CHAPTER 2

SUPPLY CHAIN MANAGEMENT AND SIMULATION CONTEXT

2.1 Introduction

This chapter introduces and clarifies the theories related to business crises, as referred to in the previous chapter. The main factors refer to the "*cost of doing business*", "*supply chain and infrastructure*" and "*knowledge and skill performance"*. In terms of the cost of doing business, "Maximizing profit and minimizing operational cost is firstly realized by investors, while the effectiveness of the supply chain and infrastructure enhances manufacturing efficiency and productivity, as well as providing knowledge and asset transfer needed to improve the skill and performance of labor within developing countries. Therefore, the first part of this chapter will explain theories and concepts associated with the supply chain and distribution network. The supply chain is then broken down into activities called "Value chain". Two theories on "s-curve" and "bathtub" analysis will also be introduced. With regards to their effect on international trade, this section helps to describe the relative contexts of the characteristics of the research problem. The processes are described and activities along the supply chain network are illustrated. The Supply Chains Operations Reference (SCOR) and simulation will then be explained. Finally, the three requirements to support investment decisions will be integrated by a model which considers the investment decisions of FDI. Foreign investors, the local industrial estate sector, and manufacturers will be represented as the key stakeholders.

2.2 Supply Chain management

During the 1980s, there was an increased interest in new techniques and strategies, which would allow companies to become more competitive in different markets. Resources were invested heavily in concepts and strategies such as just-in-time and lean manufacturing (*Kanban)*, and Total Quality Management (TQM). As part of these strategies, Supply Chain Management (SCM) evolved and is seen in Figure 2.1. Following the introduction of SCM, companies progressively recognized the need for effective coordination between companies, or networks, to compete in the global market and increasingly networked economy. More recently, it is clear that many companies have reduced manufacturing costs as much as is possible. In doing so, these companies are realizing that effective supply chain management is the next step towards an increased profit and market share.

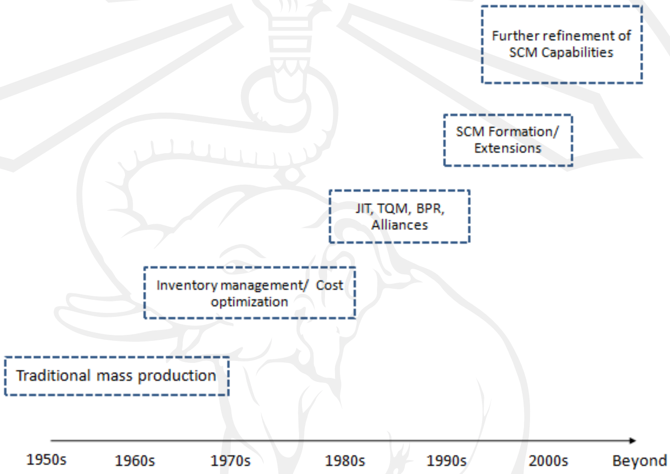

Figure 2.1 Evolution of supply chain management

In a typical supply chain, the conceptual steps are as follows:

1. Raw materials are procured
2. Products are manufactured at one or more plants
3. Products are stored and/or shipped to warehouses as an intermediate stage
4. Products are sent to retailers or directly to customers

Supply Chain Management aims to maximize efficiency and cost-effectiveness across throughout the entire process. Cost-effectiveness is considered from transportation through to distribution, the raw material inventories, work-in-process and finally, finished goods. Therefore, to reduce costs and improve service quality, the most effective supply chain strategy must be considered along with the interactions at various levels in the supply chain. The supply chain, (also referred to as the logistics network) is made up of suppliers, manufacturing centers, warehouses, distribution centers and products that flow between facilities (see Figure 2.2). There are a variety of conceptualizations and definitions with regards to SCM, but the most widely recognized and useful in this research are as follows:

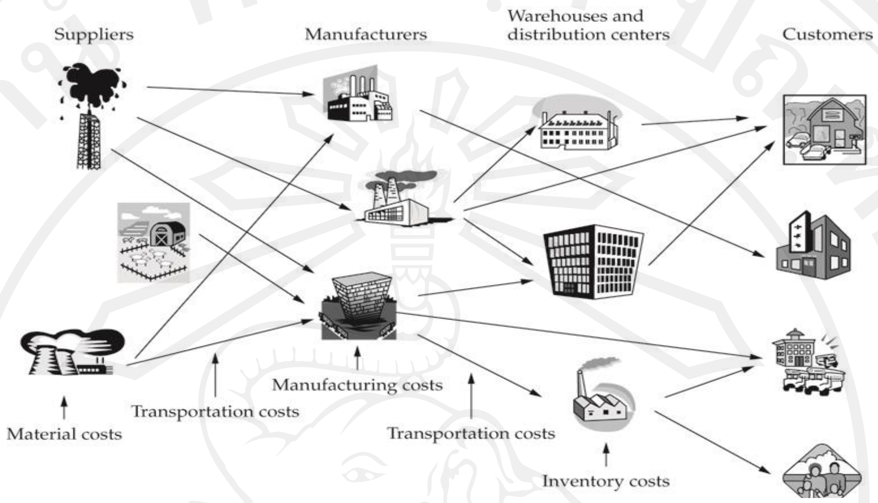

Figure 2.2 The logistics network [Simchi-Levi *et al.*, 03]

"...Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize systemwide costs while satisfying service level requirements..." [Simchi-Levi *et al.* [p.1, 03]].

"...Supply Chain Management is defined as a set of methods used to interconnect suppliers, manufacturers, warehouses and clients so that the merchandise is produced and distributed at the right quantity, to the right places at the right time with the objective of minimizing global system costs and maximizing the customer service levels ...." [T.Gonca and A.Gonca [p.1, 09]

Supply Chain Management centers on the efficient integration of suppliers, manufacturers, warehouses, and stores, and because of this it encapsulates the activities of the firm at many levels, from strategic to tactical and finally to the operational level. There are however a variety of factors leading to difficulties in supply chain management. These can be related to one or both of the following observations as describe by Simchi-Levi *et al.*, [2003]:

- To design and operate a supply chain while total system wide costs are minimized, and service levels are maintained across the system is challenging. It is often difficult to operate only a single facility. The difficulty increases significantly when considering a whole system. Finding the most effective system wide strategy is termed 'global optimization'. There are a variety of reasons as to why this optimization is a challenging process:
    - The supply chain is a complex network of facilities throughout a large geography, often worldwide.
    - Individual facilities within the supply chain often possess different and conflicting objectives. An example is suppliers who typically desire manufacturers commit themselves to procure large quantities in stable volumes and with flexible delivery dates. While most manufacturers would like to implement long production runs, they also need to be flexible to their customers' needs and demand changes.
    - The supply chain can be described as dynamic and is a system that evolves through time. Not only do customer demand and supplier capabilities change, but supply chain relationships also evolve and change through time.
- System variations should also be carefully considered over time. Even when demand from customer is precise.
- There is inherent uncertainty in every supply chain and customer demand can never be an exact forecast. Similarly, travel times can never be certain, and machines and vehicles are always susceptible to malfunction. Supply chains should be considered and planned to reduce as much uncertainty as possible effectively respond to uncertainty that remains.

To summarize thus far, supply chain effectiveness is necessary for global organizations to increase their profit and market share. To improve global supply chain performance, two major issues are the ability to effectively manage uncertainty and the ability to replace traditional supply chain strategies with a globally optimized supply chain. Existing manufacturers and new investors must improve their logistic network and be aware of existing and forthcoming uncertainties regarding FDI investment.

2.2.1 Uncertainties in supply chain management

In global supply chains, risks of variability and uncertainty in currency exchange rates, economic and political instability, and changes in the regulatory environment, are influenced on performance [Dornier *et al.*, 98]. Currency exchange rates affect the price for consumer goods that are purchased in the supplier's currency (abroad) while influence time and volume of purchases as well as the financial performance of the supply chain [Carter and Vickery 89]. Thus the studies in supply chain are usually involved with risks or uncertainties within organizations. Some evidence from the literature, for example, [T.Gonca and A. Gonca 09] mention that supply chain management without considering risk issues in a systemic perspective and their impact on the performance measures eventually lead to suboptimal results and inconsistent processes. The author noted that in real industrial environments, the sources of uncertainties are numerous and in order to get reliable results there is a need to have a reliable estimation of these uncertainties. The studies of supply chain risk management have been increasing dramatically since the year 2000 and will reach high values in 2010. At an academic level there has been a growing body of research into risk from a number of different perspectives, for example, economic [Kahnemann 79]; [Tversky92], finance, strategic management [Bettis 90]; [Simons 99] and international management [Miller 92]; [Ting 88]. In addition, more recently a number of contributions are addressing risk management from a logistics perspective by looking at the single organizations' inbound and/or outbound vulnerabilities [Svensson02]; [Johnson 01]; [Asidisim 99]; [Zsidisin 00].

In this case, efficient management with the occurrence of uncertainties and the ability of global optimized supply chain seems to enhance global performance for doing business. In addition, the integration of decisions across the supply chain also influences global supply chain design. Integrating business processes is a best practice in supply chain management that involves coordinating decisions across multiple facilities and tiers.

However, to be efficient in supply chain performance, there are the key issues to be aware of, as shown in Table 2.1. Those key issues span a large spectrum of a firm's activities from the strategic to operational level.

Table 2.1 Key supply chain management issues (Simchi-Levi et al., 03)

	Global optimization	**Managing uncertainty**
Distribution network configuration	√	
Inventory control		√
Supply contracts	√	
Distribution strategies	√	√
Strategic partnerships	√	
Outsourcing and procurement		√
Product design		√
Information technology	√	√
Customer value	√	√

The focus in each case is on either achieving a globally optimized supply chain or managing uncertainty in the supply chain, or both. From each key issue in supply chain, they are summarized them from strategic to operational decision as described in the following figure.

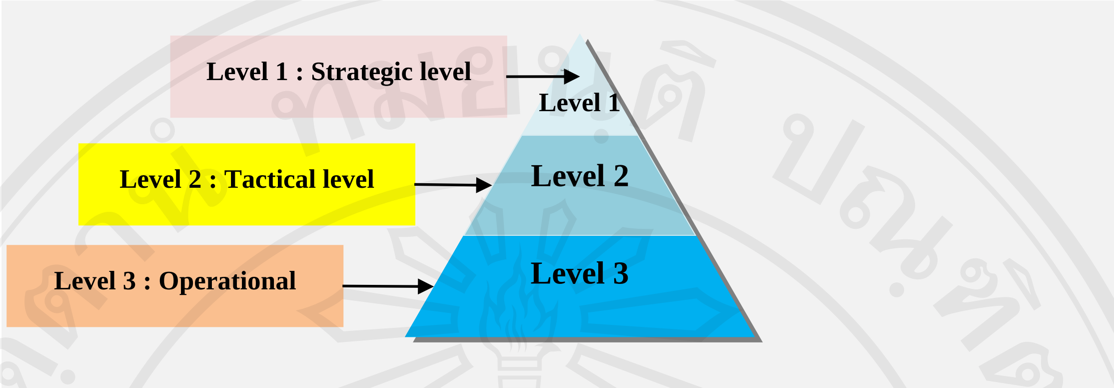

Figure 2.3: Strategic level to operational level along the supply chain (Simchi-Levi *et al.*, 03)

Figure 2.3, different levels are implemented in different decision area. The key issues associated with different decisions in each level show in Table below.

Table 2.2 Key issues in supply chain span from strategic to the operational level

Level 1: Strategic level	**Level 2: Tactical level**	**Level 3: Operational level**
Longterm decision: • Number, location and capcity of warehouses and manufacturing plants • Flow of material through the logistics networks.	Quarterly and annually decision: • Purchasing • Production • Inventory policies • Transportation strategies	Day-to-day decision: • Scheduling • Lead time quotations • Routing • Truck loading

Inventory Control: This involves carefully balancing and supervising the storage, supply and accessibility of production elements to ensure a best match between supply and demand; that is ensuring availability without oversupply. As an example, imagine a firm maintaining an inventory of a product. Customer demand changes over time and therefore the retailer can only use historical data to assess future demand. With inventory control, the aim of the firm is to decide the best point to reorder new products as well as how much with the objective of minimizing inventory, ordering and holding costs.

Outsourcing and Procurement Strategies: Redesigning the supply chain strategy involves coordinating different activities in the supply chain, but perhaps more importantly, it involves deciding what to make internally and should be sourced from outside.

Production: Manufacturing activities are a set of activities to produce and deliver goods to customer. Components are purchased from outside suppliers as the world wide networks.

Supply chain management deals with decisions on a long-term basis as well as day-to-day decisions, which occur along the entire supply chain network. This means that supply chain management must consider every facility that has an impact on cost and plays a role in ensuring the product meets customer requirements. This is from supplier and manufacturing facilities through to warehouses and distribution centers to retailers and stores [Simchi-Levi et al., 03]. Some supply chain analyses suggest there is a necessity to account for the all aspect of the chain, such as suppliers' suppliers and the customers' customers as they have an impact on supply chain performance in the form of inventories of raw materials, work in process, and finished goods. The emphasis therefore should not be on simply minimizing transportation costs or reducing inventories but should focus on taking a systems approach to supply chain management. International supply chain management can be described as the same as domestic supply chain management, but spread over a larger geographic area. Having said this, international supply chain networks often provide additional opportunities if effectively managed. There is also potential for additional problems, which firms should be aware of. International supply chains can run across the spectrum from being primarily domestic to a truly integrated global supply chain.

2.2.2 International Issues in Supply Chain Management

Manufacturers typically set up foreign factories to benefit from tariff and trade concessions, low cost labor, capital subsidies, and reduced logistics costs

[Ferdows 97]. Likewise, benefits accrue due to access to overseas markets, organizational learning though close proximity to the customer, and improved reliability because of close proximity to suppliers [MacCormack *et al.*, 94].

A supply chain design problem comprises the decisions regarding the number and location of production facilities, the amount of capacity at each facility, the assignment of each market region to one or more locations, and supplier selection for sub-assemblies, components and materials [Chopra 04]. Global supply chain design extends this definition to include selection of facilities at international locations [Meixell and Gargeya 05].

In many ways, international supply chain management is the same as domestic supply chain management spreading over a larger geographic area. However, international supply chain networks can provide a wealth of additional opportunities if they are managed effectively. At the same time, there are many additional potential problems and pitfalls to be aware of. Global supply chain design extends the definition of supply chain to include selection of facilities at international locations, and the special globalization factors involved [Meixell and Gargeya 05]. Besides, global supply chain design models are in a special class and distinct from general supply chain design models, due to the differences in cost structure and complications of international logistics.

According to international supply chains integrate global supply chain partners. The characteristic of global supply chain partners can be explained as the following.

- International distribution systems: Within this type, manufacturing still occurs domestically, but distribution and typically some marketing take place overseas.

- International suppliers:

Raw materials and components are furnished by foreign suppliers, but final assembly is performed domestically. In some cases, the final product is then shipped to foreign markets.

- Offshore manufacturing:

The product is typically sourced and manufactured in a single foreign location, and then shipped back to domestic warehouses for sales and distribution.

- Fully integrated global supply chain:

Fully integrated global supply chain: Here products are supplied, manufactured, and distributed from various facilities located throughout the world. In a truly global supply chain, it may appear that the supply chain was designed without regard to national boundaries [Simchi-Levi et al., [p.150, 03]].

Supply chain can fit into more than one of these categories. Throughout the following discussion, a consideration of how each of the issues above applies differently to firms takes place and is considered with regards to their position in the global supply chain spectrum.

Experts argue that global supply chains are more difficult to manage than domestic supply chains [e.g Dornier *et al.*, 98; Wood, 02; MacCarthy, 03]. In these global situations substantial distance not only increases transportation costs, but also leads to complicated decisions. Increasing the lead-time in the supply chain results in increased inventory cost. Variation in local culture, language, and practice diminishes the effectiveness of business processes such as demand forecasting and material planning. Similarly, infrastructural deficiencies in developing countries in transportation and telecommunications, as well as inadequate worker skills, supplier availability, supplier quality, equipment and technology provide challenges normally not experienced in developed countries [Ken and Song 09]. The difficulties inhibit how the global supply chain provides competitive advantage. Therefore, global supply chain design models are in a special class and distinct from the general supply chain design models, due to the differences in cost structure and complications of international logistics.

The origin of international business can be traced back by examining the work done by Vernon (1966) who developed the pattern of international and called it "Product Cycle" theory. He suggests that the product location for products moves from one country to another depending upon the stage of the product's life cycle. To clarify the theory and the stage of the product's life cycle, the following section describes the trade theory and pattern of international trade.

2.2.2.1 The pattern of international trade

The static framework of comparative advantages developed by Raymond Vernon had the objective to advance trade theory beyond David Ricardo. In 1817, Ricardo had come up with a simple economic experiment to outline the advantages for a country with an absolute advantage in all product categories to trade and allows its work force to specialize in those categories with the highest added value. Vernon however, focused on the dynamics of comparative advantage and drew inspiration from product lifecycle to explain how trade patterns changed over time. The International Product Life Cycle (IPLC) can be described by Vernon [66] as "*an internationalization process wherein a local manufacturer in an advanced country begins selling a new, technologically advanced product to high-come consumers in its home market*." Production capabilities can be built locally to stay in close contact with its clientele and to minimize risk and uncertainty.

Along with a rise in demand from consumers in other markets, production increasingly shifts abroad which in turn allows the firm to maximize economies of scale and bypass trade barriers. Simultaneously, the product matures, becoming more complex and the number of competitors' increases. In the end, the innovator from the advanced nation becomes a challenge in its own home market by making the advanced nation a net importer of the product. This product is produced either by competitors in less developed countries or by foreign-based production facilities, if the innovator has developed into a multinational manufacturer. The IPLC international trade cycle consists of three stages as shown in Figure 2.4:

As demand from consumers in other markets rises, production increasingly shifts abroad enabling the firm to maximize economies of scale and to bypass trade barriers. Simultaneously, the product becomes more matures and complex, the number of competitors' increases. In the end, the innovator from the advanced nation becomes challenge in its own home market making the advanced nation a net importer of the product. This product is produced either by competitors in less developed countries or by its foreign based production facilities, if the innovator has developed into a multinational manufacturer. The IPLC international trade cycle consists of three stages as shown in Figure 2.4:

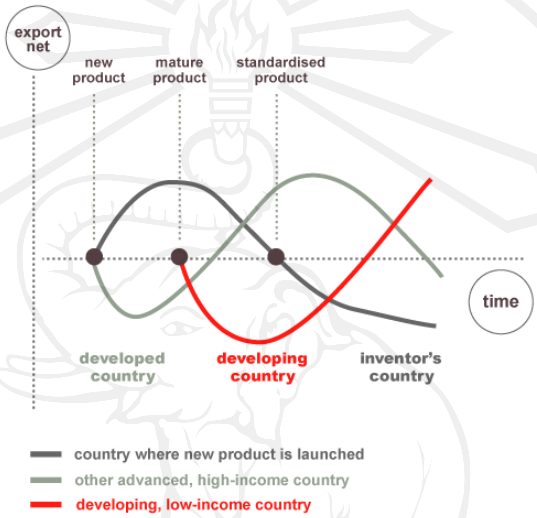

Figure 2.4 Three-stage international product life cycle

(Source: [ProvenModels 09])

- New product

The IPLC begins when a company in a developed country seeks to exploit a technological breakthrough by launching a new, innovative product on its home market. Such a market is more likely to start in a developed nation because more high-income consumers are able to buy and are willing to experiment with new, expensive product. Furthermore, easier access to capital markets exists to fund new product development. Production is also more likely to start locally in order to minimize risk and uncertainty: allocation in which communication between the markets and the executives directly concerned with the new product is swift and easy, and in which a wide variety of potential types of input that might be needed by the production units are easily come by.

- Maturing product

Exports to markets in advanced countries further increase through time, making it economically possible and sometimes politically necessary to start local production. The product's design and production process become increasingly stable. Foreign direct investments (FDIs) in production plants drive down unit cost because labor cost and transportation cost decrease. Offshore production facilities meant to serve local markets that substitute exports from the organization's home market. Production still requires high-skilled, high paid employees. Competition from local firms started in these non-domestic advanced markets. Export orders begin to come from countries with lower income.

- Standardized product

During this phase, the principal markets become saturated. The innovator's original comparative advantage based on functional benefits has been eroded. The firm begins to focus on the reduction of process cost rather than the addition of new product features.

As a result, the product and its production process become increasingly standardized. This enables further economies of scale and increases mobility of manufacturing operations. Labor starts to be replaced by capital. *"If economies of scale are being fully exploited, the principal difference between any two locations is likely to be labor costs"* [ProvenModels 09[a]]. Firms are likely to relocate to cheaper laboring countries while they counter with price competition and trade barriers or to meet local demand. As previously in advanced nations, local competitors will access knowledge and can copy and sell the product. Afterwards, the demand of the original product in the domestic country dwindles from the arrival of new technologies, and other established markets become increasingly price-sensitive. An MNC will internally maximize "offshore" production to low-wage countries as it can move around capital and technology, but not labor. As a result, the domestic market will have to import relatively capital-intensive products from low-income countries.

There are two relevant theories to illustrate corresponding to the stage of the product life cycle, the stage of there turn on investment and characteristic of human behavior. The theories are "S-curve analysis" and "Bathtub analysis", as depicted below:

- S-curve analysis

Figure.2.5 explains on the s-curve shape that an increase on the returns existed at small-investment levels and a decrease on returns occurred at high investment levels. The investor, one of the three stakeholders considered in this study, is inarguably interested in financial aspect. The s-curve can explain the life cycle of innovations for entrepreneurs of that plant. Moreover the curve will be helpful for an understanding of technologies used to manufacture. [Everett M.Rogers 62] proposed the theory of Diffusion of Innovations which described the use of “s-curve” or “diffusion curve” He suggests that the adoption of a technology begins with slow change, then is followed by rapid change and ends in slow change as the product matures or new technologies emerge. Moreover, the s-curve complies with the growth of revenue or productivity according to time. There are 3 stages of innovation in life cycle as presented in Figure 2.5

- Experimentation or the early stage of innovation: It is relatively slow as the new product establishes itself.
- Learning: At some point customers begin to demand and the product growth increases more rapidly. New incremental innovations or changes to the product allow growth to continue.
- Maturity: Towards the end of its life cycle growth slows and may even begin to decline. In the later stages, no amount of new investment in that product will yield a normal rate of return [ProvenModels 09[b]].

The s-curve is obtained from half of a normal distribution curve. It is assumed that new products are likely to have "Product Life" such as a start-up phase, a rapid increase in revenue and eventual decline.

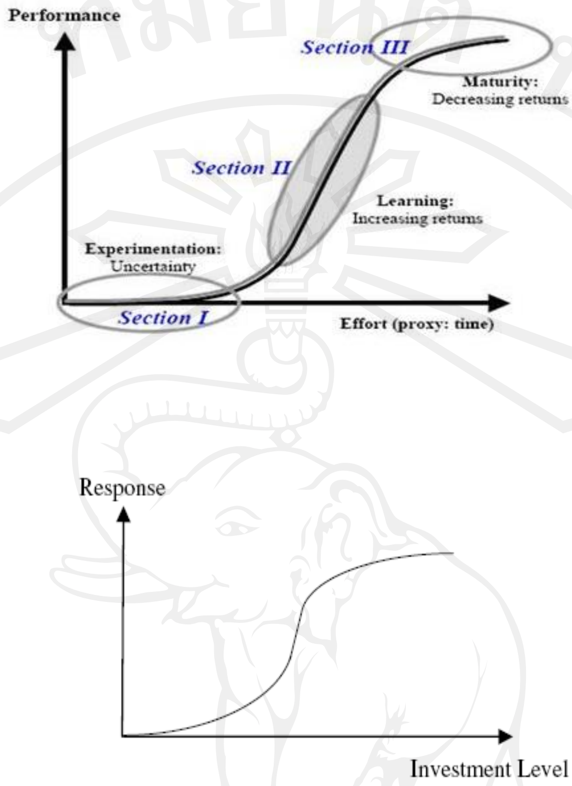

Figure 2.5 (a): An S-curve response function, and (b): S-Curve of technology
(Source: Agrali and Geunes, 09)

The assumption shows that innovative companies will typically work on new innovations that will eventually replace older ones. Successive s-curves come along to replace older ones and continue to drive growth.

For the reason of moving the stage of product life cycle, these will also influence human performance in companies. Workers need to adjust their performance and efficiency to follow the innovation. The next section explains how this situation affects skilled labor and how it should improve.

- Bathtub analysis

Slack [p.51, 96] noted Failure as *"... for most parts of an operation, is a function of time"*. In many cases, plotting the failure rate against a continuous time scale, the results will constitute the so-called "bath-tub" curve (see Figure 2.6). The typical theory of "bathtub" curve has been widely accepted as an engineering tool.

The shape of bathtub is the characteristic of failure rate curve of many well-designed products and components including the human body [Oakland 92]. The curve is a classic hazard rate which describes the failure pattern of the life of a product. The bathtub curve is also considered typical of many products and typical human life [John 95].

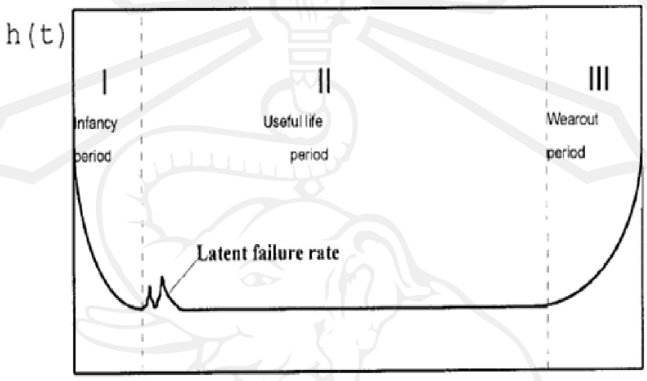

Figure 2.6 A typical bathtub curve

(Source: English *et al.*, 95)

As is shown in Figure 2.6, which is a typical bathtub curve with a Time-dependent failure rate. The curve is developed along three significant periods as described below:

- Early failure period (learning phase, infant mortality, burn-in or wearing period)

There are early failures caused by initial weaknesses of defects in material, man, machine and method. Early failures show up early in the life of a unit and are characterized by a high hazard rate in the beginning, which keeps decreasing as time elapses. Burn-in or other debugging processes usually detect these failures.

- Second period (Useful life)

The hazard rate is approximately constant and failures occur only at random. These unexpected failures are caused accidently and increase the stress level beyond the design strength and they cannot be eliminated by debugging techniques or maintenance practices. When the internal or external stresses exceed the design strength, there is often a "jump" in the hazard curve known as "latent failure" shown in Figure 2.6. No one can predict when these latent failures occur, and they are basically unavoidable. They can be reduced by redesigning for extreme conditions, such as overdesigning, or by using a specific environmental stress screening test before the product is delivered to the customer.

- Wear-out period

During this period, products fail due to fatigue at an increasing rate. The point at which wear out begins can be dramatically reduced as emerging and replacement technologies are introduced due to obsolescence.

Considered as a bathtub curve of human behavior, the model of the learning curve expresses the relationship between efficiency gain and investment in the effort [Simchi-Levi *et al.*,03]. The experience curve is shown in Figure 2.7, which is explained behavior that the more experience, the better and easier you can do. Further, fatigue and machine depreciation is the main cause leading to human error which is occurring on the last stage of the model.

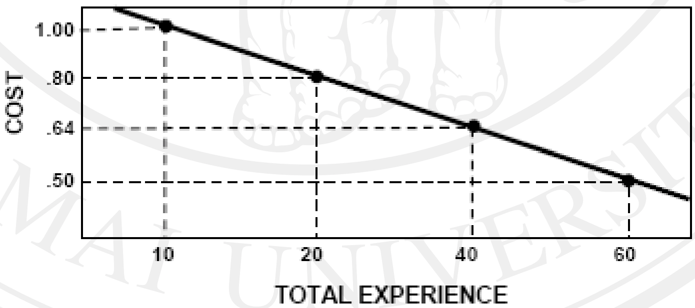

Figure 2.7 Experience Curve

[Source: Texas Instruments Incorported 73]

Consequently, business development in the form of high technology investment is introduced, e.g., automated machines, and high technology instruments. This innovation needs training and adaptation of skilled labor to operate. Then the high-skilled labor and advanced technology can prevent increasing human error. Successive s-curves will replace older ones and continue to drive growth upwards.

Acquisition of labor skill and knowledge is essential in the late stages of economic growth. The term "*innovation*" refers to significant changes leading to productivity increases that are fundamental sources of economic growth. Innovation is not limited to product innovation but it also includes innovation of process which is all activities that expand the knowledge base.

At the professional level, only a small number of establishments indicate that the supply of university graduates falls short of their demand. At the unskilled worker level, however, labor shortages could be a serious problem, especially in labor-intensive industries such as food processing and garment where many vacancies result from too few applicants [PICS 07].

There are several skills that managers feel their current workers do not possess at a satisfactory level. The local technicians lack the following skills: foreign language (English), information technology (IT), numerical skills and creativity skills. On the other hands, professional staffs have satisfied by firms even though they are not proficient in English.

In addition to enhance basic and technical skills, many firms look for loyalty in their employees. In fact, 15 percent of firms viewed loyalty as more valuable than common attributes such as educational level and experience. High staff turnover is detrimental and discourages firms from providing in-house training, thus further weakening labor skills. High turnover rates of skilled professionals can be posed as risk to the business or organization, due to the human capital (such as skills, competences, and knowledge) lost**.** Unskilled positions often have high turnover, and employees can generally be replaced without the organization or business incurring any loss of performance. High turnover often means that employees are unhappy with the work or compensation. Low turnover indicates that employees are satisfied, healthy and safe, and their performance is satisfactory to the employer. So, high turnover can be harmful to a company's productivity, if skilled workers are often leaving and the worker population contains a high percentage of novice workers. Besides, turnover incurs both replacement costs to the organization, and resulting in a competitive advantage to the business [PICS 07].

Thus, in order to reduce human failure, transferring or replacing with high technologies has been considered. Besides, sharing of expertise and knowledge will be applied to system. These lead to more reliability on the skills and abilities to work, as well as to enhance the productivity. Finally, workers can learn fast, which leads to cost reduction and improve the system's overall performance.

The production location moves from one country to another, influencing product innovation and human behavior. However this situation has caused from the nature forces of competition. These forces create danger to businesses, which are known as the five competitive forces.

2.3 Value chain

Competitive advantage is derived from the way firms organize and perform their activities. The operations of any firm can be divided into a series of activities such as sales, technicians performing repairs, scientists designing products or processes, and treasurers raising capital. Firms create value for their stakeholders by performing these activities. The ultimate value a firm creates is measured by the amount of buyers willing to pay for its product or service. A firm is profitable if this value exceeds the collective cost of performing all the required activities. To gain competitive advantage over its rivals, a firm must either provide comparable buyer value but perform activities more efficiently than its competitors (low cost), or perform activities in a unique way that creates greater buyer value and commands a premium price (differentiation).

Activities performed when competing in a particular industry can be grouped into categories as is shown in Figure 2.8, known as the "Value Chain." All the activities in the value chain contribute to buyer value. Activities can be divided generally into those involved in the ongoing production, marketing, delivery, and servicing of the product (primary activities) and those associated with providing purchased inputs, technology, human resources, or overall infrastructure functions to support the other activities (support activities). Every activity requires purchased inputs, human resources, some combination of technologies, and draws on firm infrastructure such as general management and finance. Michael Porter, (1985) suggested the value chain framework. Strategy guides the way a firm performs individual activities and organizes its entire value chain. This framework is arranged so that the organization is split into “primary activities” and “support activities”. Those primary activities, Porter [1985], reported that:

- Primary activities:
    - Operation: including machining, packaging, assembly, equipment maintenance, testing and all other value-creating activities that transform the inputs into the final product.
    - Outbound logistics: the activities required to get the finished product to the customer, namely warehousing, order fulfillment, transportation, distribution management.
    - Marketing and sales: the activities associated with getting buyers to purchase the product including channel selection, advertising, promotion, selling, pricing, retail mngt.etc
    - Service: the activities that maintain and enhance the product’s value, including customer support, repair services, installation, training, spare parts management, upgrading, etc.

- Supporting activities:
    - Procurement: procurement of raw material, servicing spare parts, building, machine.
    - Technology development: includes technology development to support the value chain activities such as research and development, process automation, design, redesign.
    - Human resources: Activities associated with recruiting, development (education), retention and compensation of employees and managers.
    - Firm infrastructure: includes general management, planning management, legal, finance, accounting, public affairs, quality management.

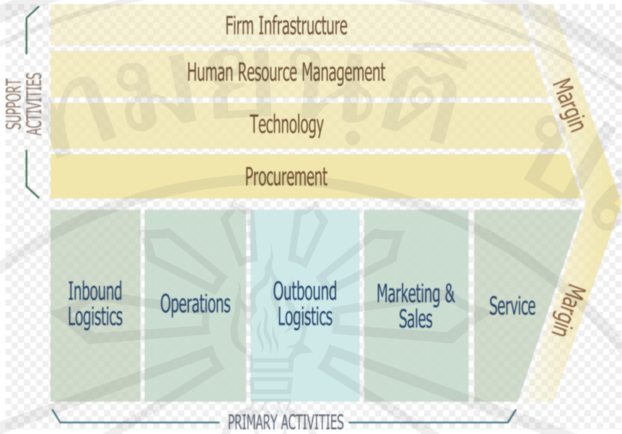

Figure 2.8 Value chain, Michael Porter, (1985)

In PICS, 2007, firm more than just its activities and synergistically combines its activities to create value. A firm's value chain is an interdependent system or network of activities, connected by linkages. These linkages occur when the way in which one activity is performed affects the cost of effectiveness of other activities. For example, a more costly of product design, more expensive components, and more inspection, these can worsen the costs of after-sale service. To achieve competitive advantage, a company must resolve such trade-offs in accordance with its strategy.

Such linkages also require activities to coordinate activities. On-time delivery requires that operations, outbound logistics, and service activities should perform in efficiency. Well coordination through activities can reduce operational costs and better information for control issues. Thus, coordinating is an important approach reducing time and increasing competitive advantage while competitive advantage is increasingly becoming a function of how well a company can manage the entire system. Moreover, this strategy not only connects activities but also create interdependencies between a firm, as suppliers and customer channels.

In any industries, whether they are domestic or international, the competition is embodied within five competitive forces. Porter [79] proposed a framework for industry analysis and business strategy development. For most industries, the intensity of competitive rivalry is the major determining factor of competitiveness in the industry. Three of Porter's five forces refer to competition from external sources (Horizontal competition). The remaining forces are internal threats (Vertical competition). Three of Porter's five forces are from 'horizontal' competition, namely the threat of substitute products, the threat of established rivals, and the threat of new entrants; and the other two forces are from 'vertical' competition, the bargaining power of suppliers and the bargaining power of customers. The five competitive forces can be summarized below (see Figure 2.9).

1. The threat of new entrants
2. The threat of substitute products of services
3. The bargaining power of suppliers
4. The bargaining power of buyers
5. The rivalry among the existing competitors

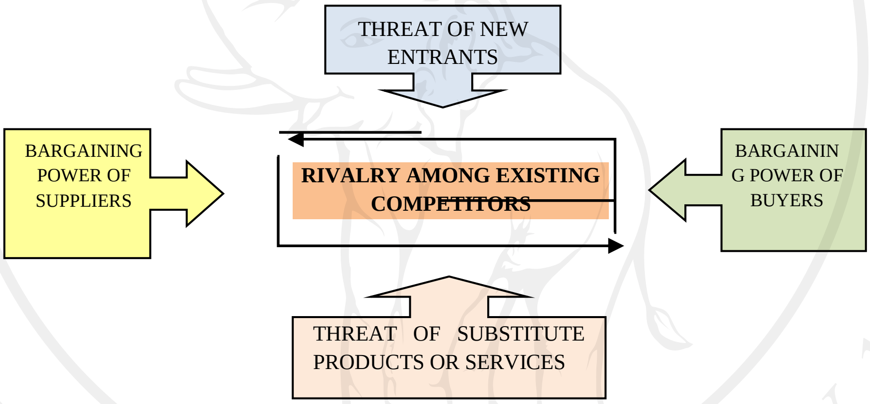

Figure 2.9 The Five competitive forces that determine industry competition [Porter 90]

Porter, 1990 described the five competitive forces is to "*determine industry profitability because they shape the prices firms can charge, the costs they have to bear, and the investment required to compete in the industry. The strength of each of the five competitive forces is a function of industry structure, or the underlying economic and technical characteristics of an industry*".

The structure of industry is significant in international competition for a number of reasons. **Firstly**, it creates differing requirements for success in different industries. Competing in a fragmented industry such as clothing requires different resources and skills from those required to compete in commercial aviation. A nation can provide a better environment for competing in some industries than others.

Secondly, industries important to high standards of living are often those that are structurally attractive. Structurally attractive industries, with sustainable entry barriers in areas such as technology, specialized skills, channel access, and brand reputation, often involve high labor productivity and will earn more attractive returns on capital. Standards of living will depend on the capacity of a nation's firms to successfully penetrate structurally attractive industries. Industry attractiveness is not reliably indicated by size, rapid growth, or newness of technology or by attributes often stressed by executives and government planners, but by industry structure. By targeting entry into structurally unattractive industries, developing nations have frequently made poor use of scarce national resources.

Finally, industry structure is important in international competition as structural change creates opportunities for competitors from a nation to penetrate new industries. Japanese copier companies, for example, successfully challenged American dominance (notably from Xerox and IBM) by stressing an underserved product segment (small copiers), and employing a new approach to the buyer (the use of dealers instead of direct sales), altering the manufacturing process (mass production versus batch), and modifying the approach to pricing (outright sales versus capital-intensive copier rental) [Porter 85]. The new strategy reduced entry barriers and invalidated the previous leader's advantages. How a nation's environment points the way or pressures its firms to perceive and respond to such structural changes are of central importance to understand the patterns of international success. In the previous section the pattern of international trade theory and the influence of the five competitive forces was outlined. The next section gives details about adaptation to those related theories.

In short, a value chain is a chain of activities for a firm operating within a specific industry. The value-chain concept has been extended beyond individual firms and can also apply to the whole supply chains and distribution networks in the companies. In order to evaluate the decision on the plant situation and to appropriately measure an organization's performance to align with activities in the supply chain it is necessary to illustrate the system in order to identify and explain disruptions along the supply chain. Thus the following section is a review of literature on strategies used to measure performance in a supply-chain context.

2.4 Applicable strategies used in a supply chain context

To date, much of the emphasis in supply chain management has been on cost reduction, although performance in real-world supply chains has multiple attributes, as defined in the Supply Chain Operations Reference (SCOR) model. Performance is measured in terms of reliability, responsiveness, flexibility, cost, and assets [SCC 08]. The SCOR model includes delivery and order fulfillment performance, production flexibility, warranty and returns processing costs, inventory, and other factors in evaluating the overall effective performance of a supply chain [Jean 07]. Meixell and Gargeya [p.534, 05] claimed that there are several authors such as [Bozarth 98], suggest delivery performance and quality as important measures in global supply chain management. Firms that had previously looked to their international manufacturing sites as a source of low-cost advantage now rely on their global production sites for improved access to customers, suppliers and skilled employees [Ferdows 97]. Nonetheless, the survey investigates which strategies are used and which supply chain decisions are relevant. The results of the survey are described on Table 2.3.

Table 2.3 Literature survey—parallel and distributed supply chain strategy

	Authors	Supply chain categories	Metrics and measures followed SCOR	VCOR	Real option theory	Fuzzy logic	Gauging absence of prerequisites (GAP) analysis	AHP	ABC based costing method	Multi agents	A multi-criteria scoring procedure	FMEA	Scheduling algorithm	SMED	System dynamics
1	A.Gunasekaran, C.Patel, Ronald E. McGaughey	Framework for supply chain performance measurement	1												
2	Federica Cucchiella, Massimo Gastaldi 06	Risk management in SC			1										
3	S.Kara, G.Freeman, B.Kayis, T.Ray and H.Abbass,IEEE 2005	MAS on manufacturing supply chain								1					
4	K.Rojanapibul, J.Pichitlamken, 2005	Assessing risk in job schedule for m-machine shopfloor problem											1		
5	Jennifer V., Kevin P.and Danny J. (2008),	Supplier risk assessment									1				
6	Fredrik Persson, Mirko Araldi, 2009,	Dynamic of supply chain analysis	1										1		
7	Sameer Kumar and P.Phrommathed 06	Improving manufacturing process												1	
8	J.W. Herrmann, E.Lin, G.Pundoor 04	supply chain simulation model for predicting supply chain performance	1												
9	Henri Pierreval, Romain Bruniaux, Christophe Caux, 2006	forecasting on the behavior of plants for supply chain in automotive industry													1
10	G.Tuncel, G.Alpan,2009	Investigate the disruption factors of the supply chain network										1			
11	Y.H.Lee, M.K. Cho, S.J. Kim, Y.B. Kim, 2002	Using IDEF3 or SCOR as biz. Flowcharts	1											1	
12	Fredrik Persson, Mirko Araldi 07	Integration of SCOR with discrete event simulation	1												
13	Carlo Di Domenico, Y.Ouzrout, Matteo M. Savinno 07	Clarify factors to minimize negative effects of supply chain dynamics, and how to effectively manage them	1	1											
14	L.Whicker, M.Bernon, S.Templar, C.Mena 06	supply chain performance improvement	1						1						
15	June Young Jung et al., 04	Determining safety stock level											1		
16	Reuven R.Levary 08	evaluating and ranking potential suppliers						1							
17	Zukjufku Mohamed Udin et al.,06	evaluate the need of of collaborative supply chain management					1								
18	Adisak Theeranuphuttana, John C.S.Tang 07	performance measurement method for supply chain management	1			1									
19	K.Hafeez, M. Griffiths,J. Griffiths, M.M.Naim(1996)														1
		Summary	8	1	1	1	1	1	1	1	1	1	3	2	2

– The most powerful way to measure performance in the supply chain is based on metrics and attributes, followed by SCOR. The samples of the evidence are [Gunasekaran 04], [Jeffrey 04], [Whicker 06], and [Theeranuphuttana 07]which studied the area of evaluating supply chain performance in organizations based on SCOR.[Carlo 07] measures and analyzes performance of supply chain dynamics, or even integrates systems with discrete event simulation [Persson 09]. These are considered with regards to the SCOR model. Other methods, for example, the scheduling algorithm, Single Minute Exchange of Die (SMED), or even system dynamic approach focus on intra-collaboration improvement of determining safety stock level [June Young Jung *et al.*, 04], shop floor control [Rojanapibul 05],[Sameer 06], [Lee 02], and forecasting on behavior in supply chain of automotive plant [Henri 06].To improve supply chain performance, evaluate and analyze supply chain process, practitioners have frequently used Supply Chain Operations Reference (SCOR)for many years [SCC 06]. Further, SCOR provides standard processes, which become a process reference model for supply-chain management. It includes delivery and order fulfillment performance, the flexibility of production, warranty and returns processing costs, inventory, and other factors in evaluating the overall effective performance of a supply chain. For these reasons, SCOR is suitable for implementing and evaluating overall supply chain performance, which is the main interest of this study.

– Performance attributes are characteristics of the supply chain that allow analysis and evaluation against other supply chains with competing strategies. Without these characteristics, it is difficult to compare an organization that chooses to be the low-cost provider with an organization that chooses to compete on reliability and performance. Also, the stochastic nature of the processes and high uncertainty make supply chain management very strenuous. Mathematical and operation research models in general do not perform well, because they make many assumptions and contain modeling problems such as representing complex systems that include many relationships, features, parameters, and constraints [Stefanovic 99].

- In order to predict supply chain performance and illustrate dynamic process or even measure indicators in different scenarios, simulation is a very useful tool in helping to illustrate dynamic processes. This method can also help to make decisions regarding location strategy.

- To illustrate what-if scenarios, several authors have developed approaches under various points of view. The growing interest of researchers and industrial decision makers are shown in the modeling and simulation. From the review of the literature, the integration of discrete event simulation and supply chain context have been introduced by several researches as shown in Table 2.4.

Table 2.4 Simulation tools used for supply chain context

	Simulation tool	WITNESS	PROSIM	ARENA	EXTEND	Vensim	I Think	Excel	VBA	MatLab programming	High Level Architecture (HLA)
1	P.Benjamin, M.Graul, R.Mayer, M.Painter, C. Marshall (2001)	1	1								
2	R.A. Phelps, D.J. Parsons, A.J. Siprelle, 2000			1	1						
3	K.Hafeez, M. Griffiths,J. Griffiths, M.M.Naim(1996)					1					
4	Henri Pierreval, Romain Bruniaux, Christophe Caux, 2006						1				
5	Sameer Kumar and P.Phrommathed			1				1			
6	Fredrik Persson, Mirko Araldi, 2009			1				1			
7	K.Rojanapibul, J.Pichitlamken, 2005			1				1	1		
8	Federica Cucchiella, Massimo Gastaldi									1	
9	J.W. Herrmann, E.Lin, G.Pundoor 04			1					1	1	
10	Carlo Di Domenico, Y.Ouzrout, Matteo M. Savinno 07			1							
11	M.W. Barnett, C.J. Miller(2000)										1
	Sum	**1**	**1**	**6**	**1**	**1**	**1**	**3**	**2**	**2**	**1**

Several simulation tools have been used to simulate the supply chain. Of these, the ARENA software application is the most well known. [Sameer 06], for example, studied the process map and data analysis for manufacturing systems, and used ARENA to demonstrate existing operations. While, [Fredrik09] simulated a *Make-to-Stock* (MTS) policy for supply chain configuration based on SCOR template which has been built with the ARENA application. The SCOR model will therefore help to construct the basic elements of the supply chain framework. This will be explained in detail in chapter 3 (Proposed Methodology) with the proposed model and its application. In the next section, discrete event simulation will be introduced.

2.5 Supply Chain Simulation

The previous section presented techniques used to introduce a supply chain context. ARENA is the most well known application used by the researchers investigating supply-chain analysis. The principle of discrete event simulation and dynamic systems will be explained in this section.

Supply-chain simulation models (such as ARENA) can be used to improve supply chain decision-making, evaluate policies (e.g. inventory management policies) or to predict the outcome of a specific alternative. Additionally, each organization has its own goals, operational policies, organization structure, and IT platforms. In these dynamic and connected systems, it is difficult to plan globally and make decisions regarding the transportation inventory and location strategy [Stefanovic 09]. Due to uncertainties in supply chain management, simulation tools are of great help to forecast future crises [Jean 07]. Computer simulation and simulation models can be used to model intricate supply networks close to real systems, execute those models, and observe system behavior. Simulation can be defined as “the process of designing an abstract model of a real system (or subsystem) and conducting experiments with this model for the purpose of either understanding system behavior or evaluating various strategies within the limits imposed by a set of criteria for the operation of the system” [Shannon 75]. Thus, the advantages of the simulation in supply chain network can be summarized, as below:

- To better understand how the supply chain dynamically behaves
- To determine the impact of possible allocation strategies for human and technological resources, for example, employees’ overtime, and new investment [Paris 01].Simulation models can also be used to evaluate policies, inventory management policies or to predict the outcome of a specific alternative [Pundoor 04].

- Simulation can be used for analysis of the complex real systems such as supply networks. Managers can test the results of "what-if" analysis in different decisions. The effects of the individual components, parameters and variables can be studied at the global level [Dusan 09].
- Simulation is a very relevant approach to study both the flexibility and the reactivity of the supply chain to unexpected event at a macroscopic level [Bruniqux 00]. Simulation also has a capability of capturing uncertainty and complexity that is well suited for supply chain analysis [Persson 09].With the simulation, it is possible to include real-world influences, for example uncertainty factor in demand or lead time [Dusan 09].
- "Time compression" is possible. Effects of a certain business policy over a long period of time (months, years) can be obtained in a short time [Dusan 09].
- More classical discrete event simulations have been used to model the supply chain and to provide animation capabilities like ARENA was used at different levels of abstraction for evaluating the business process and inventory control parameters of logistics and distribution supply chain [Jain 01].
- Simulation is a very useful tool to predict supply-chain performance. It does not interrupt real systems. For example, experimenting with different supply network configurations can be done without disruptions and significant investment.

These are the advantages of using simulation in supply chain management, especially concerning how the supply chain behaves in a dynamic environment, and to determine the impact of potential events, and evaluate policies. Illustrating on a what-if basis and analyzing different scenarios, as well as predicting performance of the systems are the main benefits. For these reasons, simulation tools are of great help to forecast future crises of manufacturing during an uncertain environment.

2.5.1 What is simulation?

One of the first efforts dealing with supply chain dynamics was undertaken by Forrester [Forrester 61], [Forrester 58] who created and developed a simple but representative simulation model of a distribution supply chain using Dynamic simulation language. Following this, a number of papers have been published, dealing with different aspects of supply chain modeling and simulation. Simulation refers to a broad collection of methods and applications to mimic the behavior of real systems, usually on a computer with appropriate software [Kelton 98]. [Pegden and Shannon 95] defines it as "the process of designing a model of real system and conducting experiments with this model for the purpose of understanding the behavior of the systems and/or evaluating various strategies for the operation of the system." In fact, "simulation" is a general term since the idea applies across many fields, industries, and applications. The popularity of simulation has grown coincidentally with computers and software.

Simulation, like most analysis methods, involves systems and models. Computer simulation deals with models of systems.

1. A *system* is a facility or process, either actual or planned, such as:

1.1. A manufacturing plant with machines, people, transport devices, conveyor belts, and storage space.

1.2. A bank or other personal-service operation, with different kinds of customers, servers, and facilities like teller windows, automated teller machines (ATMs), loan desks, and safety deposit boxes.

1.3. A distribution network of plants, warehouses, and transportation links.

1.4. An emergency facility in a hospital, including personnel, rooms, equipment, supplies, and patient transport.

1.5. A field service operation for appliances or office equipment, with potential customers scattered across a geographic area, service technicians with different qualifications, trucks with different parts and tools, and a central deport and dispatch center.

1.6. A supermarket with inventory control, checkout, and customer service.

1.7. A theme park with rides, stores, restaurants, workers, guests, and parking lots.

2. Models

2.1. Physical model

There are many different types model. The first is a physical replica or scale model of the system, sometimes called an *iconic* model. For instance:

- People have built tabletop models of material handling systems that are miniature versions of the facility, unlike electric train sets, to consider the effect on performance of alternative layouts, vehicle routes, and transport equipment.
- A full-scale version of a fast-food restaurant placed inside a warehouse to experiment with different service procedures was described by Swart and Donno (1981). In fact, most large fast-food chains now have full-scale restaurants in their corporate office buildings to experiment with new products and services.
- Simulated control rooms have been developed to train operators in nuclear power plants.
- Physical flight simulators are widely used to train pilots. There are also flight simulation computer programs, which represent purely logical models, which are executed inside a computer. Further, physical flight simulators might have computer screens to simulate airport approaches, so they have elements of both physical and computer-simulated models.

2.2. Logical (or Mathematical) Models

Such a model is a set of approximations and assumptions, both structural and quantitative; about the way the system does or will work. A logical model is usually represented in a computer program, which is exercised to address questions about the model's behavior if the model is a valid representation of a system.

The number of ways to classify simulation models is sizable, but one useful way consists of these three dimensions:

1. Static vs. Dynamic: Time does not play as a natural role in static models but in dynamic models. However, most operational models are dynamic.

2. Continuous vs. Discrete: In a continuous model, the state of the system can change continuously over time. An example would be the level of a reservoir as water flows in and out, and then precipitation and evaporation occur. In a discrete model, though, change can occur only at separated points in time, such as a manufacturing system with parts arriving and leaving at specific times, machines going down and coming back up at specific times, and breaks for workers. Both continuous and discrete change can be in the same model, are called *mixed continuous-discrete* models. An example might be a refinery with continuously changing pressure inside vessels and discretely occurring shutdowns. Arena can handle continuous, discrete, and mixed models, but our focus will be on the discrete.

3. Deterministic vs. Stochastic: Models that have no random input are deterministic; a strict appointment-book operation with fixed service times would be an example. Stochastic models, on the other hand, operate with random input-like a bank with randomly arriving customers requiring varying service times. A model can have both deterministic and random inputs in different components, whose elements are modeled as deterministic and which of random are issues of modeling realism. Arena easily handles deterministic and stochastic inputs to models and provides many different probability distributions that user can use to represent the random inputs. Since some element of uncertainty is usually present in reality, most of the illustrations will involve random inputs somewhere in

the model. As noted earlier, though, stochastic models produce uncertain outputs, which is a fact to be considered carefully in designing and interpreting project runs.

2.5.2 Comparing software simulation with supply chain context

Computer simulation or simulation software refers to methods for studying a wide variety of models or real world systems by numerical evaluation using software designed to imitate the system's operations or characteristics, often over time. However, simulation software packages support either an explicit or implicit simulation language underlying their application for representing simulation models. Several vendors provide simulation software packages that support the development of process interaction simulations. Discrete simulators (such as ProModel, ARENA, Extend, and Witness) generally rely on a transaction-flow approach to modeling systems. Models consist of entities (units of traffic), resources (elements that service entities), and control elements (elements that determine the states of the entities and resources). Also discrete simulators are generally designed for simulating detailed processes such as call centers, factory operations, and shipping facilities. However, the following sections describe some well known software packages.

2.5.2.1 ARENA Software Package

ARENA is a software package used for graphically describing SIMAN models. ARENA uses hierarchical flow chart models that include graphical objects (icons) called modules [Banks and Carson 96]. ARENA icons are connected in a flowchart to represent entity flow. ARENA uses an object-oriented design for graphically developing models [Takus and Profozich 97]. Modeling constructs of ARENA, called modules, are grouped into templates for arrangement into hierarchical model diagrams [Averill and Kelton 00]. Module specifications are authored using dialog boxes and spreadsheet-style forms. ARENA's modules represent types of data and commands within the software. These modules effectively represent a vendor-specific simulation language.

ARENA provides integration with Visio, Active X interfaces, Data Access Objects (DAO) interfaces, and Visual Basic for Applications (VBA) to extend the tool's capabilities [Bapat and Swets 00].

2.5.2.2 Automod

The AutoMod simulation package focused on manufacturing and material handling systems. Templates are used for representing common entities and resources. A simulation programming language is also available [Banks 01]. AutoMod models can describe process systems that contain complex logic to control the flow of materials, messages, resource contention, or wait times [Rohrer 00]. Automod has general programming features including the specification of processes, resources, loads, queues, and variables [Banks and Carson 96]. AutoMod processes are described in terms of traffic limits, input connections, output connections, and itineraries. AutoMod resources are described in terms of their capacity, processing time, Mean Time between Failure (MTBF), and Mean Time to Replace (MTTR). Schriber (2001) maps generic discrete event simulation terms to the concepts used in AutoMod.

2.5.2.3 ProModel

ProModel provides manufacturing-oriented modeling elements and rule-based decision logic [Banks 01]. It is a simulation tool used for modeling manufacturing and service systems [Harrell *et al.*, 00]. ProModel elements include parts/entities, locations, resources, path nets, routing/processing logic, and arrivals. Systems are modeled in ProModel by selecting modeling elements and modifying appropriate parameters [Harrell *et al.*, 00], [Harrell 03]. ProModel variants (with different graphics libraries) are available for the medical domain (MedModel) and service domain (ServiceModel). ProModel constructs have been mapped to the NIST shop model interchange format [Harward 05].

2.5.2.4 Witness

WITNESS is a simulation software package oriented towards manufacturing. The models are based on template elements that are combined into a designer element for reuse [Banks 01]. The WITNESS simulation package is capable of modeling a variety of discrete (e.g., part-based) and continuous (e.g., fluids and high-volume fast-moving goods) elements, as described below. Depending on the type of element, each can be in any of a number of "states". These states can be idle (waiting), busy (processing), blocked, in-setup, broken down, and waiting labor (cycle, setup, repair). The WITNESS user interface is Windows compliant. The primary interface to the software is either pull down menus or the button tool bar just below. The operation of the simulation model is controlled at the bottom of the screen, from a toolbar, which starts, stops, and resets the model. Once a WITNESS model has been completed and meaningful results emerge, it may be desirable to create 3D Virtual Reality version of the model. It is from this VR model that people not associated with WITNESS can begin to more easily understand the underlying logic of the simulation [Markt and Mayer 97].

2.5.2.5 ProcessModel

The ProcessModel® software package provides a graphical user interface to define and execute simulation models called process models. Process models are flow diagrams that can include objects representing process elements and connections depicting element relationships [ProcessModel 99]. ProcessModel object types include entities, activities, storages, and resources. ProcessModel connection types include entity arrivals, entity routings, resource assignments, and order signals.

2.5.2.6 SIMPROCESS

SIMPROCESS is a process modeling tool whose models are described with processes, resources, and entities [Swegles 97]. SIMPROCESS models can be simulated using an event-driven approach. SIMPROCESS is designed for Business Process Reengineering (BPR) and IT professionals of industrial and service enterprises that need to reduce the time and risk it takes to service customers, fulfill demand, and develop new products. Unlike other tools, SIMPROCESS integrates process mapping, hierarchical event-driven simulation, and Activity-Based Costing (ABC) into a single tool. The architecture of SIMPROCESS provides an integrating framework for ABC. The building blocks of SIMPROCESS, namely processes, resources, and entities (flow objects), bridges ABC and dynamic process analysis. ABC embodies the concept that business is a series of inter-related processes, and that these processes consist of activities that convert inputs to outputs. The modeling approach in SIMPROCESS manifests this concept, builds on it by organizing and analyzing cost information on an activity Basis. SIMPROCESS provides a rich array of integrated functions for modeling and analysis of business processes. From customer service to product development, from administrative to production processes, for every business process. Besides it allows visualizing and evaluating the results of process changes before commit the expensive resources, time and money [Swegles 97].

In order to select the most suitable simulation tool apply to problems of FDIs' investment, many software packages (i.e. ARENA, Automod, Witness, ProcessModel and SIMPROCESS) will be analyzed. Each technique has its own advantages and disadvantages. The way for applying the simulation in the case study is adaptable to the environment and characteristics of supply chain context. Thus, in this study, we propose the criteria for comparing and selecting software simulation for our case study as followed:

1. Since our study focuses on logistics and supply chain context on FDIs, the software simulation should be appropriate for evaluating parameters of logistics and distribution supply chain.

2. Because each organization has it own goals, several operational policies and organization structure are applied. In order to make submodels more common and useful, we aim to follow SCOR model. Thus the integration of SCOR with discrete event simulation is needed.

3. Our case study emphasizes on discrete event simulation that is characteristic process of manufacturing business.

2.5.3 Comparing and selecting software simulation for the case study

After reviewing the large number of simulation software in the survey, our study is often queried about the appropriate simulation tool for a particular area of application, or even for a given project. Thus the comparisons made will meet with our requirement. The suitable software simulation should support and help the problematic issues. However the result of the comparison shows in Table 2.5.

Table 2.5 Comparing software simulation with requirement criteria

Software package	Type of simulation	Typical Applications of the software	SCOR integration	Advantages	Disadvantages
GoldSim	Discrete + Continuous process	Complex systems, i.e.hydrological systems, ecosystems (engineered systems modeling), strategic planning, risk analysis and management, business dynamics	N	-Accommodate the addition of specialized extension modules # Financial Module, the contaminant transport module + Reliability module - quantitatively represent uncertain parameters and stochastic processes and events in the system - Hierarchical model building, distributed environment	GoldSim is less effective at tracking detailed. Flow approach using only discrete events, a pure discrete event simulator would generally be a more appropriate tool than GoldSim.
ProModel	Discrete Event Simmulator	Customizable trace, location state Gantt charts, anchored background graphics, Zoom-in-a-box, additional statement and functions.	N	Lean, Six Sigma, project & portfolio planning, capacity, cost analysis, process, cycle time improvement, supply chain (Manufacturing & logistics, pharmaceutical)	Process optimization and support company solutions
Spread sheets	the simplest and most broadly used general purpose simulators	widely used for simple simulation projects (particularly in the business world	N	Probabilistic spreadsheet programs (such as @RISK and Crystal Ball) are add-in programs for Microsoft Excel that allow users to define probabilistic distributions for input parameters. / most users are already familiar with spreadsheet programs	-Representing complex dynamic processes is difficult - Cannot display the model structure graphically -Require special add-ins to represent uncertainty
Process Model	Can analyze and improve discrete event processes in all markets	Business Process Analysis (BPA) process improvement, Six Sigma, ISO certification, requirement definition and application development	Y	-Simple flowchart and user friendly -Visual staffing provides a graphical method of assigning and viewing -reduce time	-The flowchart is a static picture of your process flow -Flowcharts require separate documents to record process parameters.
AutoMod	Discrete Event Simulator	Material handling and movement systems, warehousing, baggage handling and manufacturing	N	3D and Animation, composite models allow to import commonly used systems into new models, have multiple simulation analysis work on different sub-models	-Simulation results may be difficult to interpret -Model building requires special traning -Simulation modeling and analysis consumes time and expensive
ARENA	Discrete Event Simmulator	Manufacturing, supply chain, customer management, business process, warehousing and logistics improvement	Y	Several new features in the areas of data integration, data manipulation, sub model integration, visualization and animation	For simulating business processes,time cosuming and complicated process to create simulation models are weak point

The table illustrates that the software simulations have been compared against simulation type, application, integration of SCOR, as well as general advantages and disadvantages. It was found that the software simulation which is appropriate for evaluating parameters of logistics a supply chain distribution are Promodel, ProcessModel and ARENA. Among those software simulations that proved to be appropriate for Business Process System (BPS) and able to integrate with SCOR concept, are the ProcessModel and ARENA. ARENA is a strong simulation tool of discrete event simulation that proved to be appropriated for BPS. Although modules available in ARENA are very basic level when compared to those used in supply chain simulation models, developing models hierarchically using submodels that represent supply chain processes can overcome this limitation [Herrmann 03]. Therefore ARENA is selected in this research to evaluate supply chain performance in the context of FDI investment.

2.6 Conclusion

The three main potential factors relating to business crises are; "*cost of doing business*", "*supply chain and infrastructure*" and "*knowledge and skill performance"*. The relevant theories and research relating to each potential issue have been clarified. In terms of global supply chain and infrastructure, two issues of the ability to effectively manage uncertainties and the ability with respect to global optimized supply chain are noteworthy. Within the global supply chain, products move from one country to another depending upon cost structure and complications of international logistics. The functional cost of the s-curve shows patterns in international business based on the stage of the product life cycle. In terms of the moving stages of product life cycle, it also affects human performance in the companies who need to adjust their performance and efficiency following innovation. However, no evidence from the research has integrated each benefit of the specific theory to be considered on international business or foreign investment in crises. Many influencing factors have been studied from a relatively general perspective with regards to FDI by MNEs. To reconfirm this argument, John H. Dunning [Dunning 80, 93] claimed that, there is no general theory and it does not make sense to look for a single all-embracing theory of FDI. Model building and variable selection are carried out on a case-by-case basis depending on the specific situation of the country. Besides, to evaluate the decision on plant situation, appropriately measure the organization's performance and align with activities in supply chain is a key to illustrate the system and help to explain disruptions along the supply chain. In summary, from a comparison with the required criteria on the supply chain context, it is concluded that the ARENA software simulation is the most suitable for application to this research context. In the next chapter, an integrated framework is proposed based on three potential issues to help decision making for FDI investment.