,12,13,14,15,16	8	III
11	1,2,3,4,5,8,11,12	11,16	11	
12	1,2,3,4,5,8,12	12,16	12	
13	1,2,3,4,5,8,13	13,15	13	
14	1,2,3,4,5,8,14	14,15	14	
15	1,2,3,4,5,8,13,14,15	15	15	
16	1,2,3,4,5,8,11,12,16	16	16	

Table 7.8 Iteration IV

Factor	Reachability Set	Antecedent Set	Intersection	Level
1	1	1, 11,12,13,14,15,16	1	IV
2	2	2, 11,12,13,14,15,16	2	IV
3	3	3, 11,12,13,14,15,16	3	IV
4	4	4,11,12,13,14,15,16	4	IV
5	5	5,11,12,13,14,15,16	5	IV
11	1,2,3,4,5,11	11,16	11	
12	1,2,3,4,5,12	12,16	12	
13	1,2,3,4,5,13	13,15	13	
14	1,2,3,4,5,14	14,15	14	
15	1,2,3,4,5,13,14,15	15	15	
16	1,2,3,4,5,11,12,16	16	16	

In table 7.9, factor 11 (skilled work force), factor 12 (IT enabled logistics system), factor 13 (infrastructure development) and factor 14 (government regulation) has occupied level V. Therefore, it will be positioned at level V in the ISM model. In table 7.10, factor 15 (investment by government) and factor 16 (investment by LSP) has occupied level VI. Therefore, it will be positioned at level VI or the bottom position in the ISM model.

Table 7.9 Iteration V

Factor	Reachability Set	Antecedent Set	Intersection	Level
11	11	11,16	11	V
12	12	12,16	12	V
13	13	13,15	13	V
14	14	14,15	14	V
15	13,14,15	15	15	
16	11,12,16	16	16	

Table 7.10 Iteration VI

Factor	Reachability Set	Antecedent Set	Intersection	Level
15	15	15	15	VI
16	16	16	16	VI

Table 7.11 Level Partitions

CSF	Reachability Set	Antecedent Set	Intersection	Level
9	9,10	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	9,10	I
10	9,10	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	9,10	I
6	6,7	1,2,3,4,5,6,7,8,11,12,13,14,15,16	6,7	II
7	6,7	1,2,3,4,5,6,7,8,11,12,13,14,15,16	6,7	II
8	8	1,2,3,4,5,8,11,12,13,14,15,16	8	III
1	1	1,2,3,4,5,11,12,13,14,15,16	1	IV
2	2	2,3,4,5,11,12,13,14,15,16	2	IV
3	3	3,4,5,11,12,13,14,15,16	3	IV
4	4	4,11,12,13,14,15,16	4	IV
5	5	5,11,12,13,14,15,16	5	IV
11	12	11,12,16	12	V
12	13	13,15	13	V
13	14	14,15	14	V
14	11	11,16	11	V
15	15	15	15	VI
16	16	16	16	VI

Thus from above iterations, it is found that improved FDI (9) and economic growth (10) are put at level I. This will be positioned at the top of ISM in the digraph. Improved profit (6) and

competitiveness of organization (7) are at level II. Logistics performance index (8) occupies level III followed by reduction in cost (1), reduction in time (2), improvement in reliability (3), improvement in flexibility (4) and improvement in safety (5) at level IV. Skilled work force (11), IT enabled logistics system (12), government regulations (13) infrastructure development (14) occupies level V. Final iteration brings out level VI factors as investment by LSP (15) and investment by government (16). The six hierarchical levels identified are shown in table 7.11.

7.5 Formation of Digraph

From the final reachability matrix, a structural model is developed as shown in figure 7.2. The resulting graph is called a digraph. Removing transitivities as described in the ISM methodology in section 3.8, the digraph is finally converted into an ISM model for logistics improvement.

7.6 MICMAC Analysis

As shown in figure 7.1, the variables are divided into four categories based on their driving power and dependence power. The four categories are as follows:

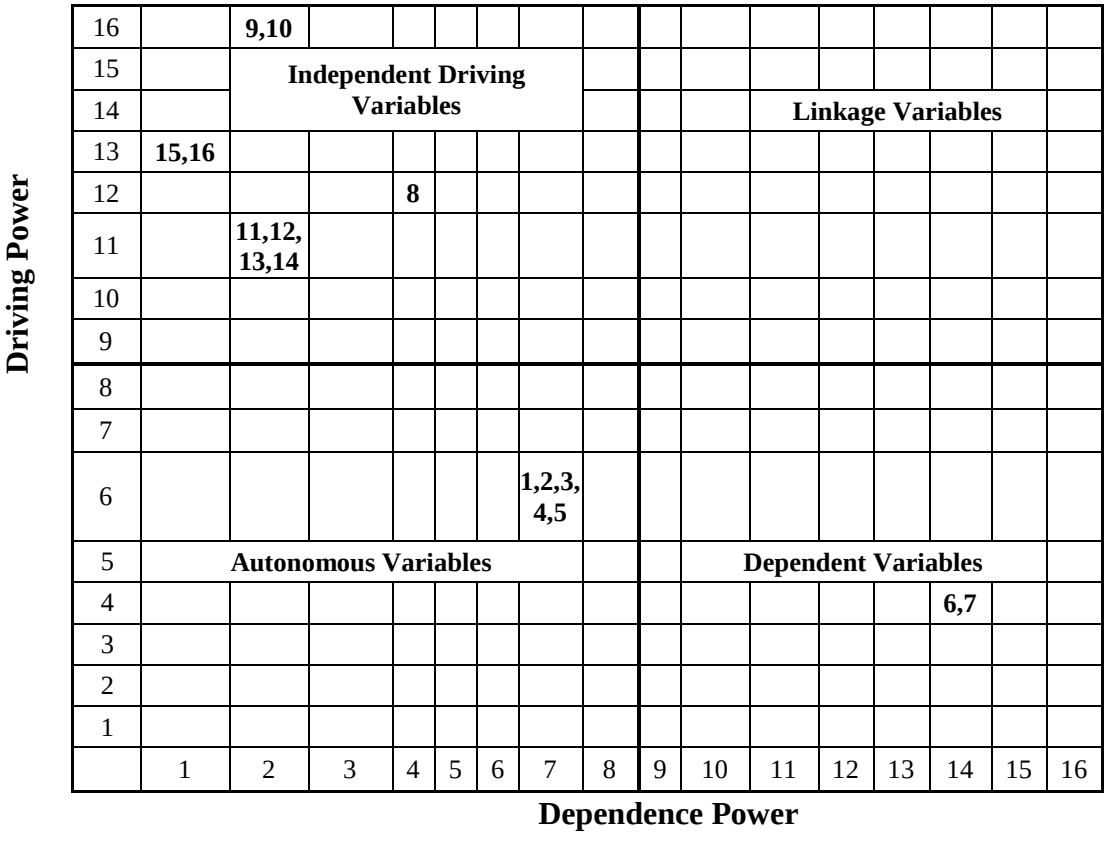


Figure 7.1 Driving Power and Dependence Diagram

1. Autonomous Variables: These performance measures have weak drive power and weak dependence. They are relatively disconnected from the system, with which they have few links, which may be very strong. The performance measures namely reduction in cost, reduction in time, improvement in reliability, improvement in flexibility and improvement in safety of the logistics system are autonomous variables. These five performance measures have a very strong relationship with the logistics performance index.
2. Linkage Variables: These have strong drive power as well as strong dependence. They are also unstable. Any action on them will have an effect on others and also a feedback effect on themselves. There are no linkage variables as shown in figure 7.1. This indicates that all the factors chosen for this study are stable.
3. Dependent Variables: This category includes those performance measures which have weak drive power but strong dependence power. From MICMAC analysis, improvement in profit and competitiveness of organization are dependent variables. Profit of any organization depends on many factors and same is the case with competitiveness.
4. Independent Driving Variables: These have strong drive power but weak dependence power. It is generally observed that a performance measure with a very strong drive power, called the "key performance measure", falls into the category of independent or linkage performance measures. As shown in figure 7.1, LPI, improved FDI, economic growth, skilled work force, IT enabled logistics system, infrastructure development, improvement in government regulations, investment by government and investment by LSP are independent driving variables.

7.7 Result and Discussion

The digraph is shown in figure 7.2. Sixteen variables have been divided into six levels. As per the digraph, investment by government and investment by LSP appearing at level six play a very significant role in improving the logistics performance index. From the digraph it can be seen that LSPs should concentrate on investment in information technology and in development of human resources. IT enabled logistics system will make the system more sophisticated and will ease the logistics processes making the system more reliable. To run such a system, skilled work force will be required; else investment in IT might backfire and can lead to huge losses. Also, if LSP decides to invest in IT and HR separately also, it will be able to gain competitive advantage against its competitors. Investment in the improvement of

human resources will make the workforce more motivated, thereby improving organizational performance and also improving the rate of retention.

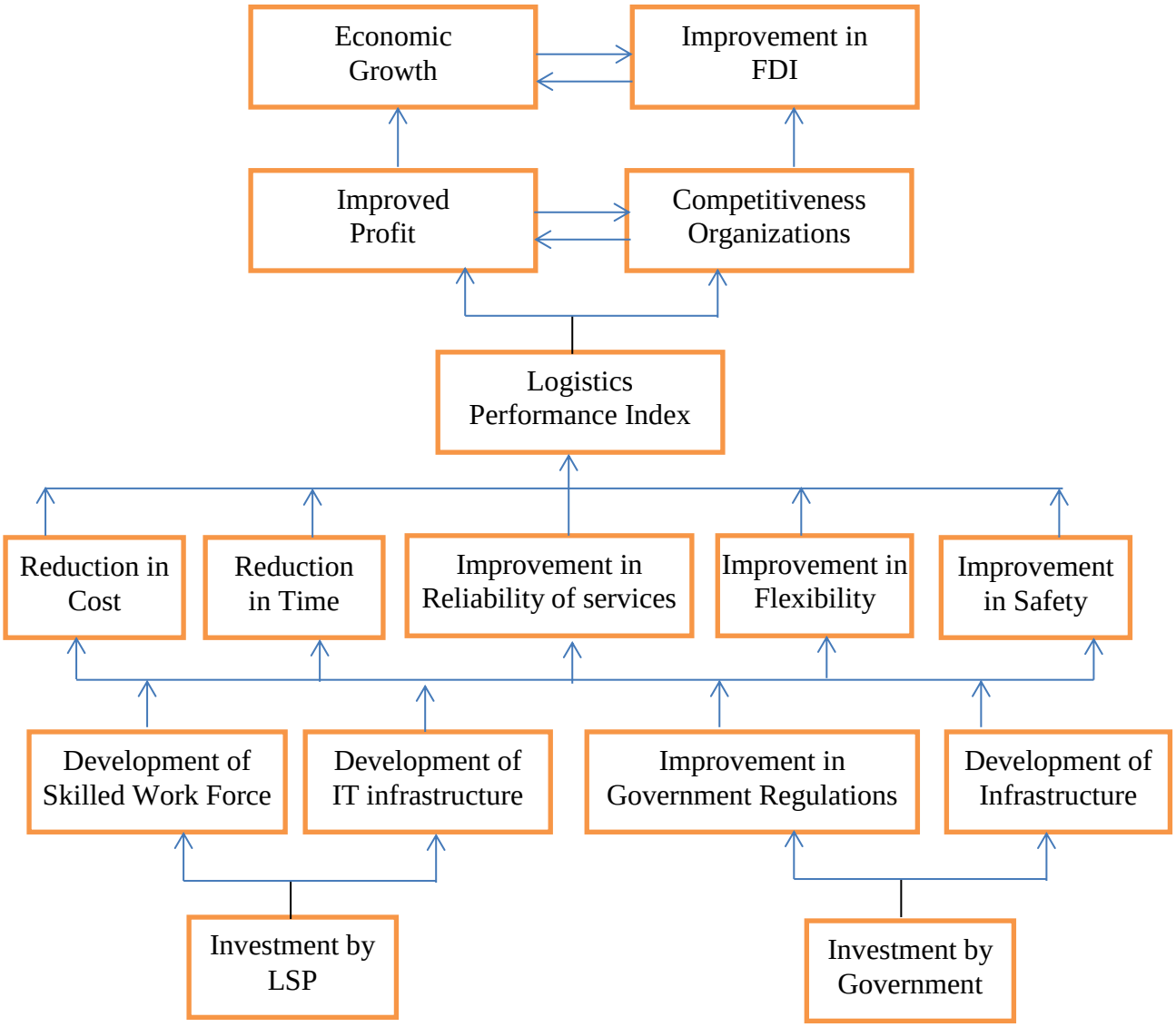


Figure 7.2 ISM Framework for Improvement in Logistics Performance

The four important components where India, have acquired the same level in the digraph, i.e. level 5. IT and HR will improve the logistics processes at the micro level. But development of infrastructure and easing of regulation will improve the processes at macro level. Government should concentrate on developing a strong and integrated infrastructure and make provisions for its maintenance also.

With a well-connected infrastructure, ease of government regulation will improve the business at the domestic and international level. Right now, all the twenty nine Indian states

have their own set of taxes which leads to a very high indirect logistics cost. Having a single uniform tax all over the country will lead to reduction in indirect costs and a lot of time will be saved in doing business and transportation of goods. These four components will act as the four pillars for logistics improvement, which will impact the five performance measures, namely, reduction in cost, reduction in time, improvement in reliability, improvement in flexibility and improvement in safety which have occupied the level 4 in the digraph.

The performance measures at level 4 will help in improving the logistics performance index which is at level 3. It is the link between the enablers and the results. The enablers are the four pillars at level 5, which will improve the performance measure at level 4, leading to improvement in LPI at level 3. LPI has a huge impact on improving the profit and competitiveness of organizations at level 2. The performance measures are the components of competitiveness. Therefore, it is obvious that improvement at level 4, will lead to improved profit and competitiveness through LPI. Competitive firms will attract more investment. Therefore, improvement in FDI and economic growth has acquired level 1. More FDI will bring more investment leading to more economic growth, thereby increasing more investments by government and LSPs leading to more improvement in LPI.

7.8 Conclusion

This chapter has tried to identify the critical factors for improving the logistics performance for a developing country like India. Better logistics performance will help the organizations improve its competitiveness in the market and to sell product at lower prices, thereby improving profit. At the macro level, better logistics performance will attract foreign direct investment and will help Indian companies to hold a strong place in the global market which will further boost the economic growth.

Logistics processes depends on several factors like infrastructure, use of information technology, skilled work force, logistics conducive government regulations etc. In this context, total 16 variables were identified in the present study. For establishing relationship between these critical variables, ISM approach has been applied. It has also helped in determining driving and dependence power of all variables.

It is observed that the key to good logistics performance is investment by government and investment by logistics service providers. Categorization of variables through MICMAC will help the decision makers to choose the investment areas appropriately.

Government should concentrate on building infrastructure and ease regulations for enhancing domestic and international trade. Through strong infrastructure, connectivity will improve which will save a lot of time and money in delivering goods. Also, good infrastructure will reduce damages to the vehicles thereby improving reliability of delivery. If the connecting links are strong, then last minute delivery changes can be made and flexibility can be improved. Good infrastructure will reduce accidents, damages to the goods etc., hence safety will also improve. When infrastructure is backed by logistics conducive government regulations, ease of trade will provide the businesses with the necessary edge. Also, "red-tape" has been quoted as the biggest hindrance after poor infrastructure to do business in India. Hence, improving that will attract a lot of foreign players to investment in the country.

LSPs should invest in the use of latest technologies along with a trained workforce. The combined investments by government and LSPs, will improve logistics performance through reduction in cost, reduction in time, improvement in reliability, improvement in flexibility and reducing damages and accidents thereby improving safety. Better logistics performance will help the organizations improve its competitiveness and profit and at the country level it will improve economic growth and FDI. The models discussed in chapter 4, chapter 5 and chapter 6 will only bear results if proper investment is done in the chosen areas. And the results of those investments are seen in chapter 7 in terms of profit improvement, improvement in competitiveness, improved FDI and economic growth. If the actors fail to invest in proper area and appropriate amount, the necessary improvement in logistics performance will not be achieved.

Chapter 8

CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

The present chapter provides the conclusion and recommendations. The contribution of work done in this research is discussed in 8.2., followed by the limitations of study and scope for future work in section 8.3. Final conclusion of research work is given in section 8.4.

8.2 Contribution of Study

1. The study focusses on the improvement of a very important area i.e. Logistics Management using system dynamics modelling.

2. The study has identified the important factors for the improvement in logistics management and then by using ISM techniques identified the focus areas for improvement.

3. The system dynamics modelling and scenario generation through simulation will help in proper improvement and investment strategy.

4. Study will help researchers to understand the challenges faced by the logistics industry in the Indian context and will act as a base for further studies.

5. Study is useful for practitioners for estimating the quantum of investment required for logistics improvement and the investment strategy.

6. Study will also help to identify the areas and strategies of investment to enhance logistics performance.

7. Simulation results will help to design effective investment policies.

8. ISM model have been developed to find the structural relationship between the critical factors influencing improvement in logistics performance and the consequences of this improvement. This will help the decision makers to formulate improvement strategies to achieve the desired results.

9. The study and the model are very versatile and generic, that can be used by governments and companies.

10. It can be highly customised according to the needs of an organization and variables/investment can be modified.

8.3 Limitations of the Study and Scope for Future Work

1. The inputs to the ISM model are qualitative in nature and based on expert opinions. The biasing of the manager to some criteria might have influenced the results. Techniques like Delphi method and structural equation modelling (SEM) can be applied or data can be collected empirically to nullify the effect.
2. The system dynamic model used to study investment in human resources and information technology is based on a case of single organization. This model is intended to serve as a starting point for further research. More companies similar to the case organization can be researched and more elements can be added to the model and data can be modified accordingly.
3. The models can be simulated by integrating them with each other and to study the actual improvement which can be achieved through the investment done.
4. The system dynamic model developed does not consider the influence of extraneous factors such as change in government policies, demonetization, strikes, terror attacks etc.
5. Interrelationship of processes or activities is not considered. For example, improvement in working condition does not affect training or wages etc. Similarly, improvement in RFID does not affect EDI. The model can be updated to study the effects of improvement in one process or activity on another.
6. Only five components are considered for LPI. Future studies can enhance LPI by including other components.
7. Limited areas of investment are considered in the study. This study can be extended further by including other areas of human resource management. Similarly, other technologies can be included to study their effect on logistics performance.
8. More investment plans can be formulated and tested.

8.4 Concluding Remarks

The objective of the study was to identify the investment areas, actors responsible for investment and formulate investment strategies for logistics improvement in the Indian context. A thorough literature review on various aspects of logistics management was done to

get a clear understanding on the studies conducted on Indian logistics industry, global logistics industry, role of logistics in economy and competitiveness, logistical studies conducted on performance measurement and research techniques used in the area.

For this purpose more than 600 journal articles, reports, new paper articles were reviewed. On the basis of the gaps identified, research objectives were formulated. System dynamics and interpretive structural modelling were the research techniques identified to be applied. Improvement in human resources, IT enabled logistics system, improvement in government regulations and development of infrastructure were chosen as the four areas for logistics improvement. The actors chosen for improvement in human resources and information technology was logistics service provider and for improvement in government regulation and infrastructure development was government.

Logistics performance index was chosen as the measure for logistics improvement. The five components of LPI identified as performance measures, were reduction in cost, reduction in time, improvement in reliability, improvement in flexibility and improvement in safety.

Improvement in training, working condition, welfare of the employees and improvement in wages were chosen for improvement in human resources. System dynamics was applied to study the effects of the improvement in these four areas. It was concluded that, improvement in human resources has a positive impact on the logistics performance index. Investment in training and improvement in working conditions were the two areas identified which can bring immediate logistics improvement.

RFID, EDI, GPS/GIS and ERP were the five technologies identified for investment in information technology. These technologies will impact the logistics processes like tracking and tracing, planning and forecasting, transportation and automation, coordination with suppliers and customers and decision optimization. Through simulation modelling, it was concluded that improvement in these processes will impact the logistics performance measures, thereby improving the logistics performance index. ERP was the technology identified which can help the organizations to attain immediate improvement.

Investment by government for infrastructure development will be routed for capacity building, network integration and maintenance of the new and existing infrastructure. For improvement in government regulation, implementation of single window, implementation of GST and electronic toll collection was chosen. Causal loop diagram and stock and flow

diagram were developed. Due to lack of availability of data, simulation of the model was out of the scope of this research work.

All the recommendations given in this research, lies on the investment done by the actors. Through ISM modelling, a digraph was created by choosing the sixteen critical success factors for logistics improvement, which will act as the roadmap to understand the positive effects of the improvement in the performance measures and LPI at the macro and micro level.

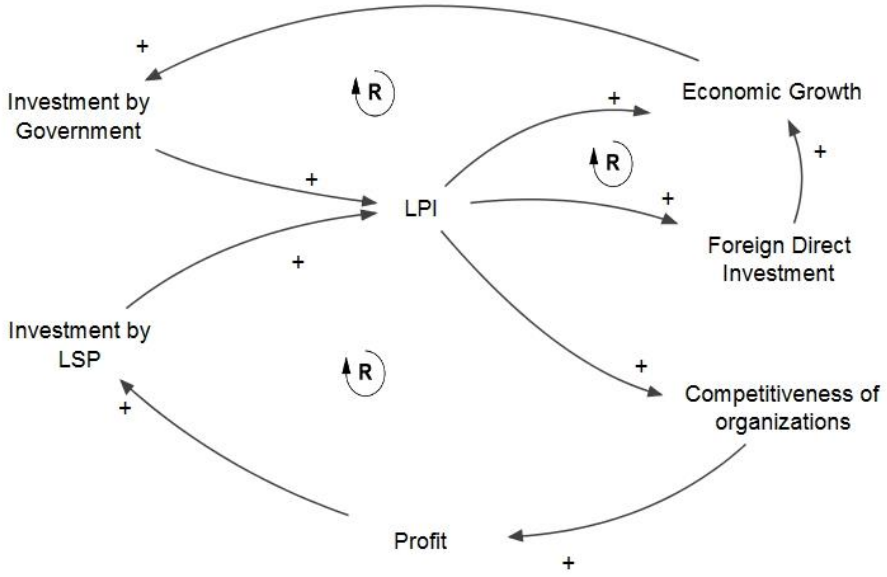


Figure 8.1 Integrated Causal Loop Diagram for Investment by Government and LSP

Figure 8.1 depicts the ultimate result which can be achieved if the recommendation of this research is followed. LPI will improve through investment by government and logistics service provider. Better logistics performance spurs growth, competitiveness and investment (Arvis et al., 2014). Therefore LPI will attract more foreign direct investment, which will increase the revenue to the government and also lead to economic growth. Therefore in figure 6, the loop between investments by government, LPI, FDI, economic growth is a reinforcing loop. Also, the competitiveness of organizations will improve which will improve the profit of the company. Competitiveness is synonymous with a firm's long-run profit performance and its ability to compensate its employees and provide superior returns to its owners (Buckley et al., 1988). Therefore the loop between investment by LSP, LPI, competitiveness of organizations, profit is a reinforcing loop in figure 8.1.

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ANNEXURE 1

Equations for Base Run Model for Investment in Human Resources

cost(t) = cost(t - dt) + (rate_of_change_in_cost) * dt

INIT cost = 163

INFLOWS:

rate_of_change_in_cost = (cost_disc/adtime)*total__improvement_cost

delivery_time(t) = delivery_time(t - dt) + (rate_of_change_in_time) * dt

INIT delivery_time = 140

INFLOWS:

rate_of_change_in_time = (time_disc/adtime)*total_improvement_time

flexibility(t) = flexibility(t - dt) + (rate_of_flex_imprvement) * dt

INIT flexibility = 55

INFLOWS:

rate_of_flex_imprvement = if(flexibility>=100) then 0 else (((100-flexibility)/100)*total__improvement_flexibility)

investment_in_HR(t) = investment_in_HR(t - dt) + (rate_of_inv) * dt

INIT investment_in_HR = 500000000

INFLOWS:

rate_of_inv = pulse(if (profit_improvement>=3) then (.01*500000000) else 0,36,1)

LPI(t) = LPI(t - dt) + (rate_of_change__of_LPI) * dt

INIT LPI = 50

INFLOWS:

rate_of_change__of_LPI = if (LPI<=95) then (total_impact__on_LPI*LPI) else 0

profit(t) = profit(t - dt) + (imp_in_profit) * dt

INIT profit = 10

INFLOWS:

imp_in_profit = lpi_improvement*.002

reliability(t) = reliability(t - dt) + (rate_of_rel__improvement) * dt

INIT reliability = 60

INFLOWS:

rate_of_rel__improvement = if(reliability>=95) then 0 else (((100-reliability)/100)*(total__improvement_reliability))

safety(t) = safety(t - dt) + (rate_of_safety_improvement) * dt

INIT safety = 52

INFLOWS:

rate_of_safety_improvement = if(safety>=100) then 0 else (((100-safety)/100)*total__improvement_safety)

adtime = 12

cost_disc = (goal_cost-cost)/goal_cost

cost_factor = (((init(cost)-cost)/init(cost))*100)*.0007

distribution_in__trng = pulse(.0833,0,1)/3

distribution_wages = pulse(.0833,0,1)/3

distribution_welfare = pulse(.0833,0,1)/3

distribution_working_condition = pulse(.0833,0,1)/3

flex_factor = (((flexibility-init(flexibility))/init(flexibility))*100)*.00035

goal_cost = 100

goal_time = 100

inv_in_training = per_in_training*investment_in_HR

inv_in_wages = investment_in_HR*per_in_wages

inv_in_welfare = per_in__welfare*investment_in_HR

inv_in_working_condition = investment_in_HR*per_in_working_condition

lpi_improvement = ((LPI-init(LPI))/init(LPI))*100

per_imp_trng_cost = .009

per_imp_wages_cost = .007

per_imp_wc_cost = .006

per_imp_wfare_cost = .006

per_in_training = .25

per_in_wages = .25

per_in_working_condition = .25

per_in__welfare = .25

per_trng_flex = .0015

per_trng_rel = .0025

per_trng_safety = .0015

per_trng__time = .007

per_wages_flex = .0015

per_wages_rel = .0025

per_wages_safety = .002

per_wc_flex = .003

per_wc_rel = .003

per_wc_safety = .002

per_wc__time = .007

per_wfare_flex = .002

per_wfare_rel = .0015

per_wfare_safety = .0015

per_wfare_time = .006

per__wages_time = .005

profit_improvement = ((profit-init(profit))/init(profit))*100

rel_factor = (((reliability-init(reliability))/init(reliability))*100)*.00035

safety_factor = (((safety-init(safety))/init(safety))*100)*.00025

time_disc = (goal_time-delivery_time)/goal_time

time_factor = (((init(delivery_time)-delivery_time)/init(delivery_time))*100)*.0005

total_impact__on_LPI = (cost_factor*.35+flex_factor*.15+rel_factor*.15+safety_factor*.1+time_factor*.25)

total_improvement_time = (training/100000)*per_trng__time+(wages/100000)*per__wages_time+(welfare/100000)*per_wfare_time+(working_condition/100000)*per_wc__time

total__improvement_cost = (training/100000)*per_imp_trng_cost+(wages/100000)*per_imp_wages_cost+(welfare/100000)*per_imp_wfare_cost+(working_condition/100000)*per_imp_wc_cost

total__improvement_flexibility = (training/100000)*per_trng_flex+(wages/100000)*per_wages_flex+(welfare/100000)*per_wfare_flex+(working_condition/100000)*per_wc_flex

total__improvement_reliability = ((training/100000)*per_trng_rel+(wages/100000)*per_wages_rel+(welfare/100000)*per_wfare_rel+(working_condition/100000)*per_wc_rel)

total__improvement_safety = (training/100000)*per_trng_safety+(wages/100000)*per_wages_safety+(welfare/100000)*per_wfare_safety+(working_condition/100000)*per_wc_safety

training = pulse((inv_in_training*distribution_in__trng),1,1)

wages = pulse((inv_in_wages*distribution_wages),1,1)

welfare = pulse((inv_in_welfare*distribution_welfare),1,1)

working_condition =
pulse((inv_in_working_condition*distribution_working_condition),1,1)

ANNEXURE 2

Equations for Base Run Model for Investment in Information Technology

coordination(t) = coordination(t - dt) + (rate_of_imp_coord) * dt

INIT coordination = 55

INFLOWS:

rate_of_imp_coord =

((100-coordination)/100)*(imp_in_CO)

cost(t) = cost(t - dt) + (rate_of_change_in_cost) * dt

INIT cost = 163

INFLOWS:

rate_of_change_in_cost = (cost_disc/adtime)*total_improvement_cost

decision_optimization(t) = decision_optimization(t - dt) + (rate_of_imp_do) * dt

INIT decision_optimization = 55

INFLOWS:

rate_of_imp_do =

((100-decision_optimization)/100)*(imp_in_DO)

delivery_time(t) = delivery_time(t - dt) + (rate_of_change_in_time) * dt

INIT delivery_time = 140

INFLOWS:

rate_of_change_in_time = (time_disc/adtime)*totaol_imp_time

flexibility(t) = flexibility(t - dt) + (rate_of_flex_imprvement) * dt

INIT flexibility = 55

INFLOWS:

rate_of_flex_imprvement = if(flexibility>=100) then 0 else (((100-flexibility)/100)*total_imp_flex)

investment_in_IT(t) = investment_in_IT(t - dt) + (rate_of_inv) * dt

INIT investment_in_IT = 2000000000

INFLOWS:

rate_of_inv = pulse(if (profit_improvement>=3) then (.01*500000000) else 0,36,1)

LPI(t) = LPI(t - dt) + (rate_of_change__of_LPI) * dt

INIT LPI = 50

INFLOWS:

rate_of_change__of_LPI = if (LPI<=95) then (total_impact__on_LPI*LPI) else 0

planning_and_forecasting(t) = planning_and_forecasting(t - dt) + (rate_of__imp_pf) * dt

INIT planning_and_forecasting = 60

INFLOWS:

rate_of__imp_pf = ((100-planning_and_forecasting)/100)*(imp_in_PF)

profit(t) = profit(t - dt) + (imp_in_profit) * dt

INIT profit = 10

INFLOWS:

imp_in_profit = lpi_improvement*.002

reliability(t) = reliability(t - dt) + (rate_of_rel__improvement) * dt

INIT reliability = 60

INFLOWS:

rate_of_rel__improvement = if(reliability>=95) then 0 else (((100-reliability)/100)*(total_imp_rel))

safety(t) = safety(t - dt) + (rate_of_safety_improvement) * dt

INIT safety = 52

INFLOWS:

rate_of_safety_improvement = if(safety>=100) then 0 else (((100-safety)/100)*total_imp_safety)

tracking_and_tracing(t) = tracking_and_tracing(t - dt) + (rate_of_imp_tt) * dt

INIT tracking_and_tracing = 30

INFLOWS:

rate_of_imp_tt = ((100-tracking_and_tracing)/100)*(imp_in_TT)

transportation_automation(t) = transportation_automation(t - dt) + (rate_of__imp_ta) * dt

INIT transportation_automation = 25

INFLOWS:

rate_of__imp_ta = ((100-transportation_automation)/100)*(imp_in_TA)

adtime = 12

cost_disc = (goal_cost-cost)/goal_cost

cost_factor = (((init(cost)-cost)/init(cost))*100)*.0007

distribution_edi = pulse(.0833,1,1)/3

distribution_erp = pulse(.0833,1,1)/3

distribution_gps = pulse(.0833,1,1)/3

distribution_rfid = pulse(.0833,1,1)/3

flex_factor = (((flexibility-init(flexibility))/init(flexibility))*100)*.00035

goal_cost = 100

goal_time = 100

impgps = .006

imp_edi = .007

imp_edi_co = .009

imp_edi_do = .008

imp_erp = .009

imp_erp_co = .007

imp_erp_do = .006

imp_erp_ta = .005

imp_gps_ta = .007

imp_in_CO =
(((inv_in_EDI/100000)*imp_edi_co)+(inv_in_erp/100000)*imp_erp_co)/100

imp_in_DO =
(((inv_in_edi/100000)*imp_edi_do)+(inv_in_ERP/100000)*imp_erp_do)/100

imp_in_PF = (((inv_in_edi/100000)*imp_edi)+(inv_in_erp/100000)*imp_erp)/100

imp_in_TA =
((((inv_in_RFID/100000)*imp_rfid_ta)+(inv_in_GPS/100000)*imp_gps_ta)+((inv_in_ERP/100000)*imp_erp_ta))/100

imp_in_TT =
((((inv_in_RFID/100000)*imp_rfid)+(inv_in_GPS/100000)*impgps))/100

imp_rfid = .006

imp_rfid_ta = .004

inv_in_EDI = pulse((distribution_edi*investment_in_IT*per_in_edi),1,1)

inv_in_ERP = pulse((distribution_erp*investment_in_IT*per_in_erp),1,1)

inv_in_GPS = pulse((distribution_gps*investment_in_IT*per_in_gps),1,1)

inv_in_RFID = pulse((distribution_rfid*investment_in_IT*per_in_rfid),1,1)

lpi_improvement = ((LPI-init(LPI))/init(LPI))*100

per_imp_co = ((coordination-init(coordination))/init(coordination))*100

per_imp_do = ((decision_optimization-init(decision_optimization))/init(decision_optimization))*100

per_imp_pf = ((planning_and_forecasting-init(planning_and_forecasting))/init(planning_and_forecasting))*100

per_imp_ta = ((transportation_automation-init(transportation_automation))/init(transportation_automation))*100

per_imp_tt = ((tracking_and_tracing-init(tracking_and_tracing))/init(tracking_and_tracing))*100

per_in_edi = .25

per_in_erp = .25

per_in_gps = .25

per_in_rfid = .25

profit_improvement = ((profit-init(profit))/init(profit))*100

rel_factor = (((reliability-init(reliability))/init(reliability))*100)*.00035

safety_factor = (((safety-init(safety))/init(safety))*100)*.00025

time_disc = (goal_time-delivery_time)/goal_time

time_factor = (((init(delivery_time)-delivery_time)/init(delivery_time))*100)*.0005

total_impact__on_LPI = (cost_factor*.35+flex_factor*.15+rel_factor*.15+safety_factor*.1+time_factor*.25)

total_improvement_cost = per_imp_co*.006+per_imp_do*.0065+per_imp_pf*.009+per_imp_ta*.007+per_imp_tt*.005

total_imp_flex = per_imp_co*.006+per_imp_do*.007+per_imp_pf*.008+per_imp_ta*.007+per_imp_tt*.0095

total_imp_rel = per_imp_co*.007+per_imp_do*.005+per_imp_pf*.009+per_imp_ta*.008+per_imp_tt*.009

total_imp_safety = per_imp_co*.007+per_imp_do*.005+per_imp_pf*.006+per_imp_ta*.009+per_imp_tt*.008

totaol_imp_time = per_imp_co*.0075+per_imp_do*.006+per_imp_pf*.0095+per_imp_ta*.008 +per_imp_tt*.007

PUBLICATIONS FROM RESEARCH WORK

Journal:

1. Jhawar, A. and Garg, S. (2010) 'Issues and Challenges of Logistics in Supply Chain Management Context', Productivity Promotion, Vol. 12, No. 49, pp. 1-17.
2. Jhawar. A., Garg. S. and Khera, S. (2014) 'Analysis of the Skilled Work Force Effect on the Logistics Performance Index- Case study from India', Logistics Research, Vol. 7, No. 1, pp. 1-10.
3. Jhawar, A., Garg, S.K. and Khera, S. (2016) 'Modelling and evaluation of investment strategies in human resource for logistics improvement', Int. J. Simulation and Process Modelling, Vol. 11, No. 1, pp. 36-50.
4. Jhawar, A. and Garg, S. (2016) 'System Dynamics Modelling to Study the Effects of Investment in Information Technology on Logistics Performance: A case study from India', International Journal of System Dynamics Applications, Vol. 5, No. 2, pp. 19-40.
5. Jhawar, A., Garg, S. and Khera, S. (2017) 'Improving logistics performance through investments and policy intervention: a causal loop model', Int. J. Productivity and Quality Management, Vol. 20, No. 3, pp.363–391.
6. Jhawar, A. and Garg, S. (2018) 'Modelling of Critical Factors for Improving Logistics Performance of India Using Interpretive Structural Modelling', International Journal of Applied Management Sciences and Engineering, Vol. 5, No. 1, pp. 29-51.

Conferences:

1. Jhawar, A. and Garg, S. (2011) 'Logistics Industry: An Indian Perspective', National Conference of Research Scholars in Management organized by Indian Institute of Information Technology and management, Gwalior, 26th-27th March.
2. Jhawar, A. and Garg, S. (2015) 'Effects of Investment in Information Technology on Logistics Performance Index (LPI) using Screening Design Experiment', International Conference on Emerging Trends in Mechanical & Industrial Engineering (ICETMIE-2015), ITM University, Gurgaon, 18th July.
3. Jhawar, A. and Bajpai, P. (2014) 'Applying FMEA and ISM Technique to Identify Factors Causing Delay in Road Construction Projects', 4th International Conference on Advances in Mechanical, Material, Manufacturing, Automobile, Aeronautical Engineering and Applied Physics, Krishi Sanskriti at Jawaharlal Nehru University 7th-8th June.

Book Chapter:

1. Jhawar, A. and Garg, S. (2018), “Logistics Improvement by Investment in Information Technology Using System Dynamics”, Advances in System Dynamics and Control, IGI Global.