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Un système d'aide à la décision pour la réorganisation des chaînes logistiques : une approche basée sur une analyse multicritère et un système de gestion des connaissances

Knowledge Based System for Manufacturing's Investment by Using Multi-criteria Analysis

Présentée le 4 Janvier 2011 devant le jury composé de :

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A mes parents, à toute ma famille

et à tous ceux qui me sont chers

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Resumé

La tendance actuelle des pays développés à s'investir à l'étranger dans le secteur de fabrication a rapidement impacté la croissance économique des pays d'accueil. De tels investissements impliquent notamment la création de nouveaux emplois, l'augmentation de l'utilisation des réseaux de distribution multinationales, ou encore les investissements dans la recherche et le développement afin de soutenir de nombreux projets nationaux. Ces impacts contribuent à l'amélioration de la productivité totale grâce à l'augmentation du capitale. De plus, plusieurs pays développés sont reconnus pour attirer les entreprises qui cherchent à s'investir à l'étranger afin de tirer profit des avantages offerts par les pays d'accueil.

Toutefois, ces entreprises font face à de nombreux défis critiques liés aux turbulences économiques, à l'augmentation du coût du travail, une chaîne d'approvisionnement et des infrastructures inefficaces. De telles crises génèrent beaucoup de problèmes entrainant une perte de bénéfices aux Investisseurs Directs Etrangers (IDE) et une augmentation des coûts d'exploitation. Les investisseurs étrangers deviennent alors réticents à investir ou à étendre leurs métiers. Bien que plusieurs approches à prendre en considération pour les prises de décision sont connus pour ces investisseurs ; la délocalisation vers de meilleurs marchés dans des pays où la main d'œuvre est beaucoup moins chère ; ou encore d'arrêter l'exploitation, représentent la stratégie souvent mise en place. Toutefois, une telle situation n'aura pas uniquement un impact sur l'organisation interne, mais aussi la situation économique locale et mondiale, entrainant ainsi des problèmes sociaux dans la région.

Ainsi, pour soutenir le fonctionnement des affaires et attirer de nouveaux IDE, ce travail de recherche vise à aider les fabricants à comprendre la situation actuelle, et à prendre les bonnes décisions en leur fournissant un ensemble d'outils pour valider leurs décisions d'investissement futures. En outre, fournir des informations utiles sur les IDE contribue également à attirer de nouveaux investisseurs. Ainsi, dans ce travail de recherche nous nous focalisons sur la problématique suivante :

1 Quels sont les facteurs potentiels utilisés pour une aide à la prise de décision dédiée aux IDE faisant face à leurs crises économiques ?
2 Comment cette étude peut aider les fabricants à prendre les bonnes décisions dans leurs situations de crises ?
3 En vue de prendre une décision de délocalisation, de transfert ou de cession d'usines de fabrication, quels sont les facteurs spécifiques qui devraient être pris en considération?
4 Comment les organisations représentantes et le gouvernement peuvent aider à prévenir les crises générées par l'offshore ou la fermeture des usines de fabrication?

Afin de répondre à la problématique, nous proposons un cadre intégré qui repose sur trois bases principales: La chaîne d'approvisionnement et l'infrastructure, les compétences des travailleurs et les performances, et la situation financière des différentes parties prenantes. Ces dernières sont représentées par des investisseurs étrangers, des intervenants locaux, et des fabricants. Cependant, les stratégies à analyser dans notre contexte de recherche peuvent être classées en analyse statique et dynamique. En termes d'analyse statique, la matrice de risques pour la prise de décision représentée comme un système de base de connaissances utilisé pour évaluer l'occurrence des risques existants dans les entreprises.

Cette analyse permet également aux investisseurs ou aux fabricants d'évaluer les risques connexes à l'égard des entreprises existantes. En ce qui concerne l'analyse dynamique, la modélisation de la simulation des chaînes d'approvisionnement est construite en fonction du modèle SCOR (Supply Chain Operations Reference). La modélisation et l'analyse de la chaîne d'approvisionnement par rapport aux coûts futurs de l'investissement sont également représentées dans ce contexte. En outre, notre recherche applique également les paramètres et les mesures du modèle SCOR pour évaluer la performance de la chaîne d'approvisionnement.

Finalement, un système de gestion des connaissances comme un outil d'aide à la décision pour les fabricants est développé. Ce système a été construit en intégrant à la

fois l'analyse statique et dynamique pour l’aide à la prise de décision sur le statut d'entreprise. En outre, les informations support dédiées aux IDE sont également offertes aux décideurs. Ces informations concernent par exemple, la comparaison sur le coût de transport, le coût des services et infrastructures publics, ou encore le coût du travail et le taux d'inflation propres à trois pays en voie de développement: Vietnam, Chine et Thaïlande.

L’implémentation du système d’aide à la décision à base de connaissance (KBDSS – pour Knowledge Based Decision Support System) et son application à une l'étude de cas concernant une usine de fabrication électronique de zone industrielle Lumphun, en Thaïlande, visent à valider le cadre méthodologique proposé dans cette thèse.

Abstract

The investments of foreign manufacturing in developing countries have resulted in rapid and increasing economic growth to the host countries. Such contributions are creating new jobs by foreign companies, increasing the use of multinational distribution networks, or even spending on research and development to support many national projects. These have led to higher productivity through increased capital, which in turn has led to high living standards. Consequently, several developing countries recognize to attract foreign investors to invest their manufacturing business that they can gain benefits from. However, they face many critical challenges linked to the economic turbulence, for example, the increasing of labor cost, ineffective supply chain and infrastructure. The crisis was raised many problems that cause the Foreign Direct Investments (FDIs) loss profits and increase operational costs. The new and existing foreign investors are reluctant to invest or expand the businesses. Several approaches to be considered on making a decision are noticed for foreign investors. The relocation to cheaper laboring countries or shutting down operation is the possible strategy to be considered for them. However, these situations will not only impact internal organization but also the local and global economic situation. Since the crises can affect people's income, as well raise economic problems, they finally lead to social problems in the area.

Thus, to sustain the business operation and attract the new comers of FDIs, this research aims to help manufacturers understand the existing crises in their business situation, and to make the right decision by providing them with a tool to validate their future investment decision. Providing useful information on FDIs' investment also contributes to attracting new investors. Thus we will focus on the problematic issues as follows.

1 What are the potential factors used for a decision making while the FDIs is faced up to crises?
2 How can the study help manufacturers make the right decision in their manufacturing crises?

3 In order to make a decision on relocating, transferring or divesting plants, are there any specific factors that should be considered?

4 How can the relevant organizations and the government participate to prevent the crises generated by offshore or plant divestment?

To answer on these problematic issues, our research proposes an integrated framework which is based on three main requirements: The supply chain and infrastructure, workers skills and performance, as well as the financial situation associated with the relevant stakeholders. These three stakeholders are foreign investor, local industrial estate stakeholders, and manufacturers. The strategies to be analyzed in our research framework can be categorized into static and dynamic analysis. In terms of static analysis, the Risk Knowledge Matrix decision is represented as the knowledge base system used to evaluate the occurrence of existing risks in businesses. This analysis also helps investors or manufacturers evaluate their related risks on existing businesses. Regarding to dynamic analysis, the modeling of the supply chain simulation is constructed according to the Supply Chain Operations Reference (SCOR) model. Supply chain modeling and analysis on future cost of investment are presented in this context. Besides, our research also applies the metrics and attributes based on Supply Chain Operations Reference (SCOR) to measure the supply chain performance.

Finally, providing the knowledge management system as a supporting tool for manufacturers' decision is developed. The system has been constructed by integrating both static and dynamic analysis for making a decision on entrepreneurial status of plant. In addition, supporting information for FDIs is also provided for the decision maker. These information are, for example, the comparison on cost of transportation, cost of public utilities and infrastructure, or cost of labor and inflation rate among three developing countries: Vietnam, China and Thailand. The implementation of the Knowledge Based Decision Support System (KBDSS) with the case study is also conducted in an electronic manufacturing plant which is located in Lumphun industrial estate, Thailand. It aims at validating the proposed framework for the real case study.

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List Of Abbreviations

ADSL	Asymmetric Digital Subscriber Line
AHP	Analytic hierarchy process
ATMs	Automated teller machines
CoP	Community of Practice
D	Deliver
DBMS	Database Management System
DR1.4	Transfer Defective Product
D2.2	Receive, Configure, Enter & Validate order
D2.9	Pick Product
D2.12	Ship Product
D4	Deliver retail products
ETO	Engineer-to-order
FDIs	Foreign Direct Investments
FRV	Financial Risk Value
GA	Genetic algorithm
GDP	Gross Domestic Product
GPP	Gross Regional and Provincial Products
GSCF	Global Supply Chain Forum
IEAT	Industrial estate authority of Thailand
ILO	International Labor Organization
IPLC	International Product Life Cycle
IT	Information technology
IRR	Internal Rate of Return
KBDSS	Knowledge Based Decision Support System
L:L	Low potential impact and low probability of the occurrence
M:H	Medium potential impact and high probability of the occurrence

M:L	Medium potential impact and low probability of the occurrence
M:M	Medium potential impact and medium probability of the occurrence
M1	Make-to-stock
M2	Make-to-order
M2.1	Schedule Product Activities
M2.2	Issue Product
M2.3	Produce and Test
M2.4	Package
M2.5	Stage Product
M3	Engineer-to-order
M	Make
MNC	Multinational Corporation
MNE	Multinational Enterprise
MTO	Make-to-order
MTS	Make-to-Stock
NCF	Net cash flow
NPV	Net Present Value
P	Plan
PB	Payback period
PICS	Productivity and Investment Climate Surveys
PN	Petri nets
P1	Plan supply chain
R	Return
R&D	Research and Development
ROI	Return on Investment
S	Source
SCC	Supply Chain Council
SCOR	Supply Chain Operation Reference

SMED	Single Minute Exchange of Die
SRV	Supply chain and Infrastructure Risk Value
SR1.	Return Defective Product
S1	Source stocked product
S1.1	Schedule product deliveries
S1.2	Receive product
S1.3	Verify product
S1.4	Transfer product
S1.5	Authorise supplier payment
S2.1	Schedule Product Deliveries
S2.2	Receive Product
S2.3	Verify Product
S2.4	Transfer Product
UNCTAD	United Nations Conference on Trade and Development
VCOR	Value Chain Operations Reference
WLAN	Wireless Local Area Network
WRV	Worker Risk Value

Introduction

For several decades, the international businesses of foreign investors have played an important role in developing countries, as a source of finance and supportive contributions to the host countries. Such benefits and contributions are, for example, high standard of living, technology improvement, nation project development, high labor productivity, and specialized skills. However, since 1997, the financial collapse of the Thai baht has caused severe economic turbulence through South East Asian countries. This crisis has led to the occurrences of massive layoffs for huge numbers of employees and also the decline of the investment climate until now. In particular, businesses concerning manufacturing in the electronic sector in developing countries most depend on the FDIs in funding, implementing and transferring technology. The main characteristics of the electronic sector are high technology and cost investment, skill requirement, continuous research and development, and intensive labor. Besides the production network of the electronic sector performs as a worldwide chain. Thus they face many critical challenges linked to the economic turbulence, from the increasing of labor cost, ineffective supply chain and infrastructure. Then International investors are reluctant to invest in businesses in developing countries of this area. Thus they have been turned to alternative solutions, in order to achieve profits. One of the alternative solutions is the business relocation in cheaper laboring countries or even in the worst case a divestment of plant which results in shutting down operations, or withdrawing plants. However, these situations will not only impact internal organization but also the local and global economic situation. Since the crises can affect people's income, as well raise economic problems, they finally lead to social problems in the area.

Thus, to sustain the business operation and attract the new comers of FDIs, this research aims to help manufacturers understand the existing crises in their business situation, and then make the right decision by providing them with a tool to validate their future investment decision. Furthermore, providing useful information on FDIs'

investment also contributes to attracting new investors. Thus we will focus on the problematic as follows.

1 What are the potential factors used for a decision making while the FDIs is faced up to crises?
2 How can the study help manufacturers make the right decision in their manufacturing crises?
3 In order to make a decision on relocating, transferring or divesting plants, are there any specific factors that should be considered?
4 How can the relevant organizations and the government help to prevent the crises generated by offshore or plant divestment?

In order to meet with the general problematic of this thesis work, we have organized our work into five chapters:

Chapter I: is dedicated to the description of the context in which the research work has been presented. In the relative context part, we describe why FDIs are important to developing countries and the reasons why they have led the host countries to attempt to attract FDIs to invest in their own countries. We also introduce the characteristic of the FDIs trend from one country to another. Then, we will present the situation on FDIs in Thailand and particularly, the investment climate in terms of cost of doing business, and the importance of supply chain collaboration and effectiveness. Afterwards, we will discover the potential factors linked to business crises with related research and methods used on FDIs investment decision. Finally, the main hypothesis and problematic issues will be defined.

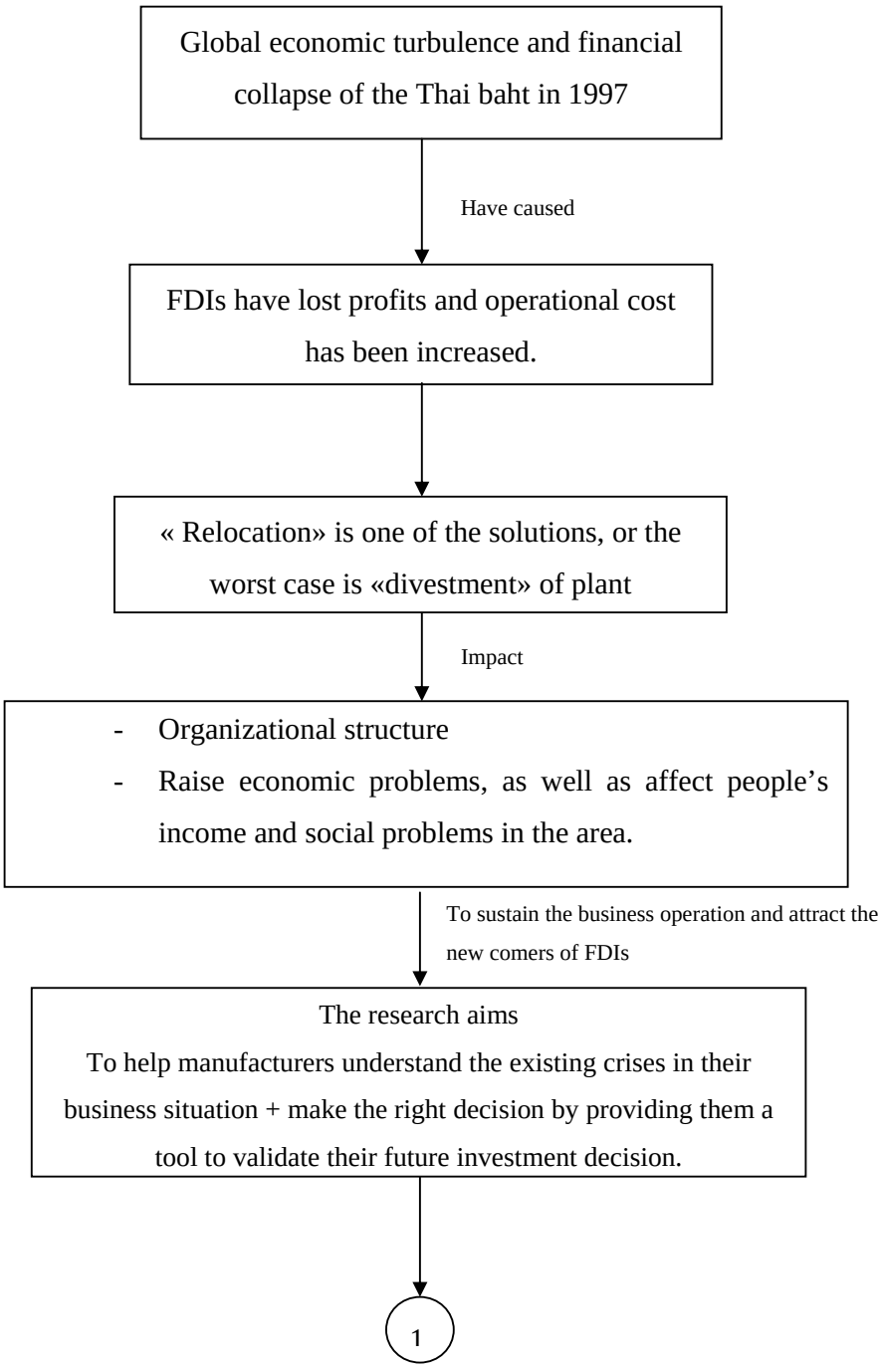
Chapter II: This chapter will clarify the relevant theories to be considered when doing business. The first part describes the characteristic of the whole supply chain and distribution networks on manufacturing plants. The intention of this part is to describe the importance of collaboration between each partner along the supply chain network which is considered as a potential factor affecting to the business. Then the second part focuses on operating in manufacturing, which falls into a series of activities called the value chain. Thus on this level of activities, to describe the standard processes along the supply chain, the Supply Chain Operations Reference Model (SCOR) will be introduced and implemented in our study. To illustrate the

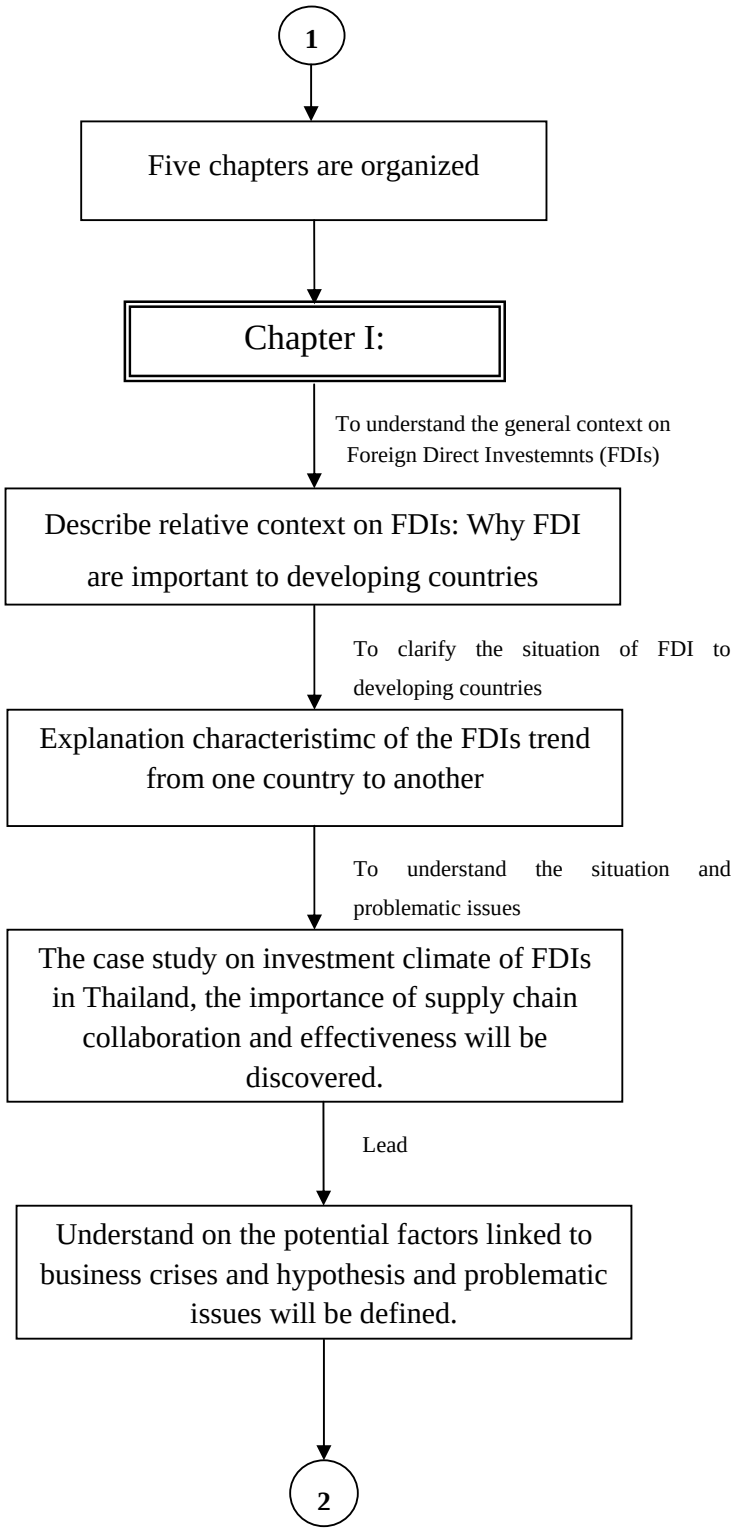
supply chain activities, simulation is suggested. Finally, the last part of the chapter, two theories on “s-curve” and “bathtub” analysis on international trade will also be developed in the pattern of product life cycle and characteristic of employee behavior. Finally, the last part of the chapter, aims to propose the model supporting investment decision for the three main requirements, according to the corresponding stakeholders among foreign investors, local industrial estate, and manufacturers.

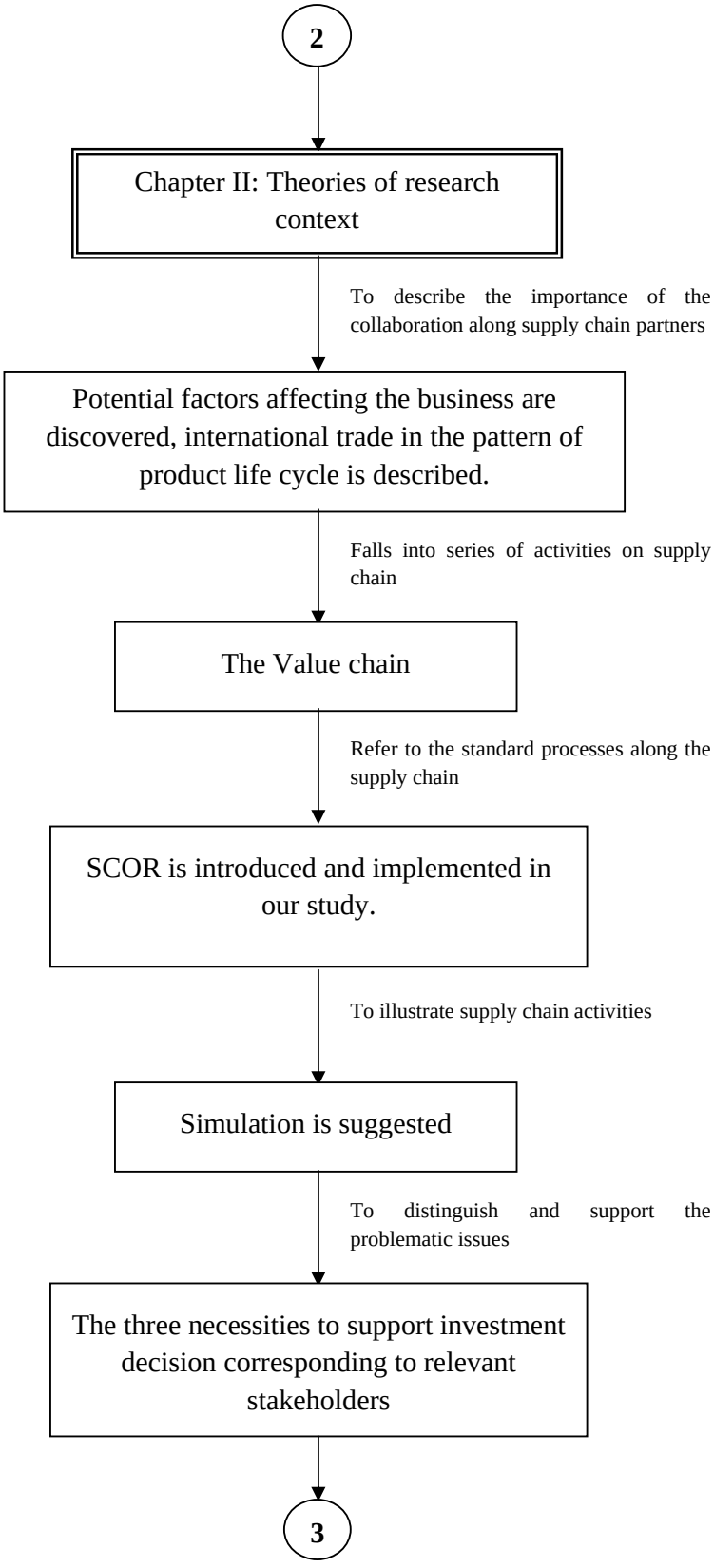
Chapter III: This chapter mainly focuses on the proposed integrated framework to help decisions for FDIs’ investment. The proposed framework is based on three main requirements: The supply chain and infrastructure, workers skills and performance, as well as the financial situation associated with the relevant stakeholders. The framework consists of two levels which are static and dynamic analysis. For static analysis, this section helps investors or manufacturers evaluate their related risks on existing businesses. However in terms of dynamic analysis, we will present supply chain modeling and analysis on future cost of investment. Besides, we not only integrate on the main requirements, but our research framework also applies the metrics and attributes based on Supply Chain Operations Reference (SCOR) to measure the supply chain performance.

Chapter IV: This chapter presents the implementation of integrating the proposed framework to Knowledge Based Decision Support System (KBDSS). In the first part, we will describe the architecture of the knowledge based system. There are mainly four components: knowledge base, procedure, simulation model, and a user interface. Afterwards, we will describe each main component in details including their function in KBDSS. Finally, the design of the user interface and the sample implementation of the application on web based system will be examined.

Chapter V: This chapter concentrates on the implementation of the KBDSS with the case study. It aims at validating the proposed framework for the real case study. The case study is conducted in an electronic manufacturing plant which is located in Lumphun industrial estate, Thailand. Thus in the first part of the chapter, we will describe the profile and crisis in the business situation of our case study. Then we will show a scenario which describes how decision makers can apply the KBDSS to this case study.


Global economic turbulence and financial collapse of the Thai baht in 1997
Have caused
FDIs have lost profits and operational cost has been increased.
« Relocation» is one of the solutions, or the worst case is «divestment» of plant
Impact
- Organizational structure
- Raise economic problems, as well as affect people's income and social problems in the area.
To sustain the business operation and attract the new comers of FDIs
The research aims
To help manufacturers understand the existing crises in their business situation + make the right decision by providing them a tool to validate their future investment decision.
1


1
Five chapters are organized
Chapter I:
To understand the general context on Foreign Direct Investemnts (FDIs)
Describe relative context on FDIs: Why FDI are important to developing countries
To clarify the situation of FDI to developing countries
Explanation characteristimc of the FDIs trend from one country to another
To understand the situation and problematic issues
The case study on investment climate of FDIs in Thailand, the importance of supply chain collaboration and effectiveness will be discovered.
Lead
Understand on the potential factors linked to business crises and hypothesis and problematic issues will be defined.
2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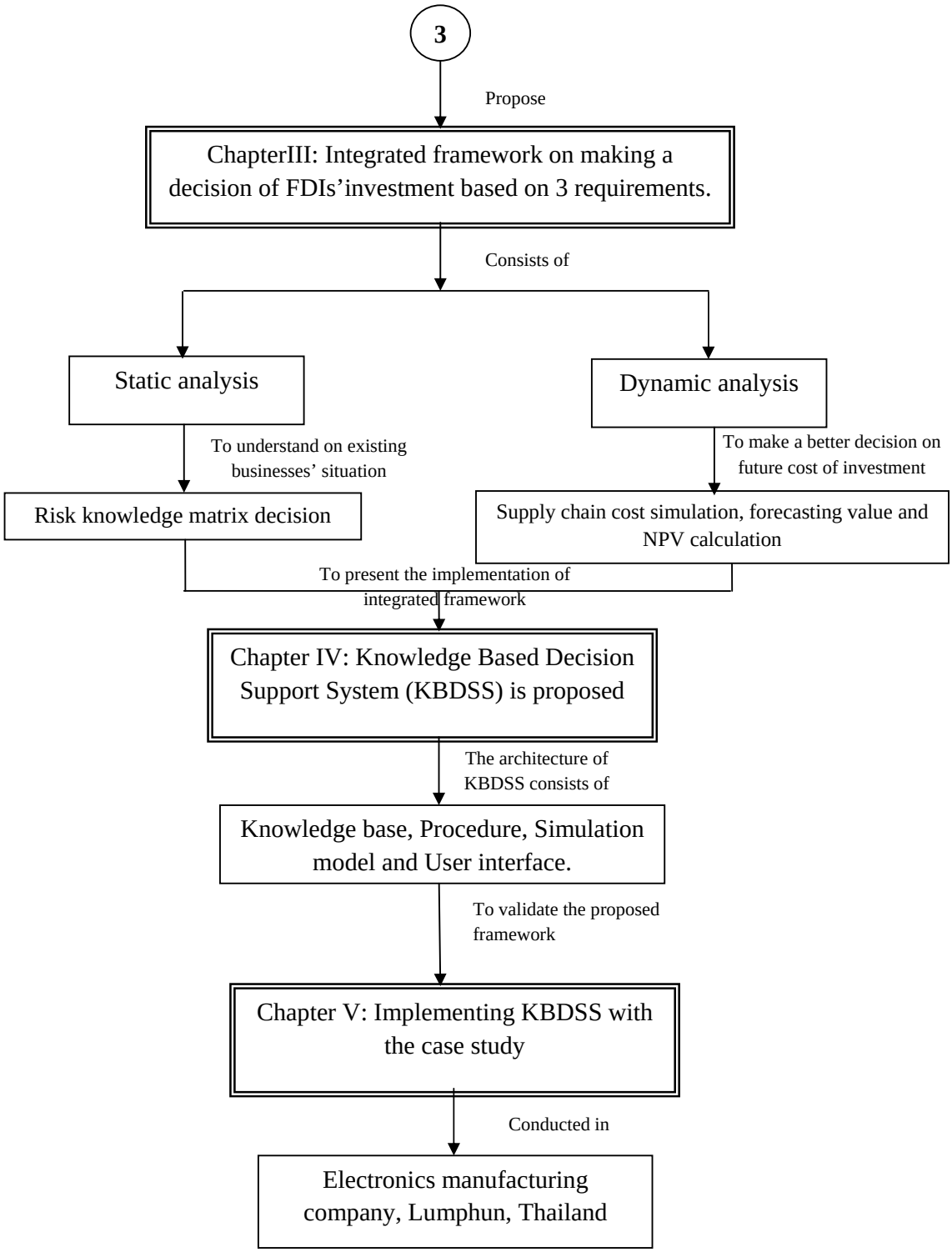
Chapter II: Theories of research context
To describe the importance of the collaboration along supply chain partners
Potential factors affecting the business are discovered, international trade in the pattern of product life cycle is described.
Falls into series of activities on supply chain
The Value chain
Refer to the standard processes along the supply chain
SCOR is introduced and implemented in our study.
To illustrate supply chain activities
Simulation is suggested
To distinguish and support the problematic issues
The three necessities to support investment decision corresponding to relevant stakeholders
3


3
Propose
ChapterIII: Integrated framework on making a decision of FDIs'investment based on 3 requirements.
Consists of
Static analysis
Dynamic analysis
To understand on existing businesses' situation
To make a better decision on future cost of investment
Risk knowledge matrix decision
Supply chain cost simulation, forecasting value and NPV calculation
To present the implementation of integrated framework
Chapter IV: Knowledge Based Decision Support System (KBDSS) is proposed
The architecture of KBDSS consists of
Knowledge base, Procedure, Simulation model and User interface.
To validate the proposed framework
Chapter V: Implementing KBDSS with the case study
Conducted in
Electronics manufacturing company, Lumphun, Thailand

Chapter I: Context and Problematic Issue

I.1. Global economic situation and foreign investment

Nowadays businesses have faced many critical challenges with regards to economic crises and the increasing competitions. In terms of economic crisis, the financial collapse of the Thai baht in 1997 has caused severe economic turbulence through the South East Asia region. The economic turbulences were, for example, massive layoffs that resulted in huge numbers of workers returning to their villages in the countryside and foreign workers were sent back to their home countries. Besides, the overall investment climate of South East Asia seemed to be worsened causing from this turbulence. Since then international investors have been reluctant to invest in developing countries of this area.

The crisis was raised many problems; one of them was that Foreign Direct Investments (FDIs) has lost profits and increased operational costs. Alternative solutions have been recognized, in order to achieve on the profit maximization of doing businesses. There are enormous literatures available on the subject of manufacturing and production; for example, factors influencing FDIs [Irene 84], [Elizabeth 02], [Manjit05], [Moshe02] international investment, divestment and relocation [Enrico 00], [Bart96], [René], [Kevin94], investment and financial planning in production [Lauren 09], [Pekka02], [Kim06]. Based on the literature review, one of the alternative solutions is the business relocation to cheaper laboring countries. Meanwhile, the worst case among those is divestment of plant which refers to shutting down of operation, or withdrawal of plant. Recently, these strategies have been recognized for foreign investors, who expected to gain more advantages and faced with the least problems of doing businesses. These situations will affect not only internal organization but also local and global economic situation.

For the first part of this chapter, we will describe why developing countries attempt to attract Foreign Direct Investments (FDIs) to invest in their countries and how FDI move to those countries. The second part of this chapter focuses on the situation on FDIs in Thailand and especially, the climate of FDIs' investment in terms of cost of labor, and supply chain collaboration and effectiveness. Afterward, the illustration on the situation and competitiveness in Northern industrial estate region, Lumphun, Thailand will be explained. In the last part, related researches and methods that are used to make decision on FDI investment, and key success factors to sustain foreign' businesses are reviewed. Thus, introduction to the problematic issues of the study will be discussed. The objective of this research aims to help manufacturers making a decision on their existing situation of investment and provide them a tool to validate their decisions by considering in three scenarios. Those three scenarios are: i) relocation ii) divestment and iii) transferring plant.

I.2. Foreign Direct Investments (FDIs) in Developing Countries

Why is FDI so important? The boom in infrastructure construction by FDI in developing countries occurred in the 1990s [Ramamurti 04]. FDI has played an effective role as a source of finance to a lot of developing countries [Manjit05]. There are many empirical findings that support its positive contributions. Some of those researches are [Mbekeani 99], on the impact of FDI on domestic investment, exports and economic growth showed positive relationship in Mexico and Malaysia. Another research by [Larrain 01], shows positive effect of FDI generated by Intel in terms of net exports, investment, wages and benefits and local purchases for the Costa Rican economy. [Thomsen 99], in his study on the roles of FDI in 69 developing countries found that it not only stimulates economic growth but also has a larger impact than investments by domestic firms. The investment of foreign manufacturing in developing countries can result in rapid economic growth to the host countries. Such contributions are creating new jobs by foreign companies and employment of interrelated industries [Cheng 06], increasing the use of multinational distribution networks or even spending on research and development to support many national

projects. These have led to higher productivity through increased capital, which in turn has led to high living standards. In addition, relocation activities interest small countries with an open economy and intensive labor firm to relocate to lower laboring cost countries [E.Pennings 99]. The developing countries are thus competing to attract those investors to invest into their own countries.

Consequently, FDI influences government of developing countries by attracting Multinational Enterprise (MNE) to invest then helping them to transfer technology and contribute skill and knowledge through employees. Thus to attract the movement of FDIs; developing countries have to improve their efficiency to gain the credibility from foreign investors. Furthermore, understanding on the characteristic of FDI's movement and what they need are necessary. Besides [Charles 07] also suggests to boost the development of emerging countries the prerequisite is to increase the transparency of the market information. Building better market information databases, providing market databases over the Internet, and decreasing political risk facilitates international investment decision-making for investors.

Although foreign divestment and international relocations by multinational firms carry important economic implications for the host countries; on the other hand, the negative impacts of foreign direct investment are also remained. The negative effect on employment of host country in which indigenous firm may be defeated by Foreign Investment Enterprises in the intensified competition and very often, employees in those firms lose their jobs [Cheng 06]. Some countries have put restriction on FDI in certain sectors. For example, India has negative perspective on Walmart, the largest grocery retailer in the United States, on the overall economy by reducing the number of people employed in the retail sector and depressing the income of people involved in the agriculture sector which is the largest employment sector nationally. Besides, host country had to be aware of the environmental impact from the inappropriate pollution control of MNEs; such as, water treatment, air and noise pollution control, chemical and garbage disposal as the protest from the residents nearby "MapTa Phut" Industrial zone, Rayong Province, Thailand.

Nevertheless the contribution of FDIs to the extremely fast economic growth in most of the East Asian countries in the last few decades, still have been recognized. Several

East Asian countries are attempted to improve their infrastructure and provide benefits to satisfy the investors than the other competitors. For instance, in the early 1990s, China as a highly attractive destination for FDIs from developed countries [Wu 02]. The main influencing factor is the advantage in labor cost. These situations have led numerous MNEs relocate their manufacturing facilities and move to China. However, from the recent evidence, both Vietnam and China are the competitive advantage countries in the areas of labor cost and availability of labors. Another evidence reported from Foreign Investor Confidence Survey, Thailand 2009,comparing on economic conditions, Thailand were stronger in market demand than other competitors in South East Asia, but not as strong as just those of China and India. Then in the next section, we will describe in detail on the characteristics of FDI relocate from developed to developing countries.

I.3. What are the characteristics of FDI's movement

This section will describe characteristics of FDIs including asset and knowledge management needed for upgrading technology and transferring the knowledge through the host factories in developing countries. Since the last 20 years, several Japanese companies have moved their production to Thailand by transferring skills, assets, and technologies to firms in Thai countries. Thus we will describe the characteristic of FDIs trend from one country to another.

Firstly, to understand FDIs' characteristics, we will clarify definitions among MNE and FDI. The Multinational Enterprise (MNE) or Multinational Corporation (MNC) is usually used as a synonym. The International Labor Organization (ILO) has defined MNC as "a corporation or an enterprise that manages production or delivers services in more than one country." International Labor Organizational defines a MNC as "a corporation that has its management headquarters in one country, known as the home country, and operates in several other countries, know as host countries. Foreign Direct Investment (FDI) refers to long-term participation by one country into another country usually participation in management, joint venture, transfers of technology and expertise. Regard to the United Nations Conference on Trade and Development

[UNCTAD 02], FDI is defined as “an investment involving a long term relationship and reflecting a lasting interest and control of a resident entity in one economy in an enterprise resident in an economy other than that of the foreign direct investor.” An equity capital stake of 10% or more of the ordinary shares or voting power of an incorporated enterprise, or its equivalent for an unincorporated enterprise, is normally considered as a threshold for FDI. Besides, [Barry 06] defines FDI as “international investment by a resident entity in one country (the direct investor) with the objective of establishing a lasting interest in an enterprise resident in a country other than that of the investor (the direct investment enterprise).”

However, the characteristic of FDI behaves as two types; inward FDI and outward FDI. Inward FDI can be defined as the foreign investors invest their manufacturing in another country. On the contrary, outward FDI refers to a domestic firm establishing a facility abroad. The coming of inward FDI is a general understanding that can contribute significantly to the economic growth of host countries (De Mello 97).

It is noticeable that FDIs involve not only the investment in manufacturing activities, but also the transfer of strategic assets, technology and expertise through the host countries. As the evidence of Japanese companies, between 1985 and 1993, nearly one half of the total increase of Japanese manufacturing FDI in East Asia went into electronics industry [Ernst 97]. According to rapid technological advances in electronics components, feature by the combination of mass production, extremely short product cycles and constant radical innovations, FDIs have brought fundamental changes to the industrial and market structure. As a result, “cost reduction” and “product differentiation” which had been the two winning strategies that were used to dominate competition in markets for electronics products, were no longer sufficient to provide sustainable competitive advantages. For this reason, firms need to build up their capabilities allowing them to constantly differentiate and upgrade their products, and swiftly commercialize these products for well-defined niche markets [Lüthje 02]. Consequently, the host country decides to relocate the existing products and processes to developing countries by transferring existing technology and assets, including expertise from knowledge workers through those workers in the host countries. Then investment of new advanced products is introduced to the potential countries.

Besides, the other sample is plant relocation from European country to China. [Bart 96] explained implementation of a relocation strategy, as shown in figure I.1.

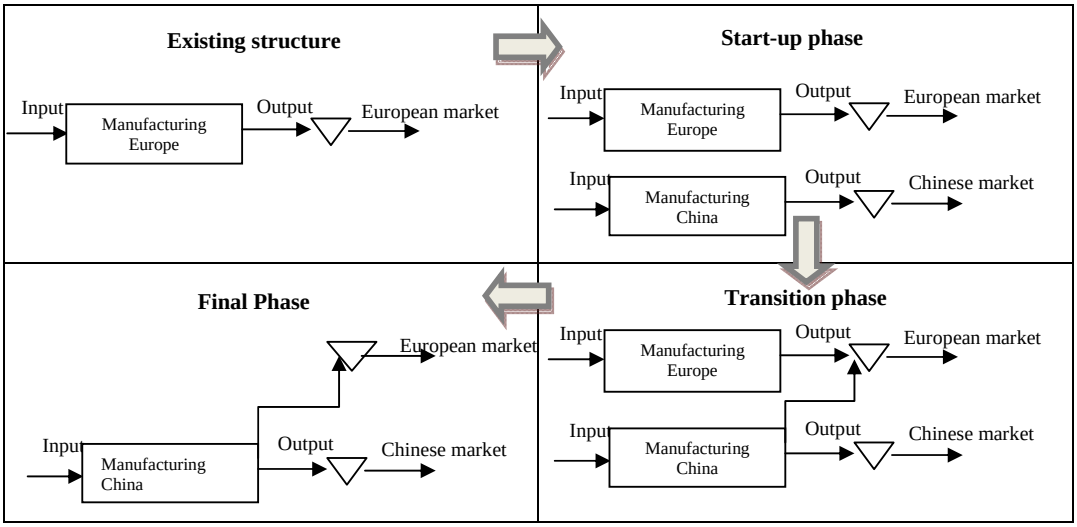


Figure I.1: Gradual implementation of a potential relocation to China [Bart 96]

Initially, a Chinese plant would sell its products in the local market, gradually exports to Europe, provided that reliable product quality and lead-times could be achieved. In the final phase, all manufacturing activities might be relocated to China. The remaining European organization would be responsible for activities like sales, distribution, and after-sales service.

Further, FDI activities are carried out to ensure optimization of available opportunities and economies of scale. In this case, the FDI is termed as “efficiency-seeking.”In the long run, through creation of dynamic comparative advantages in host countries, not only emerging markets welcome investors to boost the development of their countries but also creating knowledge and skill based to support the coming of foreign investor, hoping to gain more benefits than the other competitors.

In this case, characteristic of FDIs has had the direct results toward the developing countries, especially in electronics manufacturing. This has caused developing countries to improve their own competitiveness to match with the coming FDIs. Thus, the climate business, particularly in Thailand, and competitiveness of developing countries will be discussed in the next section.

I.4. Overall climate of doing business in Thailand

Thailand is one of the most attractive countries for FDI. Most of foreign companies located in the country are automobile industries. Thailand is classified as a developing country in which the majority of Thai people work in the agricultural sector but the labor force is moving toward the industrial sector. Consequently many farm workers become laboring employees in foreign companies. In the past, the labor cost of these workers was cheap which can draw great investment from international companies. But this labor cost advantage is being eroded by fast growing countries and skill shortages are worrisome given the need for Thailand to move toward a more skillful and knowledge-based economy.

Although a large part of the value-added process by Thai firms may come from assembly, the fact that high technology products account for a growing share of exports indicates that the production structure in Thailand is moving from labor-intensive to more technology-intensive. The shortage of skilled labor and professionals, the low level of Research and Development (R&D), and the weak cooperation between research institutes and industrial sectors remain important constraints in Thailand. Qualified professionals are difficult to find, and both skilled and unskilled production workers are scarce compared to countries with similar developmental level. Many small or medium-sized firms in Thailand do not have the capability and incentives to undertake R&D in house. Public investment in applied research is essential for their technological upgrading.

Furthermore, from the evidence [PICS 07], reports that nearly 40 percent of all firms lack of skilled workers as one of the three most binding investment constraints they faced. A similar share of firms also viewed “skills and education of available workers” as a major or severe business obstacle. This problem was also emphasized in [PICS 2004]. The key reason for numerous job vacancies, many of which are hard to fill, is the poor quality of the labor force. Over 40 percent of firm managers mentioned that vacancies arise because many applicants lack the basic skills or technical skills that firms require (see Figure I.2).

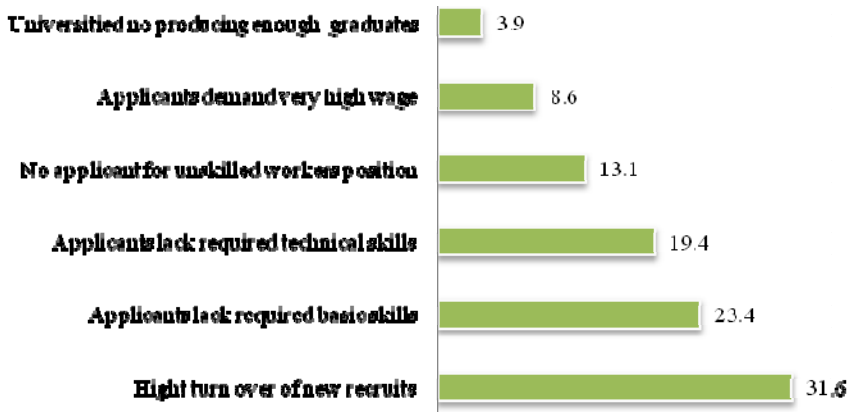


Figure I.2: Most Important cause of job vacancies (Percent of firms)

Source: Thailand PICS 2007

Thailand was ranked in 15th place out of 178 economies in terms of ease of doing business, in the 2008 Doing Business report, and outranked Malaysia, Indonesia and the Philippines. While among East Asian nations, only Singapore is better ranked. However, foreign investors' confidence during year 2009 reported that the situation in Thailand dropped from the previous year in terms of both operating results and liquidity. Such decreasing confidence naturally had an effect on this year's improvement plans in 2010 to a delay of investment projects. Besides, the prolonged political turmoil occurred in Thailand. For instance the protest against government in South-East Asian Nations Summit in April 2009, in Pattaya, worsen series of political protests happened in Bangkok, in 2010 from March to May against the democrat party, and continuing unrest in the South, had lowered their confidence and the foreign investors were worried about government stability. Thus, to describe the confidence's level of FDI, the situations of investment in Thailand since year 2007 from the BOI survey report, Thailand are indicated in Table I.1.

	Year		
	2007	**2008**	**2009**
Maintain	43%	54.80%	58.90%
Significant expansion	7%	10.50%	5.20%
Reducing or Withdraw	5.60%	3.60%	5.60%

Table I.1: Situation of investment in Thailand from 2007 to 2009
(Foreign Investor Confidence Survey Report: BOI, Thailand)

From Table I.1, it is found that existing companies have still maintained their investment levels from year 2008 until 2009. Besides, significant expansion dramatically rose up from 7% to 10.50% in 2008 however rapidly decreased to 5.2% in 2009. Besides, reducing or withdraw businesses were accrued from 3.6% to 5.6% in 2009 with noticeable. In summary, various concerns on FDIs' decisions have been specified. The worsening situation of labor cost is one of factors affecting FDIs to expand or relocate their businesses to other competitive countries such as China, Vietnam and India. However, they focus not only on costs and benefits but also both internal and external environment factors; for example, constraints related to the macroeconomic environment and policy, political situation, skilled labor, proximity of resources and markets among supply chain partners, or even reliability on supporting infrastructure and logistic networks. Besides, To describe on the overall climate business, Thailand Productivity and Investment Climate Surveys [PICS 07] has noted that the situation of Thailand's investment climate seems to be worsened between 2004 and 2007, judging by the opinions of firm' managers. This deterioration is related to the political uncertainty and the changes in global macroeconomic.

To clarify FDIs situation, the investment's characteristics of Northern region industrial estate is interesting. Thus data collections and characteristics regarding the businesses in electronic sector of this area will be discussed in the following section.

I.4.1. FDIs in Northern region industrial estate of Thailand

Since FDIs are interested in investing in developing countries in order to gain the benefits of low labor costs. Especially, in the Northern Industrial Estate, Lumphun province, the electronic sector is raised by FDIs' transferring from their host countries. The main reasons are higher laboring cost in their own countries as well as facing with higher competitions. Then they are seeking to gain the advantages from the countries that can provide them the most benefits in term of cost and skilled labor, and facilities on infrastructure.

The effectiveness in supply chain and logistics are more relative to this sector. As describe above, the structure of the electronics product's network is worldwide. In Lumphun industrial estate, most of electronic products from this area are directly exported to the parent companies or their affiliates. Few of them are sent to directed customers. The main countries of parent companies are in Asia, including Japan, Singapore, Hong Kong as well as in China. Figure I.3 shows the electronics product's network for this industrial estate.

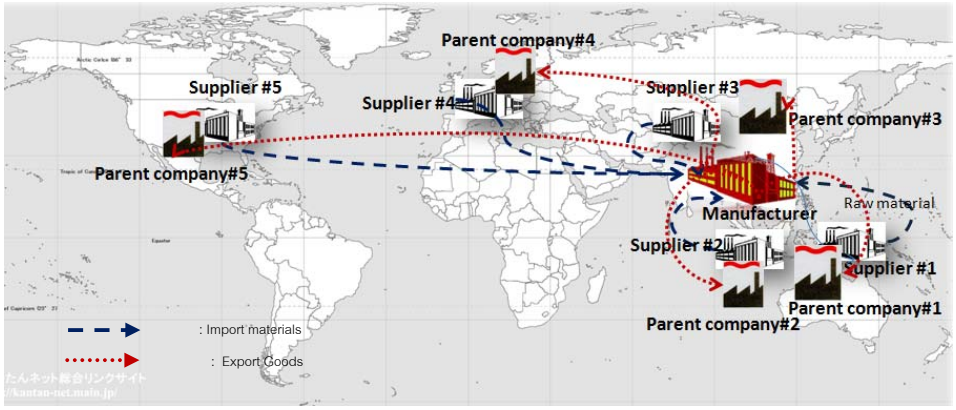


Figure I.3. Electronics product's network for Northern Region Industrial Estate, Lumphun, Thailand

The raw materials used in the electronics industry in the Northern Region Industrial Estate are mostly imported. More than 50% of the imported values are electronic

components, printed circuit board, metals, plastics and glasses. Machinery parts, computer components and instruments are the secondary percent of imported value. Within overall import of raw material, about 50% are dominated by Japanese companies. While United State, Singapore, Malaysia and Hong Kong are the second dominators.

Regarding to this characteristic of electronic manufacturing, the need of supply chain and infrastructure effectiveness, high technology and cost investment, skill based requirement are mandatory. This will affect to FDIs' decision on investing and expanding their business in this area. However, no new investors have been decided to invest in the area since 2006. As show in Table I.2, the number of factory dramatically increased since 2004 from 65 to 73 factories in 2005 which is about 10% increased. However, in the following years, number of new factory launching has not been noticed. Besides, two factories had been withdrawn from the businesses in 2005 and 2007. The reasons for the withdrawal from the businesses are the high competition among foreign countries.

Year	**Permission on launching new factory**			**Withdraw**		
	No. Of factory	Investment (Million)	Employment (person)	No. Of factory	Investment (Million)	Employment (person)
2002	64	56,442	37,139	-	-	-
2003	65	60,790	38,876	-	-	-
2004	65	65,361	42,964	-	-	-
2005	73	66,149	44,623	1	30	30
2006	75	71,340	48,973	-	-	-
2007	75	65,823	48,870	1	45	104
2008	75	65,823	64,222	-	-	-
2009	75	65,823	39,100	-	-	-
2010	75	66,837	43,591	1	n/a	1000

Table I.2: Investment situation in Northern Religion Industrial Estate, Thailand from Year 2002 to 2010 [Office of Northern Region Industrial Estate, Lumphun, Thailand].

From Table I.2, the foreign investors are still reluctant to expand or invest their businesses. Thus, up to now new FDI investors have postponed the decision to invest more in the area. Besides, most factories locate in this area are electronics manufacturing, which needs distinctive requirements; for example, intensive labors, high technology and cost investment, sufficient supply chain and infrastructure for distribution supply chain networks. Consequently, those particular characteristics depend on FDI in funding, implementing and transferring of technology and operating the businesses. These potential factors would have substantiated implications on the future development economy and FDIs situation. Thus, the next section will discuss more detail on the capabilities to attract FDIs related to the requirement base of this area.

I.4.2. Investment's climate and competitiveness in industrial estate region, Lumphun, Thailand

From the previous section, the awareness on cost of labor, skill based requirement, and supply chain effectiveness are the potential factors considering on FDIs' investment in the industrial estate region, Lumphun. To sustain the existing businesses and attract the new comers, understanding on the climate of investment and then improving on the competitive advantages will help to achieve this goal. This section will describe on the climate of FDIs' investment and competitiveness in this area. Then comparing with other competitors, for instance, China and Vietnam, will be also represented.

- Cost of labor

From the previous section, it is advisable that needs of electronic sector requires high cost of investment and advanced technology to support manufacturing processes. Besides, intensive labor is one of the main characteristics required for electronic companies in the region.

Wage of labor is the critical factor affecting to the competitive performance. Comparing to neighboring countries, the lower cost of labor in China and Vietnam can strongly attract FDIs investment which is caused by the high supply of labor in

the market. These situations result in losing of new investors to invest in this area and may decide to move to those countries. The lowest cost of labor in the province has been continually increased as shown in Figure I.4. Since2007, the minimum rate of wgages was increased considerably from 145 to 149 baht per day, which is higher than the previous year 2.8% and still has been increased continuously. For this reason, manufacturing in which mainly depends on laboring workforce to operate products, may decide to move to other cheaper laboring-cost countries.

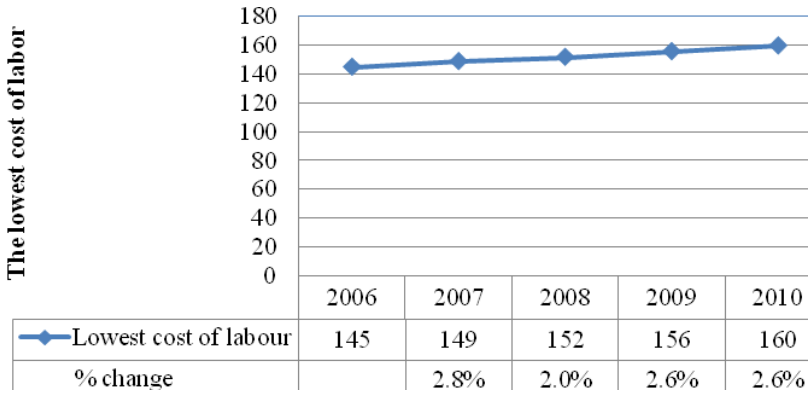


Figure I.4: The lowest cost of labor of Lumphun province, Thailand [MOL, Thailand 10]

- Asset management and skill requirement

As the evidence of Japanese companies, between 1985 and 1993 nearly one half of the total increase of Japanese manufacturing FDI in East Asia invested in electronics industry [Ernst 97]. Rapid technological advances in electronics components, featured by the combination of mass production, extremely short product cycles and constant radical innovations, have brought fundamental changes to the industrial and market structure. Hence these characteristics conduct as a critical remark to recognize the province. This means that FDIs involve not only invest on manufacturing activities, but also transfer of strategic assets, technology and expertise through the host countries.

As a result, “cost reduction” and “product differentiation” (two winning strategies) that were used to dominate competition in markets for electronics products, are no longer sufficient to provide sustainable competitive advantages. For this reason, firms

need to build up capabilities allowing them to constantly differentiate and upgrade their products, and swiftly commercialize these products for well defined niche markets [Lüthje 02]. Consequently, the home country decides to relocate the existing products and processes to developing countries by transferring existing technology and assets, including expertise from knowledge workers through those workers in the host countries. Then investment of new advanced products is introduced to the potential countries. To support the transferring of asset and knowledge and skilled expertise, the quantity and quality of the workforce are important components for running a business. However, enhancing basic and technical skills are difficult to accomplish. Skilled labor is hard to find, this is either because available workforce has poor skills (skill shortage) or workers sufficiently possess certain skills that are not the skills required by firms (skill mismatch) or both [PICS 07]. However [PICS 08] reported that a sufficient quantity and quality of skilled labors in Thailand was still perceived as an attractive investment factor for foreign investors. There have been good prospects for the group of qualified managers, but skilled labor factor has been the obstruction. This meant that the availability of qualified managers in Thailand is sufficient; although it is not a strong factor for attracting foreign investment. On the other hand, prospects for the quantity and quality of engineers, technicians were moving in a negative direction. For this reason, shortage of skilled labor remains a key business constraint. Thai government had to promptly introduce various initiatives to improve the quality of the labor force.

- Supply chain and Infrastructure

Since the network of electronic product is worldwide, over 50% of manufacturing products, importing raw materials and exporting end products among other countries are the main functions to operate the business. Considering overall business environment, foreign investors are more satisfied with infrastructure than other influenced factors, i.e., law and regulations, and economic situation. Foreign investors viewed Thailand as having better infrastructure than the competitors [Executive Summary, BOI 09]. Thailand’s infrastructure for transportation system, public utilities and communication services, and logistics management has been improved

qualitatively, as well as quantitatively. The foreign investors expressed greater satisfaction with these improvements than that in the previous years.

To be efficient in the overall supply chain network, well organize on internal supply chain can help to satisfy customer's requirement. The advent of supply chain collaboration creates the need to pay special attention, at the intra-enterprise level (between the different plants and the different processes) and at the inter-enterprises level (between the different partners). Mutual understanding and collaboration among companies will help create many beneficial outcomes on manufacturing.

Furthermore, the unwelcoming situations among existing foreign companies in this area have been appeared. For example, an unsatisfied in compensation and employee benefit in one of a subsidiary of the Japanese company in December, 2008, allowed strike of labor workers. This situation led to the worsen event by dismissal some of employees from that company [Financial assistance of the European Union, Goodelectronics on the spot, November 2009]. Besides, one of the foreign electronic companies suspended to pay the salaries to employees for 3 months since the company faced with serious internal problem in 2009.

Finally, it can be concluded that the situations of this area in which may lead to worsen foreign investors' confidence can be described as below.

- As intensive labor is one of the main characteristics required for electronic companies in the area, considering on wages of labor is the critical factor affecting to competitiveness of performance. However, the minimum wage, required by laws, in the province has been continually increased while comparing to neighboring countries. The result of the increasing of labor wages has caused manufacturers which require intensive workforce decide to move to cheaper laboring countries.
- To support the transferring of asset and knowledge and skilled expertise, especially in electronics manufacturing, the quantity and quality of the workforce has been emphasized. However, quantity and quality of engineers, technicians are insufficient, and skilled labor is difficult to recruit. This is either because available workforce has poor skills or workers possess certain skills which are not skills required by firms.

- Although infrastructure has satisfied the investors than other influenced factors of this area, infrastructure for transportation system, public utilities and communication services, and logistics management still has been improved qualitatively as well as quantitatively. More than 50% importing raw material from neighboring countries of electronic manufacturing in this area are not only high technology and cost investment, intensive labor requirement but also need on supply chain and infrastructure effectiveness.
- Existing of unwelcome situations or conflicts among the managing level in the companies and employees.

For these reasons, as the climate of doing business and the competitive advantage have been affected by those awareness cost of labor, skill based requirement, and supply chain effectiveness, or continual existence of the crises, there are many problems for FDIs; for instance whether to decide to relocate or divest the businesses. In this regard, the crises can be affected into the global difficulties; such as, people's income, economic problems that leads to social problems of the province.

To prevent the business relocation or divestment, discovering on potential factors affecting to the crises will stimulate FDIs on investment's decision. Thus, the following section will explain on factors and methods considered for FDIs decision from related researchers.

I.5. Related researches on FDIs decision

Regarding to potential factors affecting to the business crises, there are several potential factors affecting FDI decision. We will explain the argument on related researches of FDI investment decision and their influencing factors. These factors may differ significantly from one location to another depending on the attractiveness of the particular regions of country [Manjit 05]. Hence, comparing the potential factors with the case study in Northern Region Industrial Estate, Lumphun, Thailand was conducted.

The issue of international trade is first described since the principle of comparative advantage by Robert Torrens was introduced in 1815. However, the principle is usually attributed to David Ricardo who first published on the Principle of Political Economy and Taxation book in 1817. In economics, the law of comparative advantage refers to the ability of a party (an individual, a firm, or a country) to produce a particular good or service at a lower opportunity cost than another party. “Comparative advantage” can defined as “the ability to produce a product with the highest relative efficiency given all the other products that could be produced. Comparative advantage explains how trade can create value for both parties even when one can produce all goods with fewer resources than the other. The net benefits of such outcome are called gains from trade. It is the main concept of the pure theory of international trade.

Afterwards many researchers have been recognized on MNCs. Hence, several potential factors on FDIs investment are discovered in order to support their decision and help to satisfy new investors’ requirement. Then relevant factors and approaches applied for making a decision on FDI investment from related researches and empirical data from questionnaires will be described.

I.5.1. Influencing factors on FDIs decision

Several researches focused on financial and economic variables for influencing factors on FDIs decision. For example, [Chun 07] summarizes variables attracting FDI inflows. From their evidence, most selected variables are relevant with cost and benefit such as capital to labor, total sales value, total investment in Research and Development (R&D). However, there are several evidences shown the different aspects of influencing factors on FDIs. Nowadays not only cost and profit factors can be considered but also indirect factors: for example, contribution to the host country and social environment, infrastructural deficiencies, inadequate worker skills, and supplier availability [Bart 96], [Yurimoto 95], [Mzanda 2006]. In addition, [Chan 95] found that the main reasons for business relocations were cost savings and business expansion, regardless of whether the firm was a plant or a headquarter. In the work of [Chun 07], there are 24 variables from previous literatures that have been considered for FDI environment in China. Among those factors, the most frequently selected

determinants of FDI flows were productivity, research and development investment, capital to labor, educational level, and export and sales value. Meanwhile, [Bart 96] argues that factors in the international environment like taxes, barriers to trade and exchange rate, will affect the allocation. In term of technology transfer in South Africa, investigating the fact of the electronics sector, the researchers criticized the need to be integrated from the start to acquire capabilities focused on developing knowledge based, security and subcontract existence.

However, from the late of 1990 until the beginning of year 2000, the importance of workforce factors are distinctly determined. Workforce factors refer to variables such as cost of “labor wages” [Chun 07],[Yurimoto 95],[Leonard 00],“education level” [Chun 07], [Yurimoto 95], [Leonard 00], and “employee skill” [Bart 96],[Yurimoto 95],[Arntzen 95],[Matthias 06],[Haug 92],[Lowe 02],[Mzanda 06] or even “loyalty to the employer” [Bart 96],[Yurimoto 95]. Moreover, empirical evidences from variables investigated found mixed results. For example, [Globeman 99], [Jenkins 02], and [Kravis 89], found in their empirical investigation that wages are negatively associated with FDI. Besides, study of FDI in Turkey [Coskun 96] and [Galan 01] found that labor cost is only a moderate factor. While Schneider and Frey 85, in their study of FDI found that skill-level is more important than labor cost. However,[Bagchi-Sen 95] and [Dunning 89] found that real wage factor is more important for service MNCs compared to manufacturing MNCs [Manjit 05].

Finally, the consequences from review of literatures on influencing factors affected investment decision are presented in Table I.3.

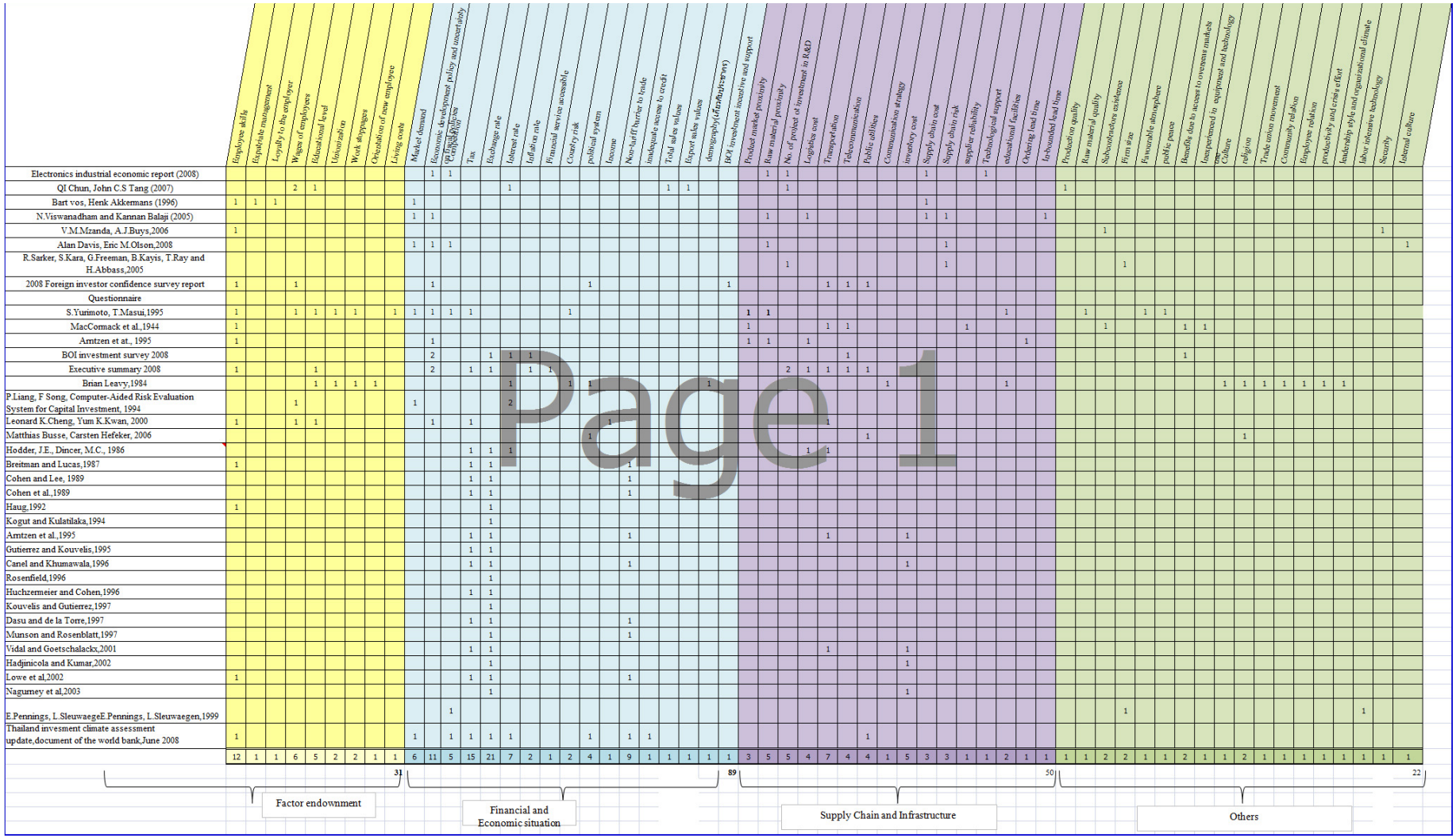


Table I.3: Influencing factors on investment decision

From Table I.3, we synthesize and classify the various studies according to the attributes used for FDI investment. Those factors can be categorized into four groups as follows: (i) Factor endowments, (ii) Financial and Economic situation, (iii) Supply chain and infrastructure, (v) Other related contexts. Consequently, the four aspects from the result of review literatures are explained as follows:

- Factor endowment

The consideration on factor endowment for FDIs investment is most placed on labor. Lack of skilled labor, engineers, specialists or local managers is a critical issue that foreign investor takes into consideration from this area. The following key issue is focused on labor cost. In addition to enhanced basic and technical skills, many researchers look for educational level and experience as more valuable than loyalty.

- Supply Chain and Infrastructure

With regard to the supply chain aspect, cost relevant to supply chain activities such as holding cost of inventory, delivery cost corresponding to the proximity of resources and product market, are crucial factors affecting foreign investors' decisions. Besides, factor of risks involved among supply chain partners has direct impact on the decision. In terms of infrastructure, availability of transportation and the number of research and development project become a priority over all others, including telecommunication, public utilities systems, and educational facilities. According to supply chain and infrastructure, the number of project on research and development (R&D), logistic and supply chain cost, telecommunication network, or even risk in the supply chain are becoming critical factor for investors.

- Financial and Economic situation

The factor group on financial and economic situation seems to be the most important factor for foreign investors when deciding to invest, especially the affecting factors of exchange rate and taxation. These were considered as vital factors by the researchers. Simultaneously, researchers have placed high importance on two other factors, namely economic development and uncertainty on fiscal policies. Moreover, from the literatures the factor of interest rate is also significant, which directly impact to economic situation. In addition to the global economic crisis, political uncertainty is another important factor affecting the country's economy.

- Others

Among those three groups of influencing factors on decision investment, there are some factors with slightly noticed. Those factors can explain as firm characteristic and regions. Different firm characteristics often imply different concerns: for example, small firms were much more concerned about inadequate access to credit than larger firms. Those factors can be grouped corresponding from literatures ordering from the most to the least argument as shown in Figure I.5.

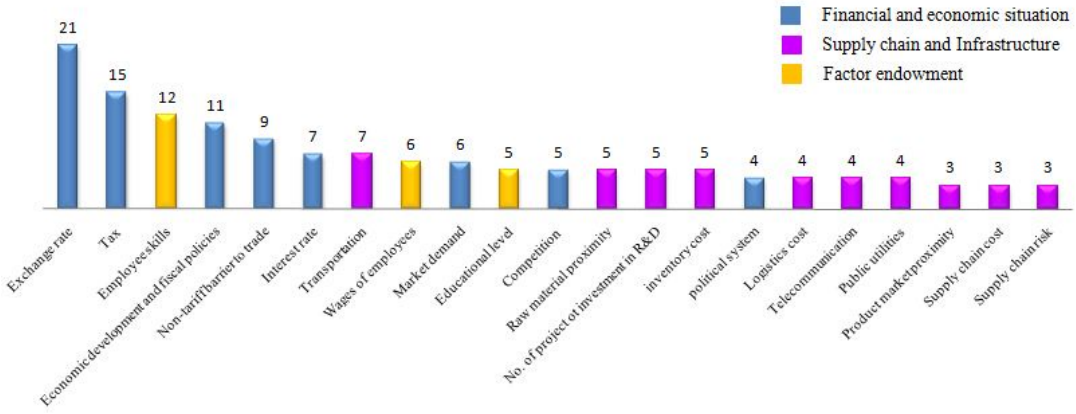


Figure I.5: Most factors influencing on investment decision

From Figure I.5, the most interesting factor is financial and economic situation. Those factors are included with exchange rate, tax and interest rate, fiscal policy, market and competitions. Emphasis in area of skill of employee, and supply chain and infrastructure are recognized as the following group. Apart from that, influencing factors frequently used to consider for FDI investment are employee skill and performance, supply chain and supporting infrastructure, including with the recognition on risk among supply chain. Regarding influencing factor on supply chain aspect, those factors can be explained as the importance of the supply chain collaboration for the decision on plant relocation and investment. Most researchers emphasize on cost of production, supply chain between supplier and customer or even supply chain risk. This includes the consideration on external factors as an economic development policy.

I.5.1.1. FDI's characteristic

Within the research studying on FDI investment, there are also several researchers studied on different FDIs' characteristics. Some of them focused on a decision to set up new plant abroad, while other aim to invest a new affiliated plant from the headquarter, including the market selection to justify their supply chain networks and gain more benefits. It is noticeable that all of those studies are considered on optimization of profits from their investment. Thus, table I.4 presents the characteristics of international investment for FDIs in several aspects.

Reference	FDIs' characteristic	Context	Method
[Shigeru 95]	Overseas plant location from Japan to European Countries.	The research designed a decision support system in order to give appropriate information to manufacturers who are going to set up plants in the European countries.	Analytic Hierarchy Process (AHP)
[Bart 96]	A decision on plant allocation from European to China	The main aim is to present a dynamic allocation method to support manager in (re)design of international facility network.	Statistic analysis: Cost function analysis Dynamic analysis: Simulation with cumulative profitability in different scenarios
[Usher 01]	Material handling investment decision	The two systems are proposed as conveyor and Automated Guided Vehicle (AGVs) Systems. Among the 2 alternatives, the decision are considered by direct economic and intangible value of non quantifiable factors,including ease of use, flexibility, safety and company image.	-Net Present Worth (NPW) -Value Score
[Viswanadham 05]	Decision between FDI and outsourcing.	None of theoretical model on literature can be applied in quantitative context for the	Mixed Integer Nonlinear Program (MINLP)

		decision between FDI and outsourcing, the used of MINLP approach applied on FDI outsourcing decision for acyclic supply chain. To propose quantitative model, three decisions are explained i) multi-product, ii) incorporate tax and iii) incorporate risk due to production.	
[Trappey 07]	International investment approach and decision making process of financial holding companies.	They develop a decision model, designed by Johanson and Vahlne's model, considering financial measures. The model helps firms manage the risks of their investments and derive accurate investment strategies based on investment objectives and constraints. To derive matching model, financial managers are also interviewed to derive the model	Lingo and excel software use to solve financial values.

Table I.4: The characteristics of international investment for FDIs in several aspects

From those characteristics of FDIs and related context listed in previous table, the definitions, relevant to characteristic of FDI's behavior, are mentioned in various aspects. Some of the researchers emphasize the meaning of "relocation" as the activities that the affiliate cannot continue the operational activity and then relocate to another country, just outside home country. Meanwhile, some of the researches argued that expected countries for relocation specially move to low cost labor countries. Besides, not only relocation or setting up a new plant but also adding production line or even increasing production loading is considered as plant relocation. This conclusion is remarked in the same meaning for offshore manufacturing. Regarding to the meaning of allocation and technology transfer

activity, both are similar meanings. Technology transfer activity describes the strategy on knowledge and technology transfer, while allocation can be defined as determining the location, capacity of manufacturing, and distribution facilities in order to (re)design of international network: for example, by establishing new plants abroad.

Divestment is subdivided in several categories: i) an affiliate is closed ii) manufacturing affiliate is turned into a non affiliate and iii) the affiliate is sold to another firm. Then a divestment was identified when the cessation or sales of manufacturing activities had actually take place. Those definitions are presented as shown in Table I.5.

Reference	**Definition**
Relocation	
[Moshe 01]	A form of organizational change which has been distinguished by 2 main features. It is a comprehensive change involving all the employees, the entire social network, and the whole material and equipment make-up. It affects not only the employees' working life but also their non-working life. Plant relocation is commonly undertaken in order to pursue company growth and development, or to solve financial and operational problems
[René 06]	Manufacturing activities that were discontinued in the affiliate were: relocated to another country, either by establishing a new affiliate, or adding product line(s) increasing the production loading in an existing affiliate in that country
[Nakosteeen 87], [Pellenbarg 03]	Relocations are also of immediate policy interest as they tend to involve larger plants and growing plants.
[Fred 96]	Global relocation takes place when a firm moves one or more business activities to a location outside its home country

	Business relocations are claimed to be job exporting with firms moving to low-cost labor-abundant locations (Arthuis,1993;OEDC,1995; Brainard and Riker,1997;European Parliament,1998) International relocation is defined as either the decision to move part of the production to another country or to replace part of the production by a combination of an investment abroad and subcontracting during the period 1990-1996.
[H.Min 99]	To adapt to dynamic changes in business environments surrounding the firm's supply chain operations. Such changes include changes in supplier and customer bases, distribution networks, corporate re-engineering, business climate and government legislation
[Derek 99]	Firms are moving facilities away from home countries to overseas low-cost sites, resulting in closures or significant staff reductions domestically.

Divestment

[René 06]	The cessation of manufacturing activities by a Japanese firm in an existing affiliate. They subdivided divestments in several categories An affiliate is closed A manufacturing affiliate is turned into a non-manufacturing affiliate The affiliate is sold to another firm. A divestment was identified only when we could confirm that the cessation or sale of manufacturing activities had actually taken place.
[James 94]	They identified types of Divestment Decision into Strategic divestment and financial divestment. For Strategic perspective of internal to the firm, there are 2 meanings 1) Shut-down of operations and 2) Reallocation of resources among a series of ongoing integrated operations. External to the firm, There are also 2 definitions: 1) Sale of a product, product line, or part or all of a division to an independent company. For financial perspective, internal to the firm, it is issuance of stock in a subsidiary to firm's

	own shareholders. External term, it is sale of a stock interest in a subsidiary to the general public.

Technology transfer

[Lan 96]	A broad set of processes, covering flow of knowledge, expertise, know-how, equipment, machinery, software, medium ware and techniques amongst stakeholders and other markets around the world.
[Gross 96]	It includes learning to understand, choose, utilize, adapt and replicate technology.
[Harry 01]	Mention as knowledge transfer. This process requires new managerial skills, but can become a powerful competitive weapon.

Allocation

[Bart 96]	Determining the location, number, and capacity of manufacturing and/or distribution facilities of multinationals on strategic decisions concerning the (re)design of international networks, for example by establishing new plants abroad.

Expand Business

Foreign investor confidence survey report [BOI 08]	Expand the businesses divided into 2 main categories:1) expand slightly or on a small scale 2) expand significantly or on a large scale.

Offshore manufacturing

[Lu 09]	Moving production facilities to low-wage countries

Table I.5: The definitions relevant to characteristic of FDI's behavior

Finally, it is found that among those definitions, there are three different strategies regarding to the characteristic on FDI's behavior. The three strategies can be referred as i) relocation plant, ii) divestment plant and iii) transferring plant, the definitions are designated in detail as following.

"**Relocation plant**" Main issues argued by [Moshe 01]: the change of employees, social network and assets that affects to not only employees but also on their non-working life. This situation aims to pursue growth of company, or to solve financial

and operation problems.[René 06], and [Fred 96] mention on the activities of the affiliated company while relocated to another country for a new establishment or adding new production line both in new and existing affiliate company. [Derek 99] explains on the moving of facilities from home countries to overseas low-cost sites.

"**Transferring plant**" is referred to a flow of knowledge, expertise, know-how, equipment, machinery, software, medium ware and techniques amongst stakeholders and other markets around the world [Lan96]. [Gross96] includes learning to understand, choose, utilize, adapt and replicate technology among the process flow. Besides, [Harry 01] requires new managerial skills among the process.

"**Divestment plant**" [René 06] mentions on the cessation of manufacturing activities in an existing affiliate by closing, turning to non-manufacturing or selling of affiliate company to another firm. [James 94] claims that there are the situations of shutting down of operation and reallocation of resources.

Since it can be concluded that the main characteristic of FDI' investment can be classified into three situations. Then the following section will discover on the applicable approach and method used for each situation on make a decision of FDIs' investment.

I.5.2. Approach used on make a decision of FDIs' investment

Several authors have developed approaches under various points of view concerning business relocation. For instance, the incorporate management participation has applied dynamic analysis on cost simulation which is used to support manager in redesign of international facility network from Europe to China. The method considers the return on investment or profitability combined with soft variables; for example, loyalty to employer, employees' skills [Bart 96]. [Viswanadham 05] proposed a quantitative model for optimal decision between FDI and outsourcing with multi-stages of supply chain risk caused from the supply chain, inventory and transportation cost. Moreover, to explore the fact of technology transfer by FDI in the electronics sector of South Africa, the researchers criticized the need to be integrated

from start to acquire capabilities focused on developing knowledge based, security and subcontract existence [Mzanda 06].

As far as investment in manufacturing is concerned, profit is a key factor for the investor. Therefore, minimizing the cost and maximizing revenue are undertaken to maximize profit. Consequently, numerous investment decisions consider on financial value: such as, return on investment (ROI), net present value (NPV), and payback period (PB). In the area of doing businesses, a number of researches in production planning have subsequently been carried out to maximize the NPV [Kersten 08].This approach used for optimizing decision making, which estimates the current value of cash flows relating to an investment [Califf 08]. [Liang 94] mentions that in term of evaluating a project, most financial analysts prefer the use of the NPV than other method which have certain shortcomings. For example, the method of internal rate of return (IRR) implies the assumption of reinvestment which is irrational in some cases; the method of payback period cannot reflect the time value of money. Thus, table I.6. analyses several techniques used for FDIs' investment.

Reference	Context	NPV	Value score	AHP	Break-even analysis	Sensitivity analysis	Game theory	IRR	Multi-criteria	Risk attitude	ROI	Delphi technique	Risk evaluation	Data Envelopment Analysis (DEA)	Mixed Integer Nonlinear Program (MINP)	Debt and equity ratio	Dividends paid as a percentage of earnings	Interview and document analysis
J.S. Usher, A.H.Kamal, S.W. Kim, 2001	Material handling investment	1	1															
Shigeru Yurimoto, Tadayuki Masui, 1995	Oversea plant location			1														
P.Jovanovic, 1999	Project investment				1	1	1											
C.J.Bacon, 1992	Investment decision	1						1										
J.J.Choi,1989	Inter. diversification							1										
Brian Leavy, 1984	Country's risk assessment								1		1	1						
C.V.Trappey et al ,2007	International Investment decision for financial companies	1								1								
P.Liang, F.Song, 1994	Capital investment												1					
W.K.Wang, 2005	Government real estate investment													1				
Bart Cos, Henk Akkermans, 1996	Plant allocation										1							
N.Viswanadham, Kannan Balaji, 2005	Investment or outsourcing														1			
Hodder and Dincer,1986	International plant location	1																
Breitman and Lucas,1987	facility location, capacity planning, material sourcing, product allocation and new product introduction														1			
Irene M.Duhaime,John H.grant,1984	Divestment decision										1					1	1	
Califf, Rasiel, and Schulman,2008	Optimize profit within legal and ethical standard in Phamaceutical and medical device industries	1																
M.M. Naim et al., 2007	selection in the ordering policy of a production planning and control system	1																
Ralf Spann,2008		1																
Magni, Carlo Alberto,August 2005		1																
Barlow 7 Wender, 1955																		1
	Sum	**8**	1	1	1	1	1	**2**	1	1	**3**	1	1	1	**2**	1	1	1

Table I.6. Survey of literatures on techniques used for FDIs' investment

From Table I.6, it is noticeable that among several techniques used, the most financial tool to evaluate cost of doing business for FDIs is Net Present Value (NPV). The relevant contexts using the technique are involved, e.g., investment in advanced material handling system [Usher 01], international plant location [Hodder 86], profit optimization in pharmaceutical and medical device industries [Califf 08] which generally used for supporting the decision of doing businesses or selection on plant location. Some researchers refer to techniques of return on investment (ROI) and internal rate of return (IRR) applying for plant allocation, divestment decision or the country's risk assessment. However, few of them mention several different techniques used, e.g.,[Qi Chun 07], have proposed a genetic algorithm (GA) as an analytical tool to define fitness function as a variable selection algorithm and analysis of inward Foreign Direct Investment (FDI). [Viswanadham 05], proposed a quantitative model for optimal decision between FDI and outsourcing with multi-stages of supply chain risk caused from the supply chain, inventory and transportation cost.

I.6. Comparison the critical factors with case study in Thailand

From the previous section, the distinguished factors resulted from the survey of literatures were presented into four aspects: i) factor endowment ii) financial and economic situation iii) supply chain and infrastructure iv) others related with internal management. Then to confirm the classification of critical factors resulted from the survey, a well-designed questionnaire was created. Twenty-five questionnaires were sent to the enterprises in the Northern region industrial estate area of the Lumphun province, Thailand. There were thirteen enterprises responded, accounting for response rate of 52%. The respondents work in managing level's position, including with managing director, division manager, and production manager.

The manufacturers were electronics, jewellery, mechanical parts and components, food and garment industries. The proportion according to the types of industries is shown in Figure I.6.

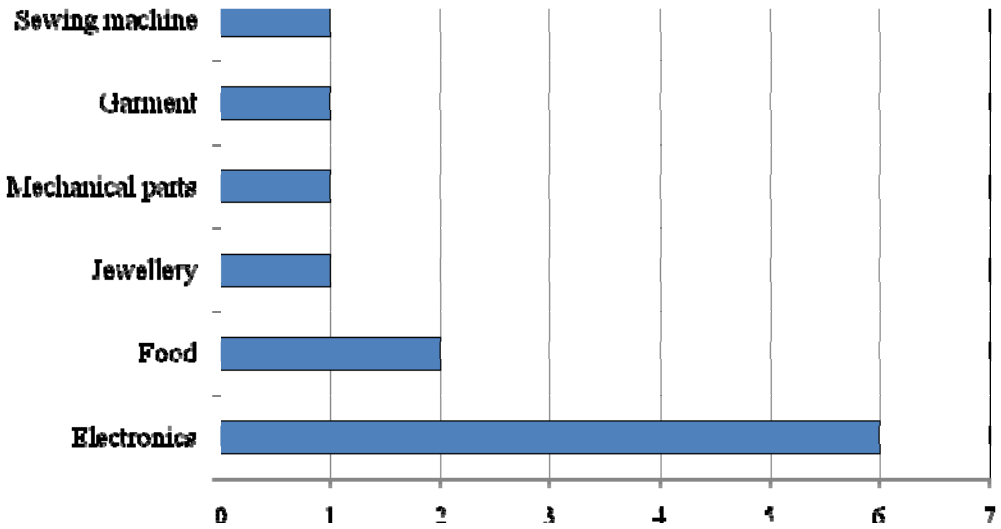


Figure I.6. The percentages of the types of industries responding the questionnaires [Northern Region Industrial Estate Office 08]

There are two parts of questionnaire; the first part aims to distinguish influencing factors which lead to each FDIs'characteristics: relocation, transferring and divestment scenarios. The second part is to evaluate the risk value by weighting on the impact and occurrence of relevant disruptions leading to those three crises of plant. The second part of questionnaire will be discussed in detail on the chapter 3.

Regarding to results of questionnaire, it is found that the major respondents were from European countries which are French, German and Swiss companies. Others were Japanese, Thai-American, American, and Thai-Japanese companies. All those companies, except German company locate the main factory as headquarter in this area, keeping the headquarter sites in their own countries and operate the operational factories in this area. Besides, 46% of the entire responses are from electronics components companies, in which the characteristic of this type of the company is attracted by FDIs' investment.

In the first part of the questionnaire, the influencing factors leading to each FDIs' characteristics can be distinguished, the factors in which the respondents believe as

important for investment's decision were found by weighting into percentage. Finally, the four major aspects of financial situation, worker skill and performance, supply chain and infrastructure are shown as the necessities. The Percentage of four major aspects of influencing factors on investment decision is illustrated in figure I.7.

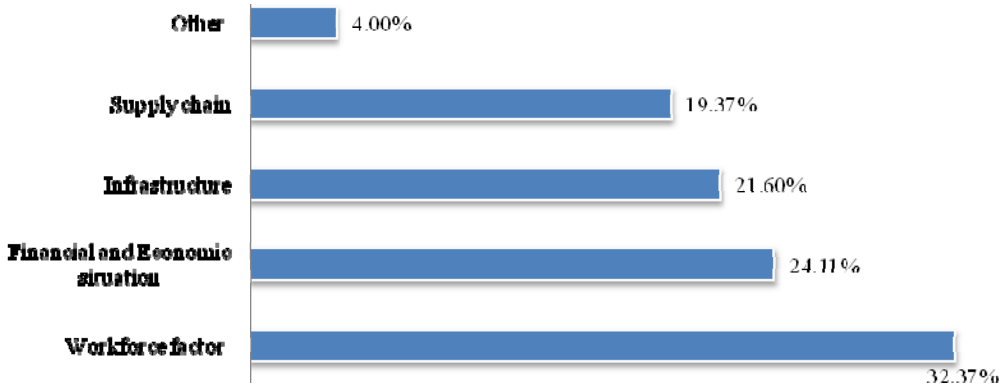


Figure I.7: Percentage of four major aspects of influencing factors on investment decision

Consequently, the four influencing factors for investment decision can be divided roughly into the following three groups:

- **Factor 1:** Financial situation

Financial situation can be described as the situation affected to financial problem. Unstable economic conditions such as inflation, interest rates, growth in gross domestic product (GDP), as well as monetary and fiscal policies are important [Root78]. For example, exchange rates can be marked effects on a company's operating profitability and debt burdens and may therefore be an influence factors used for investment decision. The extent of this influence will depend on the country economic and exchange rate policies [Campa 93], whereas, unstable of political situation and inconvenient of unattractive regulations, are also taken into consideration to this area.

- **Factor 2:** Supply chain and Infrastructure

Good infrastructure increases the productivity of investments and therefore stimulates FDI flows. Physical infrastructure like transportation and distribution, technology and

telecommunications has a positive impact for firm's ability. Besides, the collaboration among each other partners in supply chain network helps to enhance of the effective interaction and handle potential disruptions before occurring. Besides, the need for proximity of a calibration centre is required. This centre is an important factor, even though most manufacturers have their own research and development centres located in its headquarter site. In terms of logistic networks, the outbound logistics; for example, land and air freight are the major factor commonly used for transportation route. In addition, the need for telecommunication such as leased line, Asymmetric Digital Subscriber Line (ADSL) or Wireless Local Area Network (WLAN) and supporting infrastructure cannot be disregarded.

- **Factor 3:** Worker skill and performance

Workforce factor refers to variables such as work ethic and attitude, and labor conditions that are usually deemed important by firms, e.g, cost of labor and skills performance. Competency and skill-based requirement are the crucial factors required to improve the knowledge worker's performance. There are empirical investigations found that the cost of labor might be a more significant consideration for industry sectors, however technical support, skill-level and educational level in the workplace are also strongly required to improve the knowledge worker's performance [Mzanda 06], [BOI 09], [Cheng 00].

As noted above, it has been noticed that the results of questionnaire are congruent with the broad view of influencing factors from the survey of literatures which are factor endowment, financial and economic situation, and supply chain and infrastructure. Hence, these consequences help us to reconfirm that the influencing factors used for FDIs' investment decision can be classified into three general aspects. The three aspects are included with:

- Financial and economic situation
- Supply chain and Infrastructure

Worker skill and performance

Next, to consider the main aim of this research, establishing the key factors that describing on each characteristic of relocation, transferring and divestment scenarios was established. A rating scale from insignificant to catastrophic effecting

factors is suggested. Five parameters used on a scale from 1 to 5, indicating the opinion from respondents as shown in Table I.7.

Descriptor	1	2	3	4	5
	Insignificant	Minor	Moderate	Major	Catastrophic
	Interruption does not impact	With minimal interruption	Some interruptions impact	Major impact	Significant effect

Table I.7: A rating scale used to indicate the opinion from respondents

The key factors are used to be considered, corresponding to the survey. The following table (Table I.8) is the lists of issue to be analyzed and indicated from the respondents in the questionnaire.

Aspect	**Issue**
Financial and economic situation	- Financial problems such as the strong exchange rate of Thai baht, market risk etc.
Supply chain and Infrastructure	- Inefficient collaboration among company to supplier and/or customer such as supplier unreliability, inaccurate sales forecast of demand variation. - Difficulties related to internal operations such as operational and technical problem effecting product quality. - Unwelcome on facilities, infrastructure and supporting environment, such as public utilities and inconvenient regulation for company. - Inefficient internal collaboration, such as over inventory, production cost, information breakdown. - Inconvenient logistics such as transportation channels for raw material and finished good delivery
Worker skill and performance	- Inefficient employees and lack of skill requirement - High turnover rate in human resources

Table I.8: Issues to be analyzed of the questionnaire

Then our study discovers on the distinguished causes leading to divestment, relocate and transferring plant. From responded questionnaires, the outcomes have been compared into the three characteristics of plant as shown in Figure I.8.

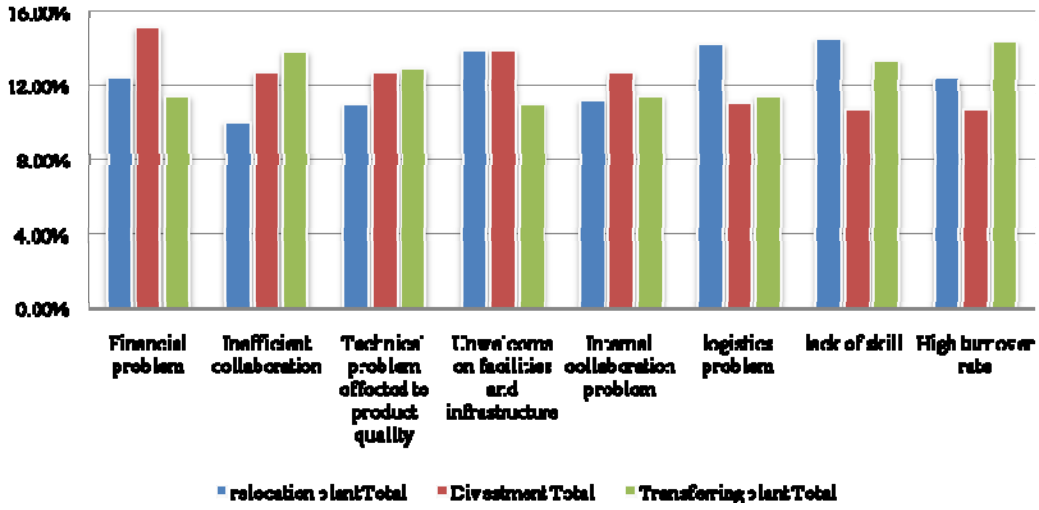


Figure I.8. Comparison of causes leading to three characteristics of plant

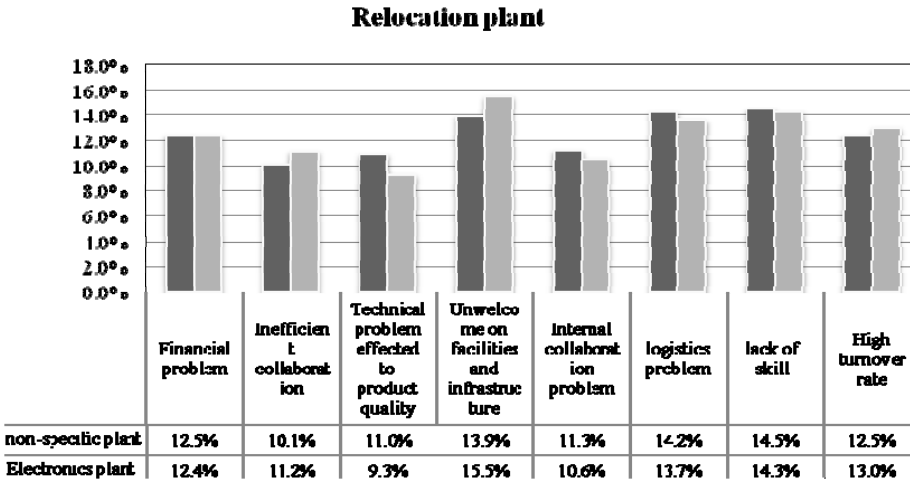
In Figure I.8 it can be shown that among all potential factors, financial problem is the key issue leading to divestment plant. Lack of skill is explained as the strong issue causing relocation of plant. For transferring plant, high turnover rate of employees is shown as the dominant criteria impacting to the scenario. Nevertheless, several factors such as inefficient collaboration among partners, logistic problem are all relatively key factors. Concerning other issues, we summarize as shown in the Table I.9. This table ranks the influencing issues among three characteristic of plant.

	Ranking		
Issue	**Relocation plant**	**Divestment**	**Transferring plant**
Financial problem	4	1	5
Inefficient collaboration among company to supplier and/or customer.	8	3	2

Difficulties related to internal operations.	7	3	4
Unwelcome on facilities, infrastructure and supporting environment	3	2	8
Inefficient internal collaboration.	6	3	5
Inconvenient logistic systems	2	6	5
Inefficient employees and lack of skill requirement	1	7	3
High turnover rate in human resources	4	7	1

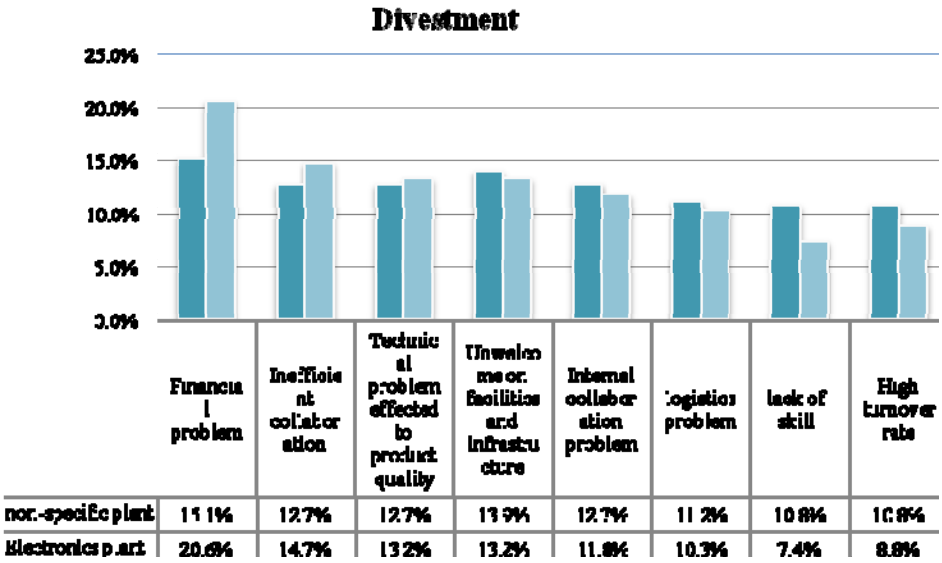
Table I.9: Ranking the influencing issues among three characteristic of plant

Then, we distinguish the influencing factors by comparing between electronics and the others sector. This comparison helps to describe dominant criteria, affecting electronics manufacturing as illustrated in Figure I.9.



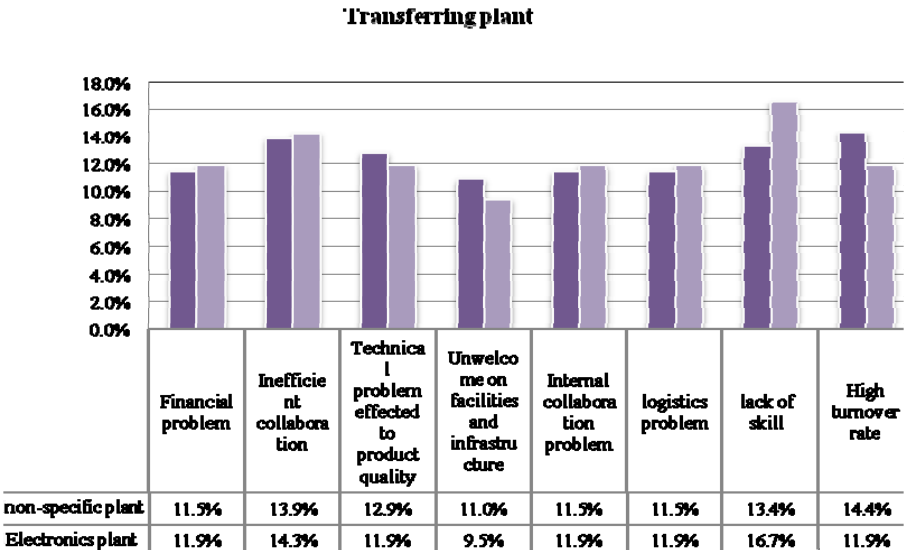
(a): relocation plant

As seen in Table above, the unwelcome on facilities and infrastructure such as public utilities and inconvenient regulation, is presented as the significantly resulted to relocate plant. The lack of relative skills and logistics problem are also presented as high percentage leading to the situation.



(b): Divestment plant

The findings show that, the financial problem such as the strong exchange rate of Thai baht, and market risk distinctively affect to the divestment situation. Inefficient collaboration among supply chain partners and supporting facilities are important to the situation as well.



(c): Transferring plant

Figure I.9: Comparison of causes leading to three characteristics of plant in electronics sector

From Figure I.9(c), it can be remarked that most significant factors impacting transferring situation is lack of skill, while the secondary indicator is inefficient collaboration among partners. Other relevant factors such as high turnover rate, financial, logistics network and internal collaboration problem are the following factors to be remarked.

Consequently, results from the first part of questionnaire show level of significant factors impacting on divestment, relocation and transferring of plant. Thus, considering on those three situations in electronics sector, it can be noticed that influencing factors of electronics sector be not different from non-specified type of manufacturing. Finally, factors can be classified into three situations of plant into the three general aspects, i.e., financial and economic situation, supply chain and infrastructure, knowledge and skill performance of employee.

From the analysis of literature and the survey on plant investment decision, there is no single set of criteria to typify relations between each decision's characteristics and the influencing factors. The attributes used in each research are different, even though the factors used to evaluate each type of decision sometimes remain too broad. For example, some authors mention the attributes which influence a decision in each type of situation, specifically the decision on production and manufacturing, for instance, supplies existence [Electronics Industrial Economic report 08], [Viswanadham 05], [Davis 08], [Sarker 05], Supply chain risk [Viswanadham 05], [Davis 08], [Sarker 05], the criteria on economic development policy [Electronics Industrial Economic report 08], [Viswanadham 05], [Davis 08], [Sarker 05], supply chain cost [Electronics Industrial Economic report 08],[Bart 96], [Viswanadham 05], and research and development support [Electronics Industrial Economic report 08], [Sarker 05] which make it difficult to get any conclusion or remark the difference among electronic sector with the other.

In this regard, we propose an integrated framework to help manufacturers or foreign investors to make a better decision on their investment. However, to prevent unwelcoming situation of plant and sustain the businesses, the identification of relevant stakeholders who are associated with three main necessities of FDIs'

investment is vital Thus, we will identify those stakeholders and what are their main responses for businesses in the following section.

I.7. Key success factors and their stakeholders to sustain foreign businesses

From the previous section, the potential factors affecting the crises and FDI's investment decision are recognized for the study as the key success factors of sustain foreign businesses. Regarding to those discovered factors, the three relevant partners are involved. Those three partners are foreign investor, local industrial estate stakeholders, and managers in the companies.

The collaboration among those three partners is the key success partners to sustain and prolong foreign businesses to totally prevent the relocation problem. Then this section presents how the three partners are relevant to the potential factors, and their objective functions. Finally, the problem of the study will be discussed.

To sustain and prolong foreign businesses, several factors on FDI's investment have been considered. The previous section was referred to the three relevant potential factors. Thus, we can identify influencing factors on based on three main necessities. Those three factors are i) low cost of labor, ii) skilled labor requirement, and iii) supply chain and infrastructure effectiveness. Among the three potential factors (the government and private sector of Industrial Estate Authority of Thailand, foreign investor and manufacturer), responding stakeholders play as a major role to create and improve competitive advantages. In order to support and provide the competitive performance of the province, mutual understanding and collaboration among the three stakeholders will help create many beneficial outcomes on manufacturing, e.g., the collaboration on information sharing of entrepreneurial investment among the three stakeholders of investors, industrial estate authority of Thailand and manufacturers benefits for the overall partners. The use of Community of Practice (CoP) which is referred to "the process of social learning that occurs when people who have a common interest in some subjects or problems collaborate over an

extended period of share ideas, find solutions, and build innovation"[Viswanadham 05].

The information sharing provides for three stakeholders. The analysis in financial aspect for manufacturing investment provides for newcomer of foreign investors, supply chain and infrastructure improvement suggests to the government and private sector. Furthermore, in order to sustain manufacturing status, knowledge skill and performance improvement are necessities to operate in manufacturing.

- Government and private sectors (IEAT)

In terms of government and private sector, restructuring the industrial sector is necessary. The restructuring plan should include (i) the development of technology and research from existing knowledge to create value-added and increase the competition potential, (ii) the appropriate and effective environmental management for industrial sector, (iii) the improvement conditions for doing business, and (iv) the linkage among the up-stream, middle-stream and down-stream within and between industries. All factors will help to build potential and capacity of Thai industrial sector for competitive advantage in the world market. Besides, the plan should aim to promote product development in terms of value creation to achieve the balance between economic benefit and environment cost.

- Manufacturer---bathtub

In case of electronic industries, the study area should be able to attract FDI investments, by focusing on their strength of high product quality and skilled labor, affect to higher competitive performance in global market and creating value-added on their own products. Besides, supprting the innovation of research and development unit within the companies will help to create in body of knowledge as well as the technology transferring through the workers in the country.

- Foreign investor

As described in the beginning of the chapter, as far as manufacturing in manufacturing is concerned, profit is a key factor for foreign investor. Thus laws and regulations related to financial of investment, tax, rate of exchange of the country become the key index drive the growth of economics, while, minimizing the costs and maximizing revenue is undertaken to maximize profit.

In this study, these three stakeholders are the key partners to be successful on FDIs' investment of the country. However, those key partners are concerned with supply chain and infrastructure, knowledge and asset transferring, as well as cost of doing business. Thus to prevent business's crises, the integration on those key issues need to be considered for foreign investors or manufacturers who are willing to invest and gain more benefits.

I.8. Conclusion

As foreign businesses in electronic sector face many critical challenges regards to the increasing of labor cost and supply chain and infrastructure ineffectiveness, high entries of new competitors to the markets, or even internal organization problems have caused the businesses slow down. Then new and existing foreign investors are reluctant to invest or expand the businesses. Regarding to our case study in Northern Region Industrial Estate, Thailand, earnings from industrial labor wage is a key factor driving the province's growth. Moreover, major type of manufacturing is electronics industrial of which effectiveness in supply chain and logistics are more beneficial to this sector.

Moreover, as described at the beginning of the chapter, the structure of the electronics product's network is worldwide, since most of electronic products from this area are directly exported to the parent companies or their affiliates. Besides, intensive labor is one of the main characteristic required for electronic companies. Thus, higher of the lowest cost of labor in the province have been affected to higher cost of production. For these reasons, the remaining on these climates of doing business and among high competitions among neighboring countries may result in the business relocation or closing plant. Consequently, the crises can be affected people's income, as well as economic problems and finally leads to social problems in the province.

As mentioned, supply chain and operational cost of doing businesses, financial and economic situation, workers skill and performance are listed as the potential factors for FDIs' investment. There is no study about the supporting decisions of investment to help them make a decision on FDIs' investment based on the integration of those three critical factors. Most of the researches are mainly focused on financial

perspective of maximize profits, while other potential factors of supply chain and infrastructure, as well as worker skill and performance, are controversial among the several researchers that needed to be considered. These issues are still insufficient on applicable researches. Thus, in this study, in order to propose a decision support system for investors or manufacturer, we propose the integration framework of three potential factors corresponding to relevant stakeholders. The collaboration among each stakeholders that are foreign investors, local industrial estate sector, and manufacturers are the key success factors of sustainable foreign businesses.Those three partners are corresponded to each potential factor, which influenced the decision of FDIs. As previous mentioned, the potential factors refer to "*cost of doing business*", "*supply chain and infrastructure*" and "*asset and knowledge transferring*" These three contexts are the main focus on the FDIs' investment decision which also the main focusofthis study. However, the research problems are explained as follows:

1 What are the potential factors used for making a decision while the FDIs face with crises of doing businesses?

2 How can the study provide or help the manufacturers make a good decision on their manufacturing's crises?

3 In order to make a decision on relocation, transfer or divest plant, are there the distinguished factors among them to be considered?

4 How can the relevant organizations and the government help to prevent the crises resulted from offshore or divestment plant?

Chapter II: Theories of Research Context

II.1. Introduction

This chapter we will clarify the theories related with potential factors linked to business crises as referred on the previous chapter. The main potential factors refer to "*cost of doing business*", "*supply chain and infrastructure*" and "*knowledge and skill performance"*. For cost of doing the business, "Maximizing profit and minimizing operational cost is first realized by the investors, while the effectiveness on supply chain and infrastructure enhance manufacturing efficiency and productivity. Besides, knowledge and asset transferring need for improving skill and performance of the developing countries. Therefore, we will initiate the first part by explaining on supply chain and distribution network then the chain is broken to activities called "Value chian". Two theories on "s-curve" and "bathtub" analysis on international trade will also be introduced. This section helps to describe relative context to the characteristic of our problematic. Then to described processes and illustrate activities along the supply chain network, the Supply Chains Operations Reference (SCOR) and simulation will be explained. Finally, the three requirements to support investment decision will be proposed the model on FDIs' investment decision. Those three relative stakeholders among foreign investors, local industrial estate sector, and manufacturers will be represented.

II.2. Supply Chain management

In the 1980s companies discovered new manufacturing technologies and strategies that allowed them to reduce costs and better compete in different markets. Strategies such as just-in-time manufacturing, *kanban*, lean manufacturing, total quality management, and others became very popular, and vast quantities of resources were invested in implementing these strategies. The evolution of supply chain management is explained in Figure II.1. Afterwards, companies increasingly recognized that they must rely on effective coordination in the companies, or networks, to complete in the

global market and networking economy. In the last few years, however, it has become clear that many companies have reduced manufacturing costs as much as is practically possible. Many of these companies are discovering that effective supply chain management is the next step they need to take in order to increase profit and market share.

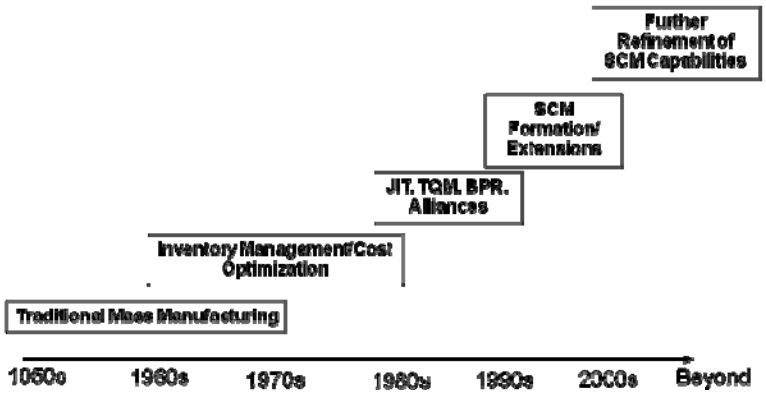


Figure II.1: Evolution of supply chain management

In a typical supply chain, raw materials are procured and items are produced at one or more factories, shipped to warehouses for intermediate storage, and then shipped to retailers or customers. The objective of supply chain management is to be efficient and cost-effective across the entire system; total systemwide costs, from transportation and distribution to inventories of raw materials, work in process, and finished goods, are to be minimized. Consequently, to reduce cost and improve service levels, effective supply chain strategies must take into account the interactions at the various levels in the supply chain. The supply chain, which is also referred to as the logistics network, consists of suppliers, manufacturing centers, warehouses, distribution centers, products that flow between the facilities (see Figure II.2). But what exactly is supply chain management?

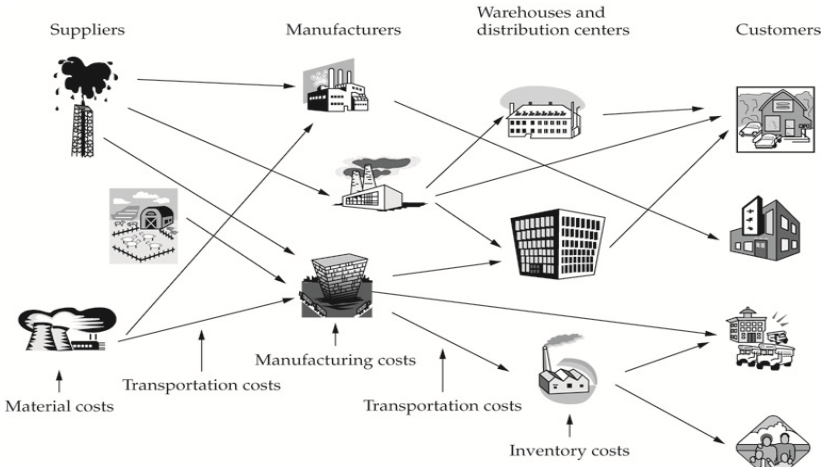


Figure II.2. The logistics network [David 03]

“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.”

“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 qty, to the right places at the right time with the objective of minimizing global system costs and maximizing the customer service levels [Gonca 09].”

Finally, because supply chain management revolves around efficient integration of suppliers, manufacturers, warehouses, and stores, it encompasses the firm’s activities at many levels, from the strategic level through the tactical to the operational level. However, a variety of reasons lead to difficulties throughout supply chain manangement. They can all be related to one of both of the following observations:

- It is challenging to design and operate a supply chain so that total systemwide costs are minimized, and systemwide service levels are maintained. Indeed, it is frequently difficult to operate a *single facility*. The difficulty increases exponentially when an entire system is being considered. The process of

finding the best systemwide strategy is known as global optimization. A variety of factors make this a challenging problem:

  - The supply chain is a complex network of facilities dispersed over a large geography, and in many cases, all over the globe.
  - Different facilities in the supply chain frequently have different, conflicting, objectives. For instance, suppliers typically want manufacturers to commit themselves to purchasing large quantities in stable volumes with flexible delivery dates. Unfortunately, although most manufacturers would like to implement long production runs, they need to be flexible to their customers' needs and changing demands.
  - The supply chain is a dynamic system that evolves over time. Indeed, not only do customer demand and supplier capabilities change over time, but supply chain relationships also evolve over time.
  - System variations over time are also an important consideration. Even when demand is known precisely (e.g. because of contractual agreements)

- Uncertainty is inherent in every supply chain; customer demand can never be forecast exactly, travel times will never be certain, and machines and vehicles will break down. Supply chains need to be designed to eliminate as much uncertainty as possible and to deal effectively with the uncertainty that remains.

Consequently, we have realized that supply chain effectiveness is necessary for the global organizations in order to increase profit and market share. Besides, to improve the global supply chain performance the two major issues are related on the ability to effectively manage uncertainty and the ability to replace traditional supply chain strategies with respect to global optimized supply chain. These two issues are recognized existing manufacturers and new investors to improve their logistic network and aware the existing and coming uncertainties on FDIs' investment.

II.2.1. Uncertainties in supply chain management

Global supply chains carry unique risks that influence performance, including variability and uncertainty in currency exchange rates, economic and political instability, and changes in the regulatory environment [Dornier 98]. Currency exchange rates affect the price paid for goods that are purchased in the supplier's currency and influence the timing and volume of purchases as well as the financial performance of the supply chain [Carter 88, 89]. Thus the studies in supply chain are usually involved with risks or the uncertainties within organizations. Some evidences from literatures, for example, [Gonca 09] mentions 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 we need to have reliable estimation of these uncertainties.Besides, 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 respected to global optimized supply chain seems to enhance global performance for doing the businesses. 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 beware of as shown in Table II.1. Those key issues span through a large spectrum of a firm's activities from the strategic to operational level.

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

Table II.1 Key supply chain management issues

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, we thus summarized them into strategic to operational decision as described in the following figure.

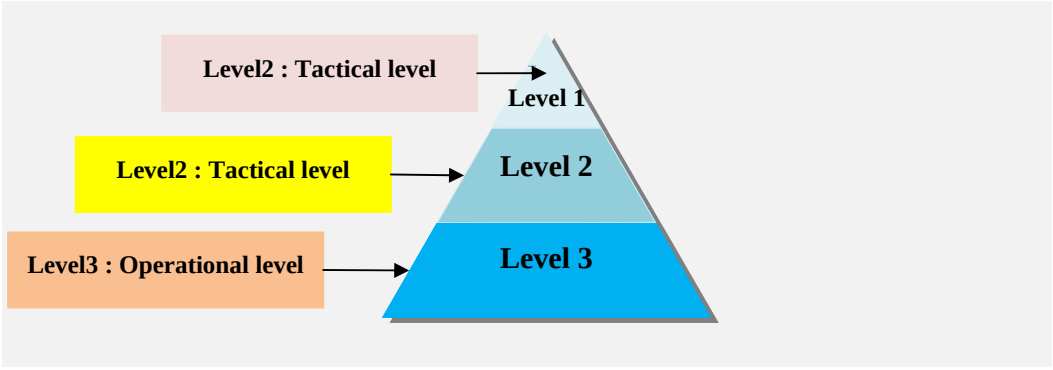


Figure II.3: Strategic level to operational level along the supply chain

- The strategic level deals with decisions that have a long-lasting effect on the firm. This includes decisions regarding the number, location, and capacity of warehouses and manufacturing plants and the flow of material through the logistics networks.
- The tactical level includes decisions that are typically updated anywhere between quarterly and annually. These include purchasing and production decision, inventory policies, and transportation strategies, including the frequency with which customers are visited.
- The operational level refers to day-to-day decision such as scheduling, lead time quotations, routing, and truck loading.

However, we introduce and discuss some of the key issues associated with different decisions, for example, inventory control (tactical level), oursourcing and procurement,

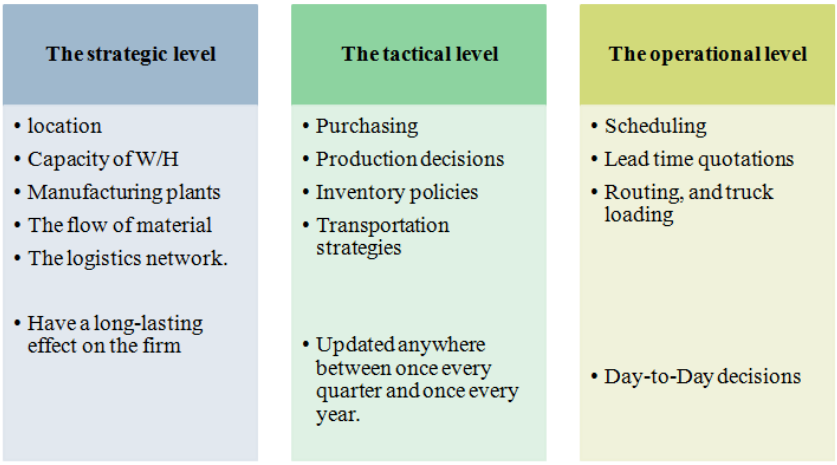


Figure II.4 Key issues in supply chain span from the strategic through the tactical to the operational level

Inventory Control: Consider a retailer that maintains an inventory of a particular product. Since customer demand changes over time, the retailer can use only historical data to predict demand. The retailer's objective is to decide at what point to reorder a new batch of the product, and how much to order so as to minimize inventory ordering and holding costs.

Outsourcing and Procurement Strategies: Rethinking your supply chain strategy not only involves coordinating the different activities in the supply chain, but also deciding what to make internally and what to buy from outside sources. How can a firm identify what manufacturing activities lie in its set of core competencies, and thus should be completed internally, and what product and components should be purchased from outside suppliers, because these manufacturing activities are not core competencies.

Since the decision levels in supply chain management deal from long term decisions to day-to-day decision along the supply chain networks. Thus supply chain management takes into consideration every facility that has an impact on cost and plays a role in making the product conform to customer requirements: from supplier and manufacturing facilities through warehouses and distribution centers to retailers and stores. Indeed, in some supply chain analysis, it is necessary to account for the suppliers' suppliers and the customers' customers because they have an impact on supply chain performance to inventories of raw materials, work in process, and finished goods, are to be minimized. Thus, the emphasis is not on simply minimizing transportation cost or reducing inventories but, rather, on taking a systems approach to supply chain management.In many ways, international supply chain management is the same as domestic supply chain management spread 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. International supply chains can run the gamut from a primarily domestic business with some international suppliers to a truly integrated global supply chain.

II.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 customer, and improved reliability because of close proximity to suppliers [MacCormack 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 [Mary 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 [Mary 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.

International supply chains can run the gamut from a primarily domestic business with some international suppliers to a truly integrated global supply chain. Some of the advantages and disadvantages that we will discuss apply equally to all of the systems in the following list, while others apply only to the most complex integrated systems.

- International distribution systems. In this type of system, manufacturing still occurs domestically, but distribution and typically some marketing take place overseas.
- International suppliers. In this system, 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. In this type of system, 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. 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.

Supply chain can fit more to one of these categories. Throughout the following discussion, it is considerable that how each of the issues discussed applies differently to firms, depending on their position in this global supply chain spectrum.

Besides, experts argue that global supply chains are more difficult to manage than domestic supply chain [Dornier 98]; [Wood 02]; [MacCarthy 03]. Since substantial geographical distances in these global situations not only increase transportation costs, but also lead to the complicated decisions. Due to increasing lead-time in the supply chain results in inventory cost. Different local cultures, languages, and practices diminish 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. These difficulties inhibit the degree to which a global supply chain provides a competitive advantage. Thus 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.

Theoretically, the origin of international business can be traced back by examining the work done by Vernon. The pattern of international trade was developed by [Raymond Vernon, 1966] and called as “Product Cycle”theory. He suggests that the product location for products moves from one country to another depending upon the stages of the product’s life cycle. Thus to clarify the theory and the stages of the product’s life cycle, in the following section is explained about the trade theory and pattern of international trade.

II.2.2.1 The pattern of international trade

A static framework of comparative advantages was developed by Raymond Vernon - the intent of his model was to advance trade theory beyond David Ricardo. In 1817, Ricardo came up with a simple economic experiment to explain that it was advantageous 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. However Vernon focused on the dynamics of comparative advantage and drew inspiration from the product life cycle to explain how trade patterns change over time. The International Product Life Cycle (IPLC) can be described 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.

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 matures and becomes more of a commodity, the number of competitors' increases. In the end, the innovator from the advanced nation becomes challenged 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, if the innovator has developed into a multinational manufacturer, by its foreign based production facilities. Thus, the IPLC international trade cycle consists of three stages as shown in Figure II.5:

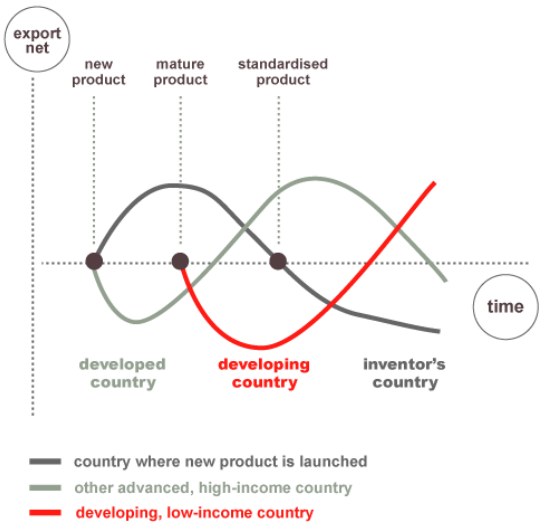


Figure II.5: Three-stage international product life cycle

- 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 becomes increasingly stable. Foreign direct investments (FDIs) in production plants drive down unit cost because labor cost and transportation cost decrease. Offshore production facilities are 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 jump start in these non-domestic advanced markets. Export orders will 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 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 the mobility of manufacturing operations. Labor can start 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." To counter price competition and trade barriers or simply to meet local

demand, production facilities will relocate to countries with lower incomes. As previously in advanced nations, local competitors will get access to first hand information and can start to copy and sell the product. The demand of the original product in the domestic country dwindles from the arrival of new technologies, and other established markets will have become increasingly price-sensitive. An MNC will internally maximize “offshore” production to low-wage countries since it can move capital and technology around, but not labor. As a result, the domestic market will have to import relatively capital intensive products from low income countries. The machines that operate these plants often remain in the country where the technology was first invented.

Corresponding to each stage through the cycle of product, there are two relevant theories to illustrate the stage on return on investement and characteristic of human behavior. Both theories are “S-curve analysis” and “Bathtub analysis”, as depicted in the followings:

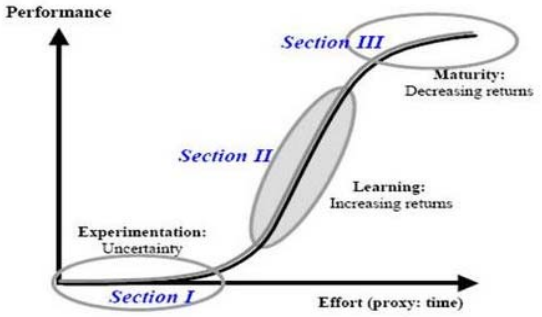
- S-curve analysis

Figure.II.6 explains on the s-curve shape that increasing on the returns exists at small investment levels and decreasing on the returns occurs at high investment levels. Investor, one of the three stakeholders to be considered of the study, is inarguable interested in financial aspect. The s-curve can explain the life cycle of innovations for entrepreneurial of plant. Moreover the curve will be helpful for an understanding of technologies used to manufacture. [Rogers 1962] proposed the theory of Diffusion of Innovations which can describeby using the “s-curve” or “diffusion curve” [Diffusion of innovation 62]. 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 maps growth of revenue or productivity against time. There are 3 stages of innovation in life cycle as presented in Figure.II.6

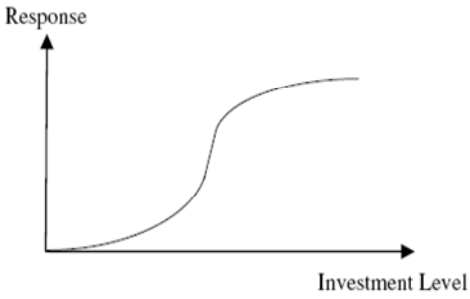
  - Experimentation or the early stage of innovation: It is relatively slow as the new product establishes itself.

- 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 [Diffusion of innovations 09].

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



(a)



(b)

Figure II.6:(a): An S-curve response function, and (b): S-Curve of technology

From this assumption, innovative companies will typically be working on new innovations that will eventually replace older ones. Successive s-curves will come along to replace older ones and continue to drive growth upwards.

For the reason of moving the stage of product life cycle, these will also effect to the human performance in the companies. Workers need to adjust the performance and their efficiency to follow the innovation occurrence. Then next section we will explain on how this situation effect to the skill labor and what they should improve.

- Bathtub analysis

Failure, for most parts of an operation, is a function of time [Slack 01]. In many cases, plotting the failure rate against a continuous time scale, the results will constitute the so-called “bath-tub” curve (see Figure II.7). The typical theory of “bathtub” curve has been widely accepted as an engineering tool. The bathtub shape is characteristic of the 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 of human life [John 95].

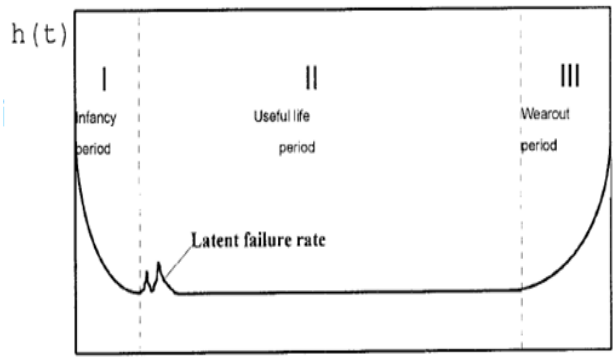


Figure II.7: A typical bathtub curve

As shown in Figure II.7, is a typical bathtub curve with a Time-dependent failure rate.However, the curve is developed along three significant periods as followings:

- Early failures 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. These failures are usually detected by burn-in or more other debugging process.

- Second period (Useful life)

The hazard rate is approximately constant andonly random failures occur. These unexpected failures are caused by a sudden and step increases in the stress level beyond the design strength and they can't be eliminated by debugging technique 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 II.6. No one can predict when these latent failures will occur, and they are basically unavoidable. They can be reduced by redesigning for extreme conditions, such as overdesigning, or by using the specific environmental stress screening test before the product is delivered to the customer.

- Wear out period

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

As considered bathtub curve of human behavior, the model of the learning curve expresses the relationship between efficiency gain and investment in the effort [David 00]. The experience curve as shown in Figure II.8 is based on the premise that "The more you do something, the easier and better you do it." In other words, the more "Experience" you have making a product, the faster and cheaper it is to make."However, upon the last stage of bathtub, fatigue and machine depreciation is the main cause leading to high-level rate of human error.

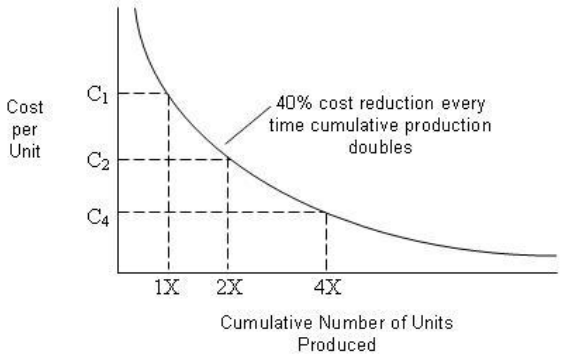


Figure II.8: Experience Curve

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

Acquisition of labor skills 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 process innovation, which are all activities that expand the knowledge base.

At the professional level, the issue is obviously not quantity-related either. 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 garments where many vacancies result from too few applicants.

There are several skills that firm managers feel their current workers do not possess at a satisfactory level. For instance, at least half of all firms rated the following skills of their local skilled technicians as poor or very poor: English, information technology (IT), numerical skills, and creativity/innovation skills. English proficiency and IT skills have in fact worsened since 2004. In general, the firms are much more positive about the quality of their professional staff, although two-thirds of them believe local professionals are not proficient in English. In addition to enhanced 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 education level and experience. High staff turnover can be 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 [Turnover (employment), wikipedia 09]. Besides, turnover incurs both replacement costs to the organization, as well as resulting in a competitive advantage to the business.

Thus, in order to reduce human failure, the transfering or replacement with the 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 fast learning, leading to cost reduction and improving overall system's performance.

Thus 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. Afterwards, we will classify these forces driven the business's change called as the five competition forces.

II.3. Value chain

Competitive advantage is derived from the way firms organize and perform discrete activities. The operations of any firm can be divided into a series of activities such as sales people making sales calls, service technicians performing repairs, scientists in the laboratory designing products or processes, and treasurers raising capital. Firms create value for their buyers through performing these activities. The ultimate value a

firm creates is measured by the amount buyers are 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).

The activities performed in competing in a particular industry can be grouped into categories as shown in Figure II.9, called as “Value Chain.” All the activities in the value chain contribute to buyer value. Activities can be divided broadly into those involved in the ongoing production, marketing, delivery, and servicing of the product (primary activities) and those providing purchased inputs, technology, human resources, or overall infrastructure functions to support the other activities (support activities). Every activity employs 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 described that the organization is split into “primary activities” and “support activities” those primary activities are:

- Inbound logistic, include receiving, storing, inventory control, transportation scheduling.
  - 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: 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 asresearch and development, process automation, design, redesign.
  - Human resource: Activities associated with recruiting, development (education), retention and compensation of employees and managers.
  - Firm infrastruction: include general management, planning management, legal, finance, accounting, public affairs, quality management.



Figure II.9 Value chain, Michael Porter, (1985)

A firm is more than the sum of its activities. A firm's value chain is an interdependent system or network or activities, connected by linkages, linkages occur when the way in which one activity is performed affects the cost of effectiveness of other activities. Linkages often create trade-offs in performing different activities that must be optimized. For example, a more costly product design, more expensive components, and more thorough inspection can reduce after-sales service costs. A company must resolve such trade-odds, in accordance with its strategy, to achieve competitive advantage.

Linkages also require activities to be coordinated. On-time delivery requires that operations, outbound logistics, and service activities such as installation should function smoothly together. Good coordination allows on-time delivery without the need for costly inventory. Coordinating linked activities reduces transaction costs, allows better information for control purposes, and substitutes less costly operations in one activity for more costly ones elsewhere. Coordinating linked activities is also an important way to reduce the combined time required to perform them, increasingly important to competitive advantage. For example, dramatic time savings are being achieved through such coordination in the design and introduction of new products and in order processing and delivery. Competitive advantage is increasingly a function of how well a company can manage this entire system. Linkages not only connect activities inside a company by also create interdependencies between a firm and its suppliers and channels.

In any industry, whether it is domestic or international, the competition is embodied in five competitive forces. [Porter 79], proposed a framework for the industry analysis and business strategy development. For most industries, the intensity of competitive rivalry is the major determinant of the competitiveness of the industry. Three of Porter’s five forces are referred to competition from external sources (Horizontal competition). The remainders are internal threats (Vertical competition). Porter's five forces include - three forces from 'horizontal' competition: threat of substitute products, the threat of established rivals, and the threat of new entrants; and two forces from 'vertical' competition: the bargaining power of suppliers and the bargaining power of customers.We can summarize the five competitive forces as the following (see Figure II.10).

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

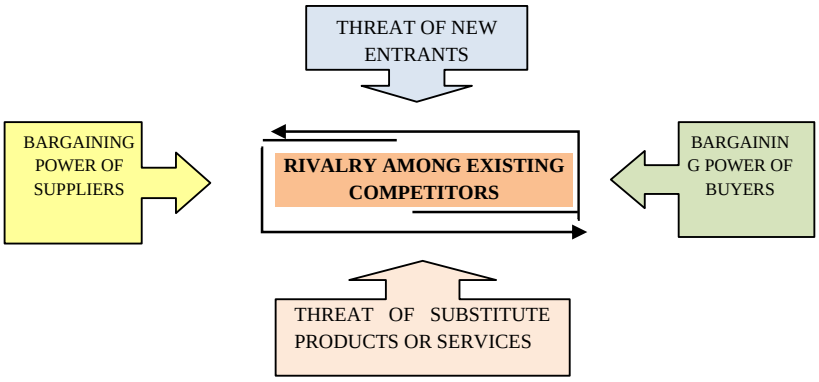


Figure II.10. The Five Competitive Forces that Determine Industry Competition [Porter 90]

The five competitive forces 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.

Industry structure is significant in international competition for a number of reasons. **First**, it creates differing requirements for success in different industries. Competing in a fragmented industry such as apparel requires greatly differing resources and skills from competing in commercial aircraft. A nation provides a better environment for competing in some industries than others.

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

A **final** reason why industry structure is important in international competition is that structural change creates genuine opportunities for competitors from a nation to penetrate new industries. Japanese copier companies, for example, successfully challenged American dominance (notably that of Xerox and IBM) by stressing an underserved product segment (small copiers), employing a new approach to the buyer (the use of dealers instead of direct sale), altering the manufacturing process (mass production versus batch), and modifying the approach to pricing (outright sales versus capital-intensive copier rental). The new strategy reduced entry barriers and nullified 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 is of central importance to understanding the patterns of international success. From the previous explained on the pattern of international trade theory and the influenced of 5 competitive forces. The next section gives detail about adaptation of those related theories.

Thus, a value chain is a chain of activities for a firm operating in a specific industry. The value-chain concept has been extended beyond individual firms. It can also apply to whole supply chains and distribution networks in the companies. Besides, in order to evaluate the decision on plant situation, measure the organization's performance in appropriately and align with activities in supply chain is a key to illustrate the system and helps to explain disruptions along the supply chain. Thus the following section we will discover review of literatures on strategies used to measure performance in supply chain context.

II.4. Applicable strategies used for supply chain context

Up-to-date, much of the emphasis in supply chain management has been on cost reduction, but 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]. 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].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 decision on supply chains are relevant as described onTable II.2.

	Authors	Supply chain categories	Metrics and measures followed SCOR	VCQR	Real option theory	Fuzzy logic	Gauging absence of prerequisites (GAP) analysis	ABC based costing method	AHP	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

Table II.2. Literature survey—parallel and distributed supply chain strategy

It is undoubtedly that the most powerful way to measure performance applying for supply chain is based on metrics and attributes followed SCOR. The samples of the evidence are [Gunasekaran 04], [Jeffrey 04], [Whicker 06],[Theeranuphuttana 07] which have been studied on the area of evaluating supply chain performance in organization based on SCOR. [Carlo 07] measures and analyzes performance of supply chain dynamic, or even integrate systems with discrete event simulation [Fredrik 09]. Those are pondered in the area of SCOR model. While other methods, for example, scheduling algorithm, Single Minute Exchange of Die (SMED), or even system dynamic approach are focused 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]. Besides, to improve supply chain performance, evaluate and analyze supply chain process, Supply Chain Operation Reference (SCOR) has been usually used by practitioners for many years [SCC 06]. Further, SCOR provides standard processes of which becomes a process reference model for supply-chain management. It includes delivery and order fulfillment performance, production flexibility, warranty and returns processing cost, 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 are the main interests of our study.

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

Consequently, to predict supply chain performance and illustrate dynamic process or even measure indicators in different scenarios, simulation is a very useful tool helping

to illustrate in dynamic process. This method can also help to make decision regarding the location strategy.

However, to illustrate on 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.Besides, from the review of literatures, the integration of discrete event simulation and supply chain context have been introduced for several researches as shown in Table II.3.

	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**

Table II.3: Simulation tools used for supply chain context

Several simulation tools have been used for supply chain, ARENA software application is the most well-known software applied for the context. [Sameer 06], for example, studied the process map and data analysis of manufacturing system, the use of Arena is demonstrated on existing operation. While, [Fredrik09] simulated a *Make-to-Stock* (MTS) policy for supply chain configuration based on SCOR template in which has been built with ARENA application. So SCOR model will help to construct the basic elements used on supply chain framework. This will be explained in more detail in chapter III (Proposed Methodology) of the proposed model and model application. In the next section, discrete event simulation will be introduced.

II.5. Supply Chain Simulation

From the previous section, techniques used to introduce on supply chain context were presented. The simulation, specially, Arena simulation is the most famous application used for the researchers in terms of supply chain analysis. Then the principle on discrete event simulation and dynamic system will be explained in this section.

Supply chain simulation models can be used to improve supply chain decision-making. Simulation models can be used to evaluate policies (such as inventory management policies) or to predict the outcome of a specific alternative. Additionally, each company has its own goals, operational policies, organization structure, and IT platforms. In such dynamic and connected systems, it is very hard to plan globally and make decisions regarding the inventory transportation, and location strategy [Stefanovic 09]. Because of 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, we can summarize advantages of the simulation in supply chain network as:

- 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 [Fredrik 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 such as 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 for predicting 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.

Then we realize on the advantages of using simulation in supply chain, especially concerning to, explain how the supply chain behaves in dynamic environment, determine impact of possible, and evaluate policies. Besides, illustrating on what-if analysis in different scenarios, as well as predicting performance of the systems is all the main benefits. For these reasons, simulation tools are of great helps to forecast future crises of manufacturing among uncertainties environment.

II.5.1. What is simulation?

One of the first efforts dealing with the supply chain dynamics was undertaken by Forrester [Forrester 61], [Forrester 58] who created a simple but representative simulation model of a production distribution supply chain developed using the Dynamic simulation language. Afterwards, a number of papers have been published, dealing with different aspect 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 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” can be an extremely general term since the idea applies across many fields, industries, and applications. These days, simulation is more popular and powerful than ever since computers and software are better than ever.

Simulation, like most analysis methods, involves systems and models of them. 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.

People often study a system to measure its performance, improve its operation, or design it if it doesn’t exist.

2 Models

2.1 Physical model

There are lots of different kinds of models. Maybe the first thing the word evokes 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, not 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 toexperiment 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 for experimentation with new products and services.
- Simulated control rooms have been developed to train operators for nuclear power plants.
- Physical flight simulators are widely used to train pilots. There are also flight simulation computer programs, with which you may be familiar in game form, that represent purely logical models executing inside a computer. Further, physical flight simulators might have computer screens to simulate airport approaches, so they have elements of both physical and computer-simulation models.

2.2. Logical (or Mathematical) Models

Such a model is just 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 that's exercised to address questions about the model's behavior; if the model is a valid representation of system.

There are a lot of ways to classify simulation models, but one useful way is along these three dimensions:

1. Static vs. Dynamic: Time does not play as a natural role in static models but does 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 is let out, and as 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; which elements are modeled as deterministic and which as 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 illustrations will involve random inputs somewhere in the model. As noted earlier, though, stochastic produce uncertain output, which is a fact to be considered carefully in designing and interpreting the runs in your project.

II.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.

II.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 96]. Arena icons are connected in a flowchart to represent entity flow. Arena uses an object-oriented design for graphically developing models [David 96]. Modeling constructs of Arena, called modules, are grouped into templates for arrangement into hierarchical model diagrams [Averill 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 00].

II.5.2.2 Automod

The AutoMod simulation package is 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 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.

II.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 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 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 [Harward05].

II.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 pulldown 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 97].

II.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.

II.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 [Scott 97].

In order to select the most suitable simulation tool to be applied on 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 criteria for comparing and selecting software simulation for our case study as follows:

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

2. Due to 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 the SCOR. Thus 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.

II.5.3. Comparing and selecting software simulation for the case study

After reviewing the large number of simulation software in the survey, our studied is often queried about the appropriate simulation tool for a particular area of application, or even for a given project. Thus the comparisons that have been made will be compared to our requirement. The suitable software simulation should support and help on the problematic issues. However result of the comparison shows in Table. II.4.

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

Table II.4: Comparing software simulation with requirement criteria

From the comparison, the software simulations have been compared on simulation type, application, integration of SCOR, advantages and disadvantages. We found that software simulation which appropriate for evaluating parameters of logistics and

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 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 at a very basic level compared to those used in supply chain simulation models. However, developing models hierarchically using submodels that represent supply chain processes, can overcome this limitation [Jeffrey 03]. Thus we have realized that ARENA is the selected software simulation to evaluate supply chain performance in our context of FDIs' investment.

II.6. Conclusion

Regarding to the three main potential factors on business crises refer to "*cost of doing business*", "*supply chain and infrastructure*" and "*knowledge and skill performance"*. The relevant theories and researches of each potential issue are clarified. In terms of global supply chain and infrastructure, two issues of: abilitiy to manage uncertainties effectiveness and the ability respected to global optimized supply chain are interested. Among global supply chain, product moves from one country to another depending upon cost structure and complications of international logistics. The fuctional cost of s-curve shows pattern internaltional business based on the stage of product life cycle. In terms of the moving stages on product life cycle, it also effects to the human performance in the companies who need to adjust the performance and their efficiency following innovation. However, no evidence from the researches have been integrated each benefit of the specific theory to be considered on international business or foreign investment in crises. Many influencing factors in the broad term have been studied for FDI by MNEs. To reconfirm this argument, John H.Dunning [Dunning 80, 93] claimed that, there is no general theory of FDI and it not makes sense to look for a single all-embracing theory of FDI. Model building and variable selection are carried out on a case by case depending on the specific situation of country. Besides, to evaluate the decision on plant situation, measure the organization's performance in appropriately and align with activities in supply chain is a key to illustrate the system and helps to explain disruptions along the supply chain. In summary, from comparison with the required criteria on our supply chain

context, we agreed that Arena software simulation is the suitable one for applying in our context. In the next chapter, we will propose integrated framework based on the three potential issues to help decision for FDIs' investment.

Chapter III: Proposed Methodology

III.1. Introduction

Regarding to the analysis from state of arts, several benefits for each theory and the specific aspects of each theory only cannot help to answer the problematic. The decision on investment should be derived from an integrated analysis of various theories. However, our collections of survey on literatures and questionnaires were conducted to indicate main factors impacting on Foreign Direct Investment (FDI). Those factors are financial and economic situation, supply chain and infrastructure, and knowledge skill and performance.

In this chapter, the main aim is to propose an integrated framework to help decisions for FDIs. The framework is considered based on those three main necessities. In this regard, we introduce a risk knowledge matrix helped to evaluate the impact of existing risks, as well as, the modeling of the supply chain simulation which is used to analyse on future cost of investment. However the framework is consisted of two levels of static and dynamic analysis. Thus the first part of this chapter, resulting from the survey of questionnaires we will reconfirm the selected potential factors and classify them into sub factors. In the second part, we have discovered on how to construct our research framework with three main requirements pertaining to the three questions of: “Who”, “What” and “How” which will introduce to our proposed framework. Finally, to clarify our proposition, following section will be explained in detail of the strategy to be analyzed for static and dynamic analysis.

III.2. Potential factors and sub factors classification

Several factors are considered as key factors that have been taken into account for the FDI. Besides, the attributes used in each research are different and the contents of each type of decision remain very general. The distinguished factors resulted from the

survey of literatures were presented into three aspects: i) factor endowment ii) financial and economic situation iii) supply chain and infrastructure. To confirm the critical factors resulted from the survey, as we described on chapter I (section I.5.1, I.6), a research was done by the use of questionnaires provided to the case study area of Northern Region Industrial Estate, Lumphun, Thailand (see Appendix.A: Questionnaire). Finally, we have, thus, subdivided each factors separately used for our integrated framework. Those are composed of “Financial and economic situation”, describing the situation effected to financial problem, “Supply chain and infrastructure”, explaining on physical infrastructure like transportation and distribution network, communication or even public utilities, and “Worker skill and performance” which is referred to factor of labor worker, for instance, worker attitude, skill and performance and educational level. Thus the following section, we categorize sub factors by grouping all discovered factors from literatures in the context of FDIs’ investment context shown in chapter 1 (section I.5.1). Then sub factors are classified and represent on the following table (Table III.1).

Factor		Sub Factor	Discovered factors	Definition
Worker skill and performance	1	Employees' skill and requirement	Employee skills Experienced in equipment and technology use.	The ability to do the good job. The experience to work and improve the job Sufficient qualified and number of technicians, engineers, and managers.
	2	Work ethic and attitude of the employees	Work stoppages Loyalty to employer Employee relationship	A willingness to work and do the job well. Looking for something useful to do if their job description work is completed. A positive attitude on their work and the company.
	3	Educational level of employees	Qualified of educational system for labor	Educational level of labor workers in the companies.
	4	Turnover rate in human resources	High staff turnover Impatient attitudes and frequent turnover of workers.	Qualified technical skill are hardly to find Labors are considered to be impatient, which resulted in high turnover. This affected business in a negative way by making it necessary to recruit new employees or suspend production temporarily.
Financial and economic situation	5	economic situation	Exchange rate Tax Economic development and fiscal policies Interest rate/ inflation rate country risk market demand non-tariff barrier to trade	Fiscal and monetary policies Market demand, competition, policy environment, domestic inflation rates, and domestic interest rates and international trade.
	6	Unstable of political situation	Transparency of government policy Corruption Credibility of government	The government was appointed or elected; it has been able to show more transparency in managing the country.
	7	Uncompetitive wages	Wages of employees	Wages of labor, local intensive, low average wages
	8	Unattractive and inconvenient regulations for company	Benefits due to access to overseas markets Financial service accessible	Investment and business support from government
Supply chain and infrastructure	9	Inefficient collaboration among company with supplier and/or customer	Subcontractors existence Supplier reliability Raw material proximity Product market proximity Supply chain cost Supply chain risk	Availability of qualified local suppliers Availability of local raw material of good quality

		Sub Factor	Discovered factors	Definition
	10	Difficulties related to internal operations	Production quality Raw material quality Leadership style and organizational climate Internal culture	Organizational changes (communications, goals, policies, and operating condition.
	11	Unwelcome on facilities, infrastructure and supporting environment	No. of project of investment in R&D Telecommunication Public utilities Educational facilities Technology support BOI investment incentive and support	Infrastructure, labor intensive technology, distance of the locating from market, supplier and customer, Utilities, Cost of land, Good airport facilities, geographical concentration
	12	Inconvenient logistics	Availability of transportation infrastructure Availability of quality logistics service providers Logistics cost	The availability and performance to utilize the channel of transportation Transportation network

Table III.1: Classification of factors and lower sub factors from review of literatures.

In summary, among three main factors, we thus categorize discovered factors from literatures into 12 of sub factors groupgs. Those sub factors are needed to explain on risk knowledge matrix of our proposed framework.

In the following sections, we will explain how to integrate these potential factors to be considered within the proposed framework. The components, techniques and tools of each model in this research framework will also be described. Finally, the integrated framework on making a decision for entrepreneurial status of plant will be clarified.

III.3. Components to construct the research framework

As described above, the research studies in the three areas of potential factors for FDIs' investment. There are finance, supply chain infrastructure and knowledge skill in companies. To construct the research framework, we, thus, discovered on the components with 3 questions of: "***Who***" are the relevant stakeholders for FDIs' investment, "***What***" are their needs from FDI's investment, and "***How***" to measure their performance and capability for FDIs' investment.

Who: As explained in chapter 1, three relevant stakeholders who correspond to the potential factors. The partners or stakeholders consist of foreign investor, local industrial estate, and manufacturer. To sustain foreign businesses and attract new FDIs' investment, each stakeholder performs as an agent in supply chain network. The effectiveness on each partner leads to the achievement in overall supply chain. This means that the success in the FDIs' investment depend not only on how well their internal processes are performed but also on how well they integrate and manage the relationships with all their business partners.

What: in general terms, the decision for foreign investors when decide to do the business is to gain profits and reduce costs. Investor always interests on value of the investment in financial. Local industrial Estate deals and supports facilities of logistics network and utilities, in which expects on welcome the newcomers to invest in their own land. Besides, to improve productivity, manufacturers need to enhance skill and performance of workers by controlling human error working on their workplace. However, to be assure of these partners' expectation, the empirical data was conducted a survey of 3 sample manufacturers in the case study area. Table III.2 (a, b, c) shows the responses of what each stakeholder expects from respondents.

Objective, Expectation	Stakeholder: Investor		
	Manufacturer A	Manufacturer B	Manufacturer C
1. More profits	1	1	
2. Sustain the existing investors and attract the new comers			
3. Stable sale forecast		1	
4. On time delivery			
5. Good/qualified quality of product and raw material			
6. Exactly quantity of product and raw material			
7. Supply chain effectiveness		1	
8. Effective networks for transportation and logistics infrastructure (road, rail, seaport, airfreight)			
9. Best practice on skillled and labor performance		1	
10. Reduce ordering lead time			
11. Reduce operation time			
12. Reduce delivery lead time			
13. Reduce operation cost	1	1	1
14. Effective network in communication services			
15. Stable situation in social	1		1
16. Stable situation in economic	1	1	
17. Stable situation in political	1		

(a) Investor's expectation

From table a), all of the respondents considered the objective of investor aimed to reduce operational cost, and gain more profits from doing the businesses is also remarked respectively.

Objective, Expectation	Stakeholder: IEAT		
	Manufacturer A	Manufacturer B	Manufacturer C
1. More profits		1	
2. Sustain the existing investors and attract the new	1	1	1
3. Stable sale forecast			
4. On time delivery			
5. Good/qualified quality of product and raw material			
6. Exactly quantity of product and raw material			
7. Supply chain effectiveness	1		
8. Effective networks for transportation and logistics infrastructure (road, rail, seaport, airfreight)	1		1
9. Best practice on skillled and labor performance	1		
10. Reduce ordering lead time			
11. Reduce operation time			
12. Reduce delivery lead time			
13. Reduce operation cost			
14. Stable situation in social		1	
15. Stable situation in economic		1	1
16. Stable situation in political		1	1
17. Effective network in communication services	1		1

(b) Local industrial estate

In term of local industrial estate, the attempt to sustain the existing investors and attract new comers is given by all respondents. Also, considering on effective of logistics networks is another main point by industrial estate's responsibility.

	Stakeholder: Manufacturer		
Objective, Expectation	**Manufacturer A**	**Manufacturer B**	**Manufacturer C**
1. More profits		1	
2. Sustain the existing investors and attract the new comers			
3. Stable sale forecast	1	1	
4. On time delivery		1	1
5. Good/qualified quality of product and raw material	1	1	1
6. Exactly quantity of product and raw material		1	
7. Supply chain effectiveness	1	1	1
8. Effective networks for transportation and logistics infrastructure (road, rail, seaport, airfreight)	1	1	
9. Best practice on skillled and labor performance	1	1	1
10. Reduce ordering lead time	1		
11. Reduce operation time	1	1	1
12. Reduce delivery lead time	1	1	
13. Reduce operation cost	1		
14. Stable situation in social	1	1	
15. Stable situation in economic	1	1	
16. Stable situation in political			
17. Effective network in communication services			

(c) Manufacturer

Table III.2: what each stakeholder expects from FDI's investment

Indeed, manufacturers are most aware and concerned on reducing time and cost along manufacturing activities and processes. Besides satisfying the need of customers, quality of goods and raw materials, best practice of skill and labor performance are also recognized from manufacturers. From the results, we thus concluded the main objectives of manufacturer aim at the best practice of skill and labor performance, and also supply chain effectiveness.

How: As noted earlier in chapter I (section I.5.2: Approach used on make a decision of FDIs' investment) about approach used on making a decision of FDIs' investment, we thus agree that technique of Net Present Value (NPV) suits for evaluation cost of business. Since NPV is a well-known technique used to present value of the future

cash flows associated with an investment. Whereas, to measure supply chain performance, SCOR is suggested from many practitioners to perform the standard processes and measure system performance. In a system with such interdependencies, the occurrence of a risk event has ever widening consequences, both within and across enterprises [IBM 08]. Thus, to estimate existing risks and mitigate on the occurrence of the related risks leading to the crises is necessary.

However, table III.3 summarizes again all components with three questions that help to construct research framework.

Who are relevant (see chapter 1, I.7)		**Foreign Direct Investors (FDIs)**	**Local Industrial Estate**	**Manufacturers**
What are their needs		Maximum return on investment ***(Financial)***	SC and infrastructure effectiveness ***(Supply chain and infrastructure)***	Internal SC effectiveness and best practice of labor skill and performance ***(Supply chain and worker performance)***
How to measure their performance	**Static**	Risk analysis	Risk analysis	Risk analysis
	Dynamic	NPV	SCOR Attribute	SCOR attribute SC cost

Table III.3: Components to construct research framework.

Finally, all components are represented as the guideline to construct our research framework. The purposing on decision framework of FDI's investment will be explained in the following section.

III.4. Integrated framework on making a decision for FDI's investment

In this section, the proposing on integrated framework is presented according to the components as provided. This framework helps manufacturers to analyze the

capability on current situation of plant and support the decision making of FDIs' investment. The framework focuses on three perspectives. There are financial, supply chain and infrastructure, and knowledge skill and performance. The knowledge framework is shown in Figure III.1.

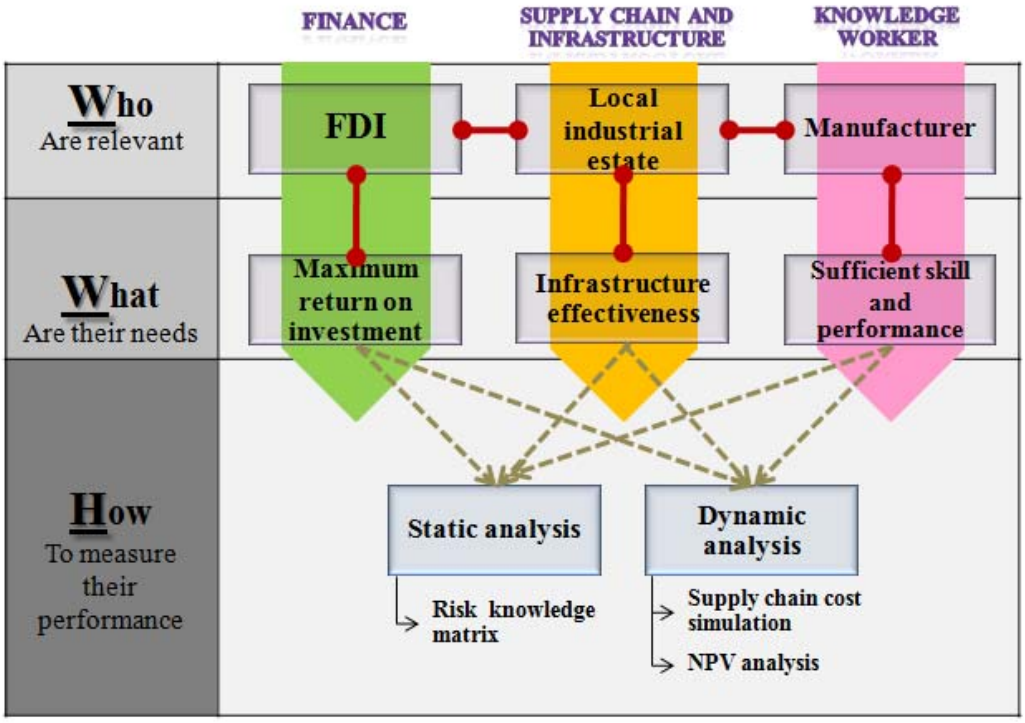


Figure III.1: Proposed framework on making a decision for FDIs' investment

From the proposed framework, the relevant stakeholders of foreign investors, local industrial estate, and manufacturers are the major partners to perform actions. Thus finance, supply chain, and worker skill and performance are contexts responded among them. Regarding to each partner's expectations in its own criteria, integrating with different useful methods to evaluate distinguished performance is applied to our study. As described above, we conclude that foreign investor needs to gain maximum return on the investment, local industrial estate concentrates on effective infrastructure and logistics networks, while internal supply chain effectiveness and enhancing skill and performance of employees are main objectives for manufacturers. Thus, to evaluate those objectives, it can be concluded that there are two type analysis

of static and dynamic method. For static analysis, this section helps investors or manufacturers evaluate their related risks on existing businesses. Results of risk evaluation will be suggested into the most possibility among three scenarios of relocation, transferring, or divestment of plant. For dynamic analysis, measurement of supply chain performance, forecast on cost of future investment, supply chain modeling and calculation of NPV will be presented (see chapter IV, Section IV.5.2: Cost simulation). In order to constructing the modeling of supply chain, software simulation of Arena will be performed to illustrate manufacturing processes and activities based on SCOR model. While outcomes from the simulation, will be used to forecast on NPV calculation of future investment of plant. The following section will be explained in detail of the strategy to be analyzed for static and dynamic analysis. In addition to, the detail of the application will be discussed respectively in Chapter IV.

III.4.1. Static analysis

In terms of static analysis, this method aims to help manufacturers or foreign investors evaluating the occurrence of risks on their current plant situation. Analysis of risks is often useful for manufacturers or investors to consider categories of risks as a starting point in initial assessment of their risks. The results of the evaluation will be explained into three scenarios which are relocation, transferring and divestment of plant.

Due to the group of sub factors considering on FDIs' investment as represented on the beginning of the chapter, these sub factors explain the unwelcoming situation or occurrence of risks. Thus we summarize into 20 potential of occurrences of sub risks detail corresponding to each category of sub factors and three main necessities of FDIs' investment as shown in Figure III.2.

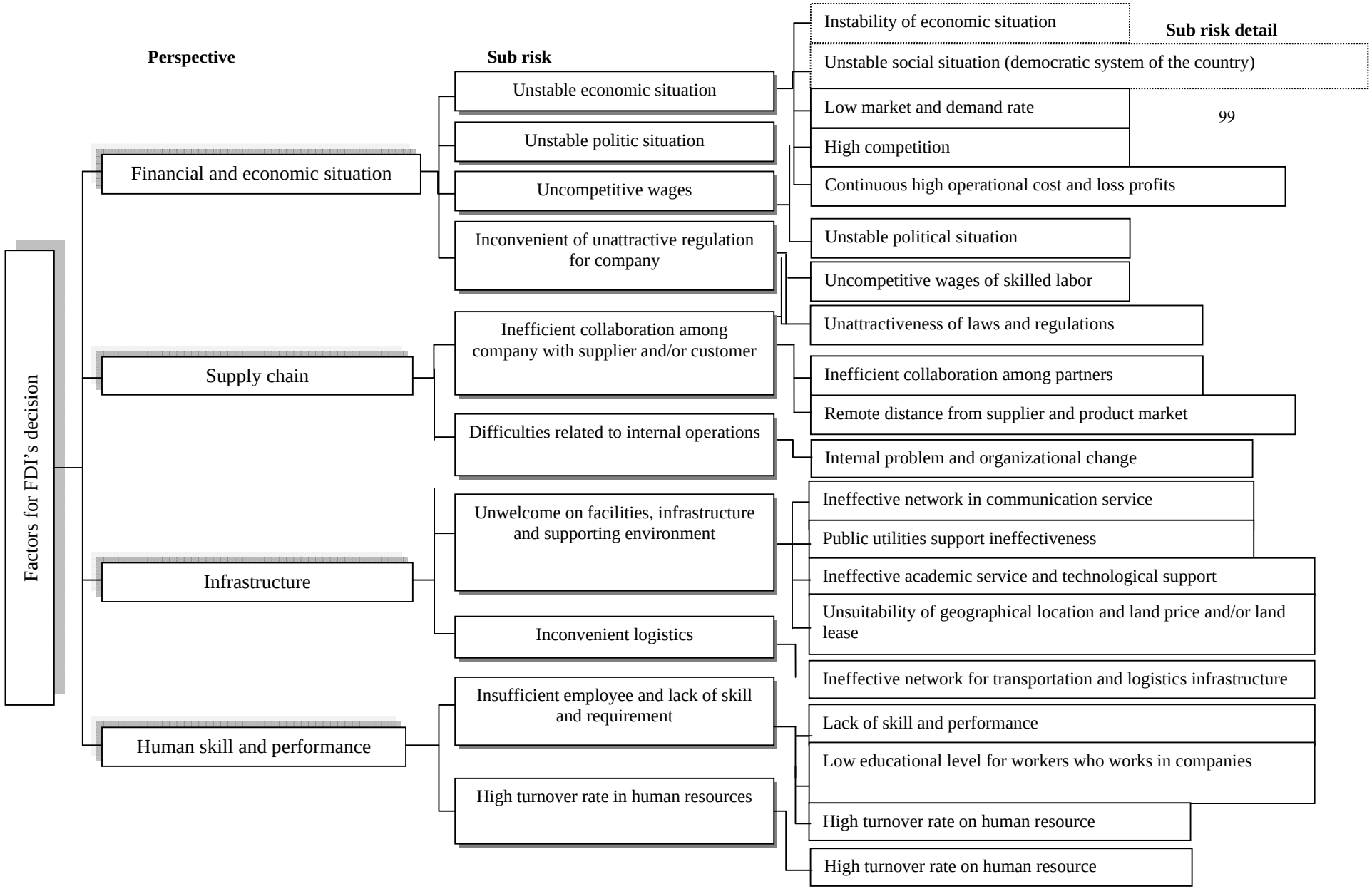


Figure III.2 The proposition of risk and sub risk factors

From Figure III.2, each factor has lower-level risks for a total of 20 lower-level risks in all. Consequently, the three major aspects on “financial and economic situation”, “supply chain risk and infrastructure”, and “worker skill and performance”, construct the “***Risk Knowledge Matrix***”. Factors influencing on FDIs’ investment and related risks are identified, then the next step is to evaluate the risks. Several methods used to develop and measure risk attitudes. However, the difficulty of risk evaluation is that there is no precise methodology to estimate the associated risk. The risk estimation from experiences or experts is somewhat arbitrary [Liang 94]. For example, [Tuncel 09]; applied petri nets (PN) to observe the cause and effect relation between events of risk factors on supplier performance. [Wu 06] developed an analytic hierarchy process (AHP) to determine weight of supplier risk. Weight and probability of each risk was calculated for overall risk index. Those analyses used to evaluate risk in terms of measureable value, such as total revenue, customer order fill rate, and order delay.

Meanwhile, [Kersten 06] used five point Likert scales to collect data concerning supply chain risk between manufacturing companies and logistics service providers. They explain value of risks in terms of the estimation from experiences and experts. The significance of risk can be expressed as a combination of its consequences or impacts on a process’s objectives and outputs, and the likelihood of those consequences arising (Impact and Likelihood) [Jean 07]. Based on quantity analysis, the “Calculated Risk,” a simple arithmetic formula, is used to classify risks. The Calculated Risk refers to the risk that a firm can handle or the cost it is willing to support in case it happens. ISO/FDIS 31000, which is the international standard provides principles and generic guideline on risk management, purposes terms and definitions of risk as is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated likelihood of occurrence.

The risk evaluation corresponding to rating scale from 1 to 5 will be focused. The scale used to explain potential impact and likelihood of occurrence from experts or experiences. The level of Risk which is referred as magnitude of a risk, expressed in terms of the combination of consequences and their likelihood [ISO/FDIS 31000:09], formerly expressed by the risk exposure as follows:

Level of risk = (*P x I*)

Where:

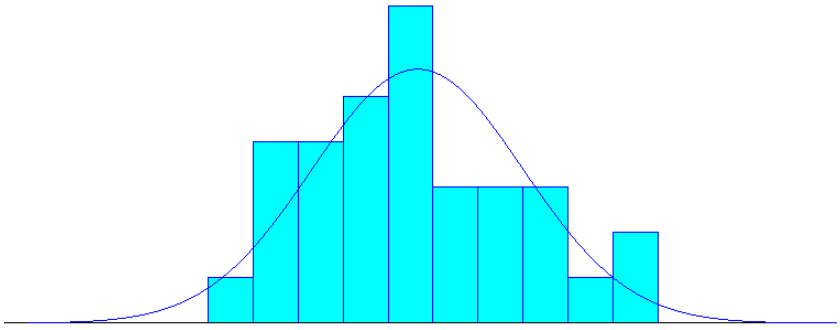
- « P » denotes in risk management terminology, the likelihood is used to refer to the chance of something happening whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically. This parameter depends on previous experience, the circumstance in the environment and the risk criteria (i.e. business, politic, technology, etc.) [Dobos 06]
- « I » denotes the impact of a risk in order to highlight its effect on the organization. This parameter is important to the normal functioning of a process has one of the following values: 1 (very insignificant), 2 (insignificant), 3 (moderately), 4 (important), 5(very important).

Thus, risk exposure might be on a scale from 1 to 25. Then we suggest mapping risk value into 4 classes of “Low”, “Medium”, “High”, and “Critical” value as shown below.

Risk value	Risk level
>11.50	Critical
9.15-11.50	High risk
6.81-9.15	Medium risk
< 6.81	Low risk

Table III.4: indicator to mapping risk exposure

However, risk values for each risk level’s decision are derived from all responded outcomes by questionnaires to the case study, afterward fitting all values with normal distribution. The expression in norm and standard deviation represent as 9.15 and 2.34 respectively [shown in Figure III.3]. Thus we identify the range into lower, medium, high and critical by using standard deviation.



```
        Distribution Summary

Distribution:   Normal
Expression:     NORM(9.15, 2.34)
Square Error:   0.012591

Chi Square Test
  Number of intervals   = 4
  Degrees of freedom    = 1
  Test Statistic        = 1.39
  Corresponding p-value = 0.242

        Data Summary

Number of Data Points   = 33
Min Data Value          = 4.84
Max Data Value          = 13.8
Sample Mean             = 9.15
Sample Std Dev          = 2.38
```

Figure III.3 Expression of norm and standard deviation

Finally, to evaluate the result of risk analysis, we propose into three scenarios of plant situation as described below.

- Relocation plant:

"The move of manufacturing process to low-cost labor-abundant locations by a combination of an investment abroad and subcontracting"

- Transferring plant:

"Remain high technology process and expand processes that need laboring in other countries such as China, Vietnam or Philippines"

- Divestment plant:

"Withdraw the investment, a plant closure or downsizing"

The questionnaires sent to the case study area, consist of two parts. The first part focuses on factors impacting to FDIs' investment decision, which we explained in the

first chapter. This section is an implement of the second part. It will focus on the respondents providing the value of impact and likelihood of the risk ratings. Those values are demonstrated to construct the Risk Knowledge Matrix decision. Consequently, values of the level of risk will be presented as guideline matrix to distinguish corresponding to the three scenarios. In each case the ratings given by thirteen respondents as well as the mean calculated are shown, afterward, the level of risk is interpreted as per the method described above. All the results are tabulated in summary from Table III.5.

						Likelihood(1-5)			Impact(1-5)		
Risk perspective		Risk		Sub risk		Relocation	Transfer	Divest	Relocation	Transfer	Divest
1	Labor skill and performance	Lack of skill labor and requirement	1.1	Insufficient employee and lack of skill and requirement	A negative attitude on	3.6	2.6	2.5	3.4	2.8	2.4
					Lack of skill and				3.6	3.6	3.4
					Low educational level for workers who works in companies				2.2	2.8	2.8
			1.2	High turnover rate in human resources	High turnover rate on human resource	2.8	2.7	2.7	4.0	3.0	3.0
2	Financial and their environment situation	Financial problems	2.1	Unstable economic situation	Instability of economic	3.5	2.2	3.6	2.4	3.0	2.2
					Unstable social				2.6	2.6	2.4
					Low market and demand rate				4.0	4.0	3.0
					High competitiion				3.0	4.0	4.0
					Continuous high operational cost and loss profits				4.0	4.0	5.0
			2.2	Unstable of Thai political situation	Unstable political situation				2.8	3.2	2.6
			2.3	Uncompetitive wages	Uncompetitive wages of skilled labor				3.6	2.8	2.8
			2.4	Inconvenient of unattractive regulations for company	Unattractiveness of laws and regulations				2.6	2.2	2.8
3	Supply chain and Infrastructure situation	Supply chain ineffectiveness	3.1	Inefficient collaboration among company	Inefficient collaboration among partners	2.9	2.6	2.7	4.2	4.2	3.6
					Remote distance from				3.0	3.8	3.8
			3.2	Difficulties related to internal operations	Internal problem and organizational change	2.7	2.5	2.9	4.0	4.0	4.0
4		Facilities and infrastructure ineffectiveness	3.3	Insufficient on facilities, infrastructure and supporting environment	Ineffective network in	3.46	2.1	3.18	2.4	2.6	2.0
					Public utilities support				1.8	1.4	2.2
					Ineffective academic service and technological support				1.8	2.4	2.6
					Unsuitability of geographical locationand land price and/or land lease				2.4	2.2	2.3
			3.4	Inconvenient logistics	Ineffective network for transportation and logistics infrastructure	3.5	2.2	2.6	3.0	3.0	2.2

Table III.5: Calculated mean of likelihood and impact value of risk

From table III.5, the combination of level of importance and likelihood are interpreted and represented into three scenarios: i) relocation, ii) transferring, iii) divestment as shown in Table III.6.

	Risk perspective	Risk detail		Sub risk	Sub risk detail	Relocation	Transferring	Divestment
1	Labor skill and performance	Lack of skill labor and requirement	1.1	Insufficient employee and lack of skill and requirement	A negative attitude on their work and the company	14.5	7.7	4.9
					Lack of skill and performance	14.5	10.2	7.4
					Low educational level for workers who works in companies	7.2	5.1	4.9
			1.2	High turnover rate in human resources	High turnover rate on human resource	11.3	8.2	8.0
2	Financial and their environment situation	Financial problems	2.1	Unstable economic situation	Instability of economic situation	13.8	13.8	10.9
					Unstable social situation (democratic system of the country)	13.8	6.5	10.9
					Low market and demand rate	13.8	8.7	10.8
					High competition	10.38	8.7	14.5
					Continuous high operational cost and loss profits	13.8	8.7	18.1
			2.2	Unstable of Thai political situation	Unstable political situation	13.84	8.7	10.8
			2.3	Uncompetitive wages	Uncompetitive wages of skilled labor	13.8	6.5	10.9
			2.4	Inconvenient of unattractive regulations for company	Unattractiveness of laws and regulations	3.5	6.5	14.5
3	Supply chain and Infrastructure situation	Supply chain ineffectiveness	3.1	Inefficient collaboration among company with supplier and/or customer	Inefficient collaboration among partners	11.7	10.6	10.7
					Remote distance from supplier and product market	5.8	7.9	8.0
			3.2	Difficulties related to internal operations	Internal problem and organizational change	10.7	9.8	11.4
		Facilities and infrastructure ineffectiveness	3.3	Insufficient on facilities, infrastructure and supporting environment	Ineffective network in communication service	13.8	6.3	9.5
					Public utilities support ineffectiveness	10.4	6.3	12.7
					Ineffective academic service and technological support	6.9	4.2	6.4
					Unsuitability of geographical location and land price and/or land lease	6.9	4.2	3.2
			3.4	Inconvenient logistics	Ineffective network for transportation and logistics infrastructure	10.6	8.7	7.7

Table III.6: The Risk Knowledge Matrix of FDI's investment

These risk exposures are presented as the Risk Knowledge Matrix. It shows how much level of risk is adopted in different scenarios of FDI's investment. Afterwards, we will distinguish the consequences of this Risk Knowledge Matrix decision regarding to the three scenarios.

III.4.1.2. Analysis of Risk Knowledge Matrix decision among three scenarios of relocation, transferring and divestment of plant

According to the previous section, the proposing on Risk Knowledge Matrix decision is shown. We will distinguish which risk value are most and less important corresponding to the three scenarios of relocation, transferring and divestment of plant. In this regard, we denote the three perspectives of finance, supply chain and infrastructure, as well as worker skill and performance as FRV, SRV and WRV. Consequently, the analysis of Risk Knowledge Matrix decision can classify risks into four groups, according to the level of impact and level of probability of the occurrence. Details of each group are summarized below:

1. Factors with medium potential impact and high probability of the occurrence (M:H)

Factors in which have medium potential impact on entrepreneurial status of plant and high potential probability of the occurrence of risks.

2. Factors with medium potential impact and low probability of the occurrence (M:L)

Factors in which have medium potential impact on entrepreneurial status of plant and low potential probability of the occurrence of risks.

3. Factors with medium potential impact and medium probability of the occurrence (M:M)

Factors in which have medium potential impact on entrepreneurial status of plant and medium probability of the occurrence of risks.

4. Factors with low potential impact and low probability of the occurrence (L:L)

Factors in which have low potential impact on entrepreneurial status of plant and low probability of the occurrence of risks.

According to the four classifications, they are derived from the interesting results of the exploration as we will present in Figure III.4, 5 and 6. The results showed the critical factors leading to the scenario of relocation, transferring and divestment plant. Focusing on three aspects of worker, supply chain and infrastructure, and financial risk, we found the distinctive factors among each three scenarios as explained below:

- Worker Risk Value (WRV)

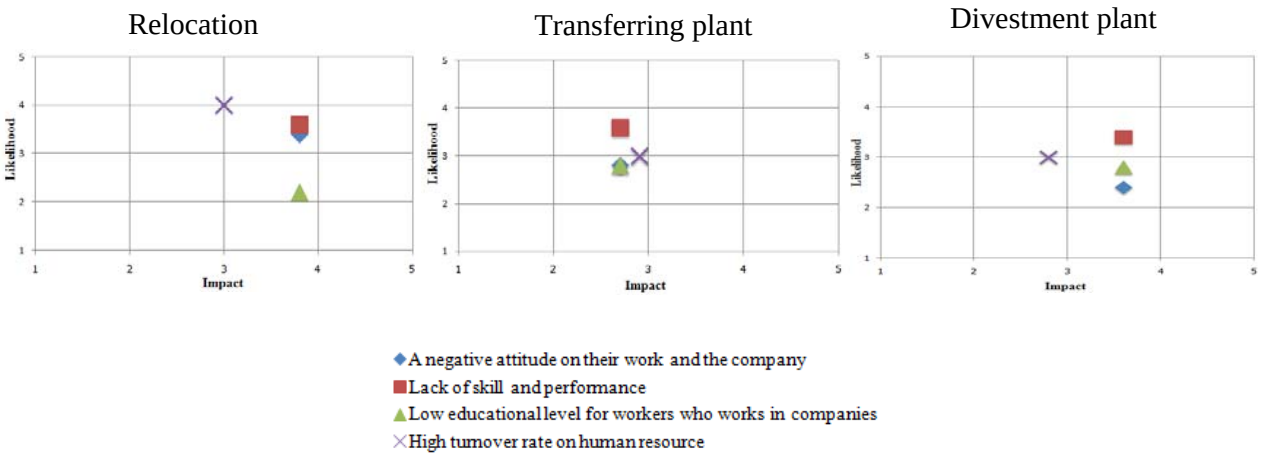


Figure III.4: The analysis on Worker Risk Value (WRV) among relocation, transferring and divestment plant.

Most factor related on worker risk value are presented in medium potential impact and medium probability of occurrence (M: M). However, some relevant factors are identified in difference from other scenarios. For example, a negative attitude on their work is rather affected to relocation, while low educational level for workers is most focused on divestment plant. Besides, high turnover rate is also considered for relocation.

- Supply chain and Infrastructure Risk Value (SRV)

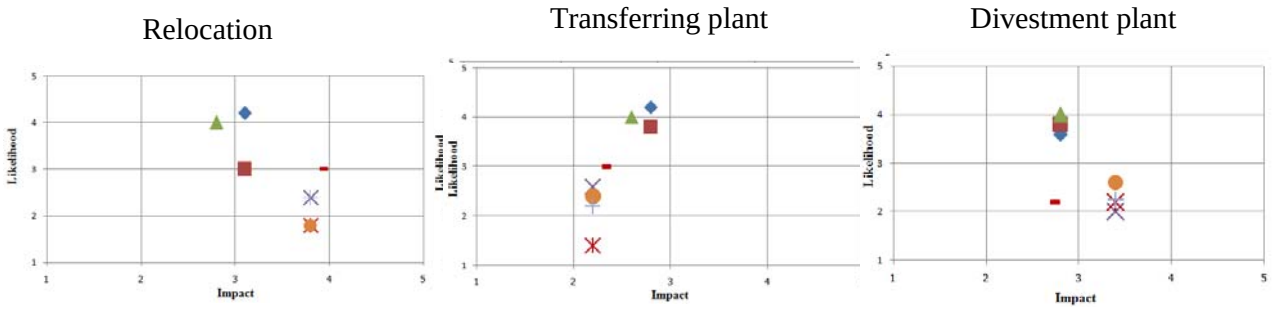


Figure III.5: The analysis on Supply chain Risk Value (SRV) among relocation, transferring and divestment plant.

From Figure III.5, it has been noticed that factors related to supply chain and infrastructure aspect are most considered for relocation of plant. Those factors from supply chain are inefficient collaboration among partners (M: H), remote distance from supplier and product market (M: M), inefficient communication network (M: M), unsuitability of geographical location (M: M), and inefficient on transportation network (M: M). The same evaluation for three scenarios is internal problem and organizational change (M: H). However, ineffective academic service and technological support is less considered for offshore plant (M: L).

- Financial Risk Value (FRV)

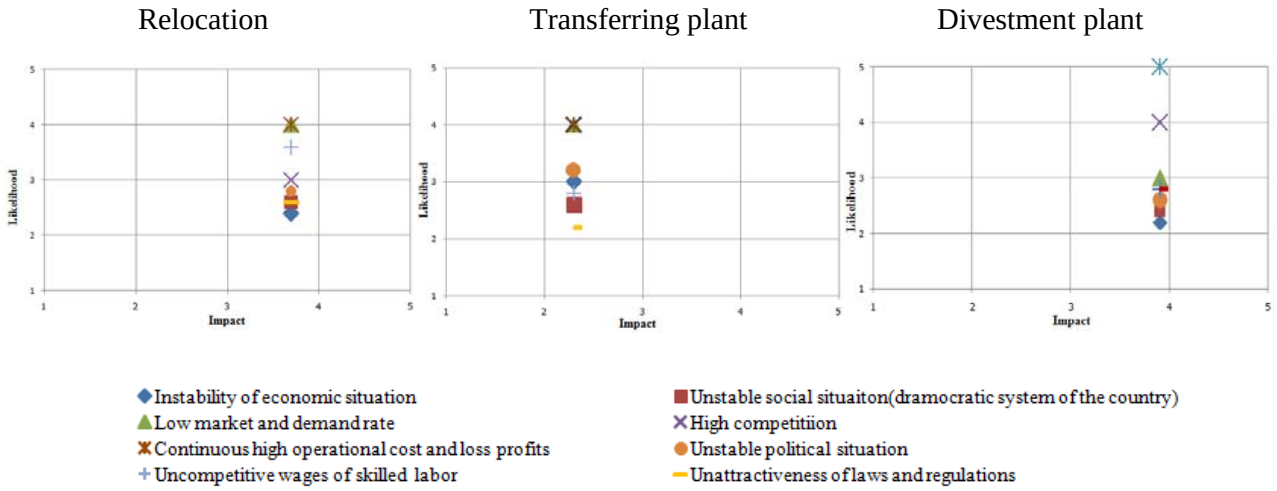


Figure III.6: The analysis on Financial Risk Value (FRV) among relocation, transferring and divestment plant.

The distinct factors caused to divestment plant are continuous high operational cost and loss profit, and high competition (M: H). The influencing on economic situation, such as politic, economic situation and uncompetitive wages (M: M) are rather less considered for relocation, whereas the important factors for this scenario is identified to low market and demand rate.

On the contrary, focusing on three scenarios of relocation, transferring, and divestment, we conclude that the distinctive factors among each three aspects denoted as explained below:

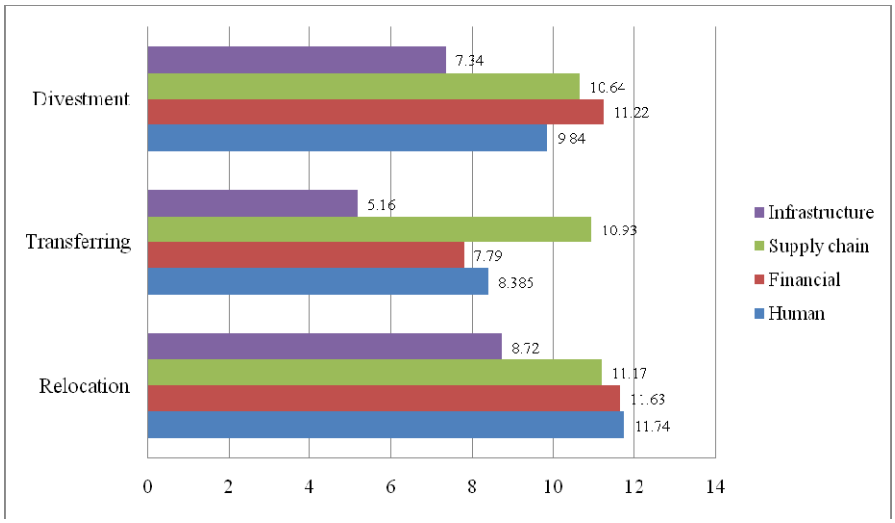


Figure III.7: Degree of influencing factors cause to FDI's decision corresponding to the three scenarios.

Figure III.7 illustrates influencing factors that may cause to FDI's decision in three scenarios of relocation, transferring and divestment of plant. The bar chart reflects both the issues that are the comparison of each potential factor among three scenarios as well as of those factors within the scenario.

Regarding to the comparison among three scenarios, infrastructure is considered as the least influencing factor. For scenario of relocation, factor of infrastructure is not differentiated from supply chain, financial and human aspects, while human skill and performance is considered as the most influencing factor leading to this situation. Financial and supply chain aspects, both are also remarked respectively. Besides the scenarios of divestment, financial perspective is placed as the most important role for this status, while Supply chain and human performance are noticed as second and third priority. One of the important decisions to make while deciding to transferring

plant is supply chain aspect. On the contrary, human and skill performance, and financial perspective, these factors are considered respectively as the following concerns.

Among three scenarios, financial aspect is shown as the most critical issue leading to divestment of plant, while human and skill performance is focused on the main potential factors causing to relocation of plant. Besides the impact on supply chain aspect, most affects to transfer of plant.

Since two types of analysis are needed for constructing on our framework architecture, this section we described static analysis which is referred to the risk knowledge matrix. Thus the following section, dynamic analysis will be distinguished.

III.4.2. Dynamic analysis

It is necessary to find or develop an estimate of future cash flows when decided to invest. It is also important to estimate the uncertainty in these estimates. This is normally done by comparing to the past results, for example, by looking at actual results versus predicted results at a one year prediction horizon.

Regarding to dynamic analysis, the modeling of supply chain system, and carrying out "what if" analysis in different scenarios, are the main focuses. Different scenarios in dynamic analysis refer to "Existent" and "Expected" location of plant. To experiment with supply chain environment, simulation is undoubtedly one of the most powerful techniques to apply, as a decision support system [Sergio 04]. The framework building supply chain simulation is constructed corresponding to the SCOR model, and implemented using Arena application and Microsoft Excel Spreadsheet. However, to measure the performance of supply chain network, metrics and attributes provided of SCOR helps to explain how well the chain's performance. Besides supply chain cost will be calculated as the outcome of the framework application, while forecasting on investment cost using NPV technique will also be applied in order to suggest for further investment. Thus the following section will be clarified about these contexts.

III.4.2.1. Supply chain simulation framework

The hierarchical simulation modeling approach presented here is based on the Supply Chain Operations Reference model, proposed by the Supply Chain Council [SCC 07]. The SCOR model was developed to describe the business activities associated with all phases of satisfying a customer's demand. SCOR is founded on five distinct supply

chain management processes: Plan, Source, Make, Deliver, and Return. Supply chains can be described using these process building blocks, which are known as process categories [Herrmann 03].

For explaining our approach, it is convenient to identify three kinds of participants: customer, manufacturer, and supplier [see Figure III.8]. Customer is the participant who places orders for finished products, but do not supply any products to any other participant. Here is the most downstream participant in the model of the supply chain. Supplier is the most upstream participant in the model of the supply chain. Since supplier supplies parts to manufacturer. Manufacturer is the intermediate participants in the supply chain. Manufacturer places orders to supplier and deliver orders to customer.

In this framework, a simulation model of a supply chain had three levels. The first level is the simulation model. The second level has sub models that correspond to the supply chain participants. The third level has sub models that correspond to the process elements (across all process categories) that each participant performs. From the proposed model, the scope of level 1 processes (Plan, Source, Make, Delivery and Return), process categories, and process element are explained. With the Source, Make, Deliver process elements, a common internal structure has been upon. However, the proposed model focuses on Make-to-Order (MTO) environment.

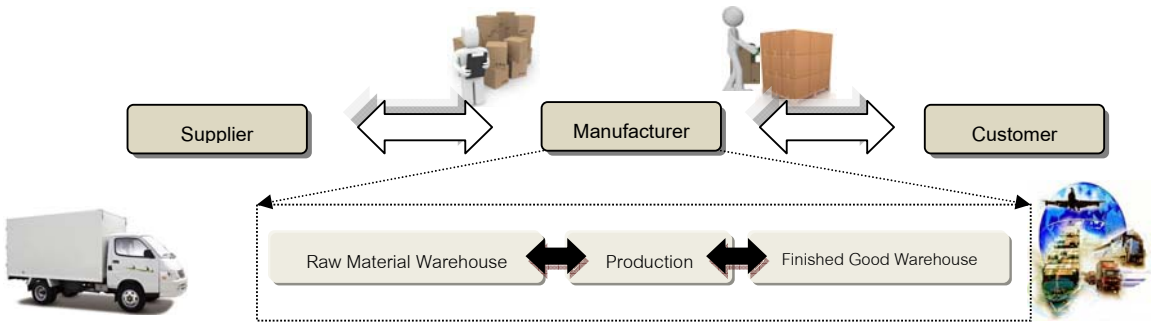


Figure III.8: The three participants of supply chain model

In a MTO environment, the planning of the Source, Make, and Deliver processes is established on the basis of customer orders and the different lead times (production lead time, supplier lead time, etc.) [Persson 09]. There are differences in the sub models for supplier, manufacturer, and customer. In the case of the supplier, raw material sourcing is not performed. Batch quantity is fixed as user defined. The

numbers of batch quantity depend on ordering quantities from manufacturer requirement and assumed to be available all the time. The customer acts as a place for receiving the products corresponding to the orders that he/she places, implying that the customer does not perform production and delivery activities. These processes are represented as SCOR model structure. Each entity contains elements that determine the simulation flow. Thus, we describe the supply chain structure as modeled in SCOR, shown in Figure III.9, as follows:

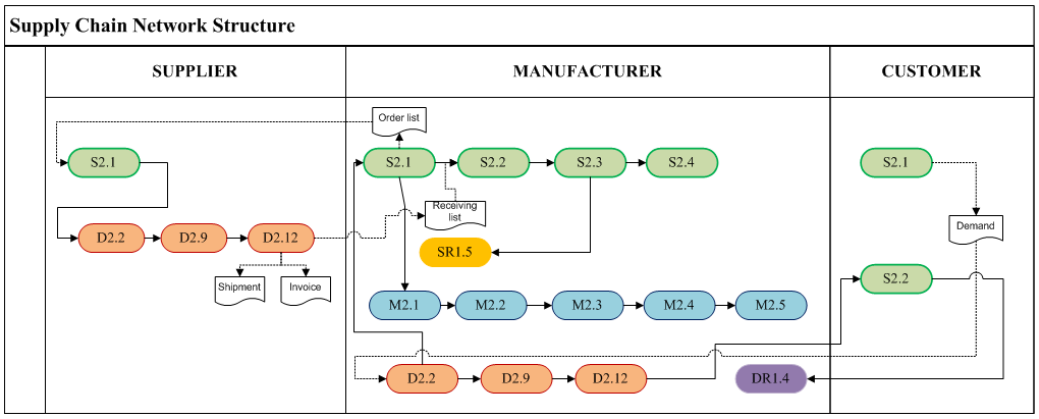


Figure III.9: Flowchart of processes and activities of the supply chain model

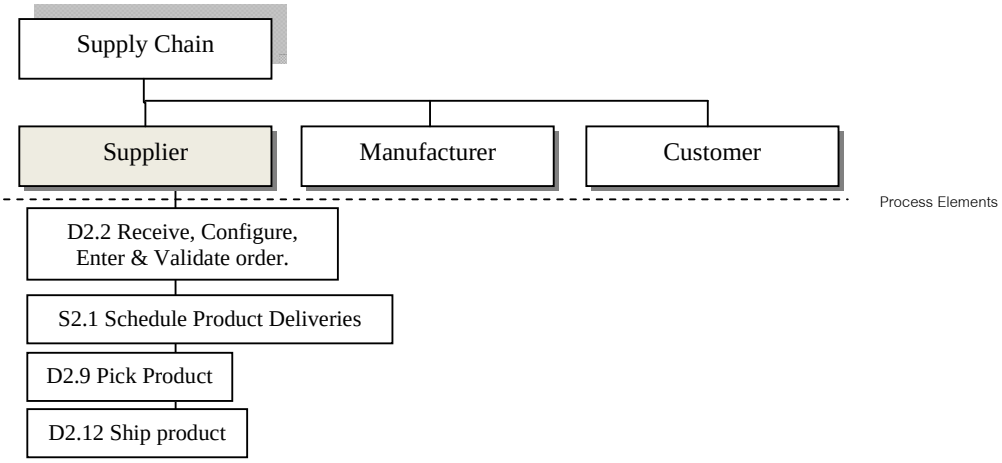
As shown in Figure III.9, supply chain structure sub model represents a set of processes at all nodes which are interrelated. Processes are related to SCOR Level3.

Besides, process symbols used in the above figure are consistent to the SCOR model. Process IDs and process names are given in Table III.7.

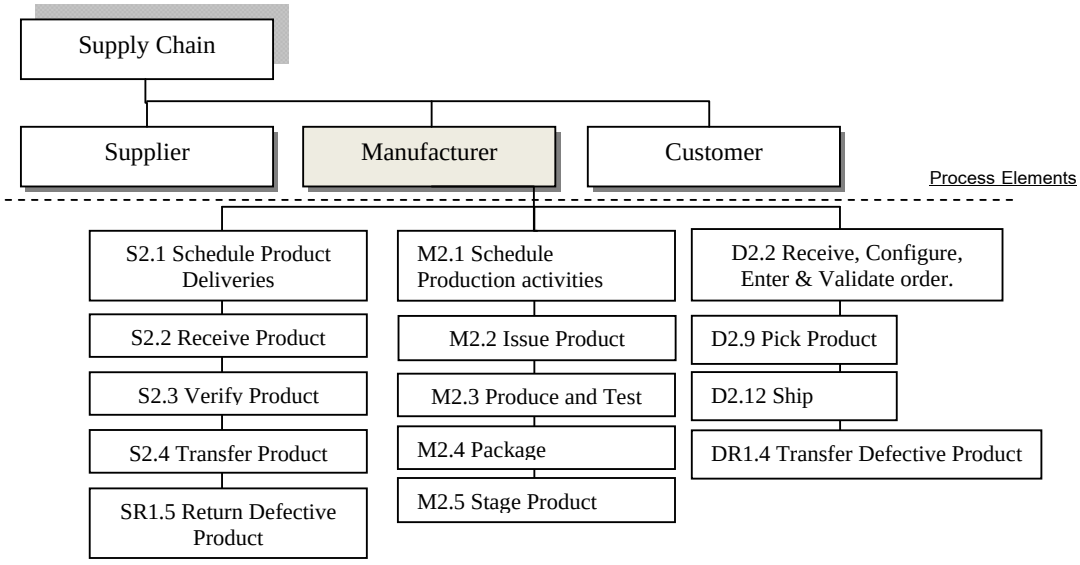
Process ID	Process name
S2.1	Schedule Product Deliveries
S2.2	Receive Product
S2.3	Verify Product
S2.4	Transfer Product
M2.1	Schedule Product Activities
M2.2	Issue Product
M2.3	Produce and Test
M2.4	Package
M2.5	Stage Product
D2.2	Receive, Configure, Enter & Validate order
D2.9	Pick Product
D2.12	Ship Product
SR1.5	Return Defective Product
DR1.4	Transfer Defective Product

Table III.7: Process IDs and process names.

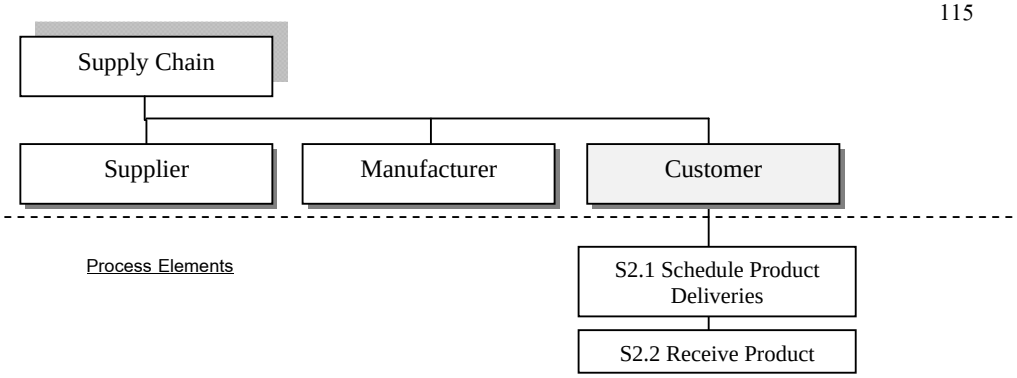
Figure III.10 (a, b, c) displays the corresponding hierarchy of sub models for supplier, manufacturer and customer. Each participant sub model includes a subset of the process element sub models shown in Figure III.10. Each process element is implemented as a separate submodel that represents a specific activity in the supply chain. Also it has clearly defined interfaces, which are used to integrate the submodels. The process element submodels contain Arena blocks. While the participant submodels contain process element submodels and other submodels needed to initialize the simulation model [Herrmann 03].



(a): Supplier



(b): Manufacturer



(c): Customer

Figure III.10: Sub model hierarchy of manufacturer

The implementation on Arena software simulation will be applied. However we will describe in details on chapter IV.

III.4.2.2. Supply chain management cost analysis

From the supply chain framework, analysis on cost of supply chain is also performed. The sum of the costs associated with the SCOR level 2 processes to Plan, Source, Make, Deliver and Return are all referred to supply chain costs. To explain the structure of total supply chain management costs, the hierarchical metric structure is shown below.

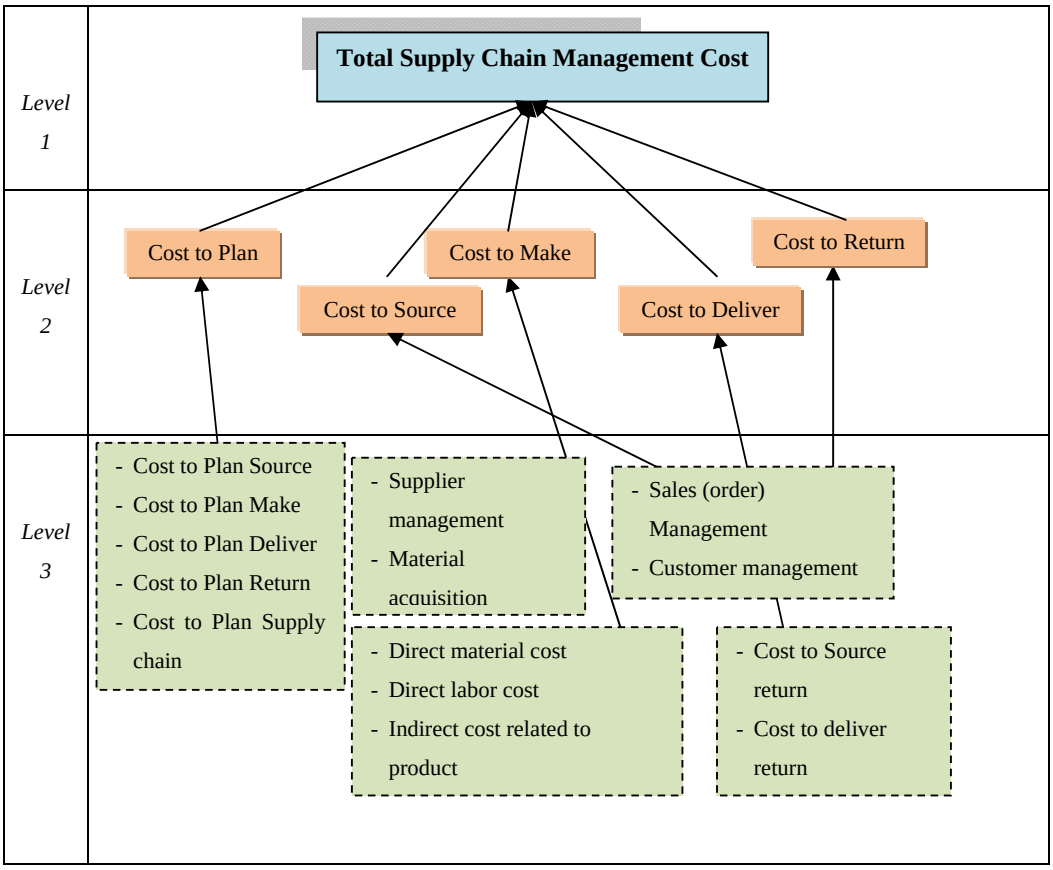


Figure III.11: Hierarchical metric structure of supply chain management cost (SCC 07)

Regarding to the construction of supply chain modeling, we design submodels and activities which are associated with source, make, deliver and return processes. Thus our simulation attempts to incorporate parameters required to represent each cost. However representing on related cost of supply chain in level 3 of SCOR, consist of both costs from management and activities, thus we focus on cost from activities while supply chain simulation can determine the outcomes. The following are parameters using for our calculation.

Cost category	Parameters and calculations
Cost to Source	Supplier management + Material acquisition management
	Supplier Management = material planning + planning procurement staff + supplier negotiation and qualification + etc. Material Acquisition Management = bidding and quotations + ordering + receiving + incoming material inspection + material storage + payment authorization + sourcing business rules and requirement. +

	inbound freight and duties + etc.
- Calculation	= ordering + receiving + incoming material inspection + material storage + inbound freight and duties
Cost of Make	Sum of Direct Material, Direct Labor, and Direct non-Material Product-related Cost (equipment) and of Indirect Product-related Cost
- Calculation	Direct material+ Direct labor + indirect cost (utilities, land) + additional cost (scrap cost)
Cost of Deliver	Sum of Cost of (Sales order management + Customer Management)
- Calculation	= distribution + transportation + outbound freight and duties
Cost to Return	Sum of Cost to Return (to Sources + from Customers)
- Calculation	- Cost to Return to Source (SRx) = Verify Defective Product Costs + Disposition of Defective Product Costs + Identify MRO Condition Costs + Request MRO Return Authorization Costs + Schedule MRO Shipment Costs + Return MRO Product Costs + etc. -Cost to Return From Customer (DRx) = Authorization Costs + Schedule Return Costs + Receive Costs + Authorize MRO Return Costs + Schedule MRO Return Costs + Receive MRO Return Costs + Transfer MRO Product Costs + etc.

Table III. 8: Parameters and equations used for supply chain cost calculation

From table III.8, we put the formula on excel spreadsheet linking with parameters derived from outputs of supply chain simulation. The details of these calculations will discuss more on chapter 4. Finally, combination costs among source, make, deliver and return costs will be represented on total supply chain cost. However, the outcome of the calculation is provided as an initial cost (year = 0) in order to forecast following investment cost (year = 1, 2, 3, 4 and 5) by using NPV technique. The following section will describe on the analysis of this investment cost.

III.4.2.3. Investment cost analysis

The term net present value used in capital budgeting means the present value of the future cash flows associated with an investment minus the amount of the investment. The investment required normally takes place at time zero, the beginning of the first period [Joseph 86]. This analysis will determine the capital investment by taking into

account the net cash flow over an extended period using the net present value technique. This technique used as a fundamental tool used to optimize decision making, which estimates the current value of cash flows relating to an investment [Robert 08].

Our research manipulates on a simple investment scenarios of a property held over a five year period. The technique of net present value with anticipated returns is shown criteria as follows.

$$NPV = \frac{NCF}{(1+r)^t}$$

Where

NCF_t = Net cash flow (receipts minus payments) at time *t*

r = Interest rate

Net present value is the present value of the benefits minus the present value of the costs. Often, to emphasize this partition of benefits and costs, the terms present worth of benefits and present worth of costs are used, both of which are just present values. New present value is the difference between these two terms. To be worthy of consideration, the cash flow stream associated with an investment must have a positive net present value.

However, inflation is another factor that often causes confusion, arising from the choice between using actual dollar values to describe cash flows and using values expressed in purchasing power, determined by reducing inflated future dollar values back to a nominal level. Inflation is characterized by an increase in general prices with time. Inflation can be described quantitatively in terms of an inflation rate *f*. Prices one year from now will on average be equal to today's prices multiplied by (1+ *f*). Besides, inflation compounds much like interest does, so after k years of inflation at rate *f*, prices will be $(1+f)^k$ times their original values. Indeed, inflation rates do not remain constant, but in planning studies future rates are usually estimated as constant.

Another way to look at inflation is that it erodes the purchasing power of money. A dollar today does not purchase as much bread or milk, for example, as a dollar did 10 years ago. In other words, we can think of prices increasing or, alternatively, of the

value of money decreasing. If the inflation rate is *f*, then the value of a dollar next year in terms of the purchasing power of today's dollar is 1/ (1+*f*).

For these reasons, leading us to define a new interest rate, termed the real interest rate, which is the rate at which real dollars increase if left in a bank that pays the nominal rate. To understand the meaning of the real interest rate, imagine depositing money in the bank at time zero, then withdrawing it 1 year later. The purchasing power of the bank balance has probably increased in spite of inflation, and this increase measures the real rate of interest [David 98].

We illustrate now how an analysis can be carried out consistently by using either real or nominal cash flows.

$$r_0 = (r-f) / (1+f)$$

Where:

r_0 = real interest rate

r = interest rate

f = inflation rate

To consider on future investment cost, we consider into 2 investment decisions that existent location (Thailand) and expected location of plant in other developing countries (Vietnam or China). In the first scenarios, a manufacturer or investors decide to manufacture on existent plant in Thailand which is the case study is located on. In the second scenario, they must decide either to manufacture in developing country in China or Vietnam. The reason to decide to china or Vietnam, it is due to both of them are the most competitive countries' advantages of Thailand.

In summary, this chapter introduces tools that use to analyze risks and costs from investment to foreign investors. Static analysis is used to examine risks might that occurred from an existing plant, while dynamic analysis is applied to identify costs of supply chain management and costs of future investment. Comparing among two presented scenarios on present value of the investment, project with the highest potential financial value is more likely to be undertaken by a decision maker. This outcome is conducted from the formula providing on excel spreadsheet which will be discussed in next chapter to support the decision of manufacturers or investors to decide on what scenario is the most preferable. Further, chapter 4 will describe the implementation of using Arena and Microsoft Excel to explain how the sub models

interact. The knowledge based system will conduct as a supporting tool to integrate two analyses of static and dynamic approach which will results in applying and implementing on the web application to the case study.

In addition, as the effective performance on supply chain and collaboration help manufacturers gain more benefits by reducing costs and satisfying customers' need. The last section then looks at a supply chain context that not only suggests on measure supply chain performance but also gives a supply chain cost consideration as a result from running model of simulation. To evaluate supply chain performance, Supply Chain Operation Reference (SCOR) has been usually suggested and supported from Supply Chain Council (SCC) as standard descriptions of management processes, standard metrics to measure process performance. So SCOR is suitable for implementing to evaluate overall supply chain performance of our study to build a model applies to design process categories and decomposing processes which implemented in Arena simulation.

Chapter IV: The application of the proposed framework

IV.1. Introduction

From the previous chapter, the integrated framework helping FDIs on investment's decision was proposed. There are two types of static and dynamic analysis. The results from those analyses will be used to evaluate risks and forecast future investment by using NPV calculation. Thus this chapter mainly focuses on integrating of these two analyses within knowledge based system. In the first part, we will describe the architecture of the knowledge based system. There are mainly four components: database, procedure, simulation model, and a user interface. Afterward, we will describe each main component in detail including their function in Knowledge Based Decision Support System (KBDSS). Finally, the design of the user interface and the implementation of the application on web based system will be examined.

IV.2. Web application architecture

In this section, the system architecture of the Knowledge Based Decision Support System (KBDSS) for FDI investment will be illustrated in order to visualize the main components on their functions, tools, and interface construction. The knowledge based system is constructed based on web application. This system was designed using PHP and JavaScript language, and managed data using MySQL. The Figure IV.1 illustrates the main architecture of the Knowledge Based Decision Support System (KBDSS) on FDI investment. The system provides a user-friendly interface. The likelihood and impact value from the decision maker(s), and also the estimations of operational costs can be provided as input through the interface. Consequently, the results from risk evaluation can be reported to the user(s) in the form of data, graphs and figures. In order to construct KBDSS, the system is composed of four main components: 1) a user interface, 2) database, 3) model base, and 4) a procedure as shown in Figure IV.1. The database management subsystem mainly contains a relational database. The model base includes simulation model which is performed to estimate and investigate

the supply chain cost of investment. Besides, the procedure is the process to operate actions and also to manipulate the results from simulation model. User interface is the interaction between decision makers and the knowledge based system. Excel spreadsheets and text editor are also used jointly to exchange input and output data between the simulation model and the web application. Finally results from simulation are used as input to estimate investment cost which is conducted on Excel spreadsheet.

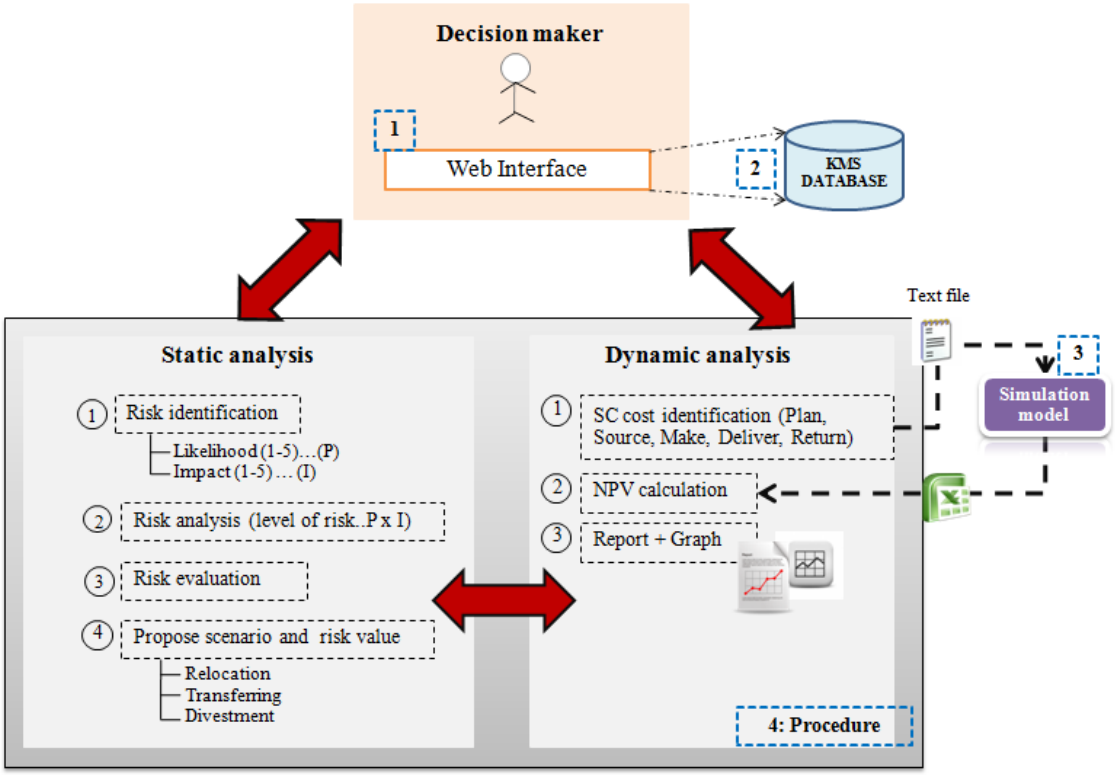


Figure IV.1: Architecture of the knowledge system on FDIs' investment

Thus, the next section, we will examine each component of the knowledge-based decision support system and use practical examples to illustrate its' operations.

IV.3. Structure and database design

A Database Management System (DBMS) is a set of computer programs that controls the creation, maintenance, and the use of a database. A DBMS is a system software

package that helps the use of integrated collection of data records and files known as databases. It allows different user application programs to easily access the same database. Our approach uses MySQL to create a database. The database in this knowledge-based decision support system consists of 9 tables, including the Company_info, FinancialRisk, HumanskillRisk, InfrastructureRisk, SupplychainRisk, Share_holders, Template, Cost and RiskExplanation tables. The main segment of the logical database schema related to modeling, which adequate set of entities and their relationships, is shown in Figure IV.2.

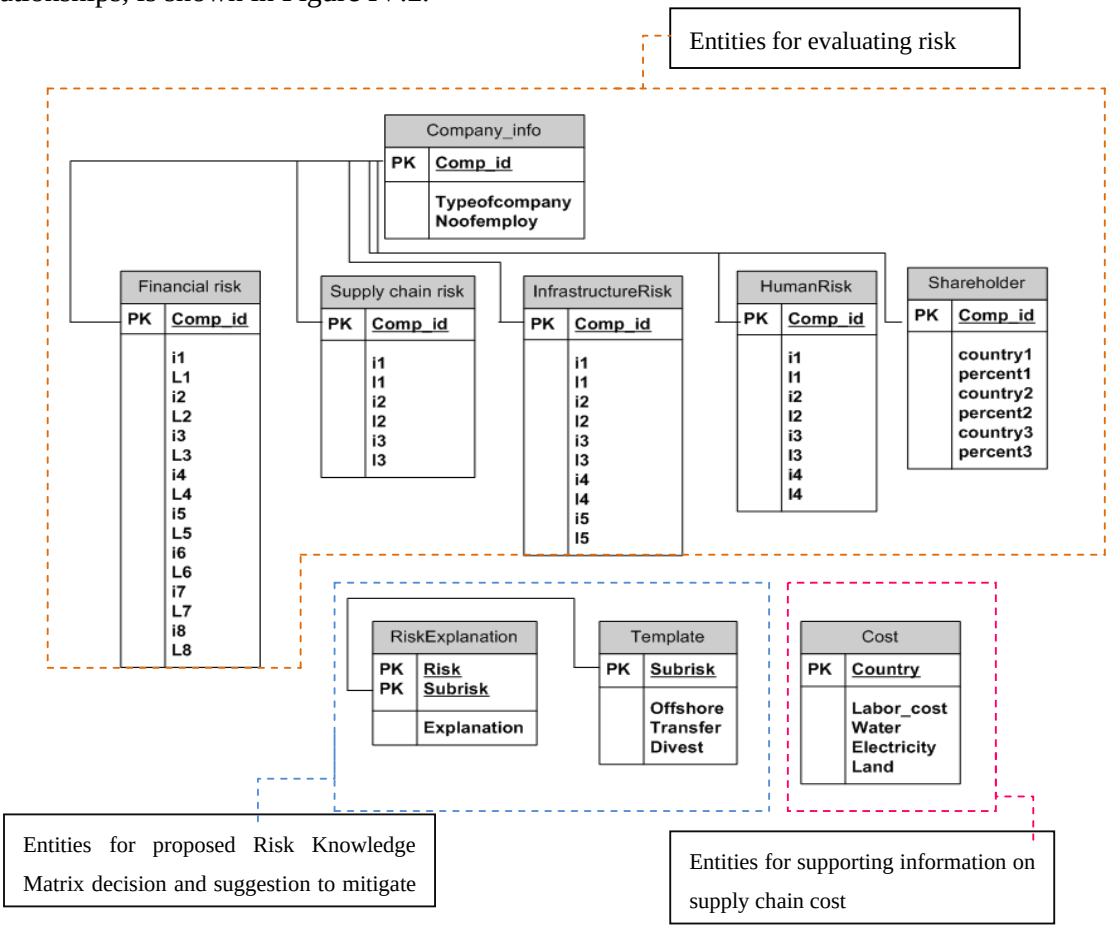


Figure IV.2: Set of entities and their relationships of database design

Data is related to the simulation model is included in several associated entities. The first group of entities represents the database structure for evaluating risk. The structure consists of impact and likelihood from risk evaluation corresponding to profile of decision makers. The second group of entities is related with two objectives. The first objective is the suggestion to mitigate risks, and the second objective,

containing risk values of the proposed Risk Knowledge Matrix, is used for comparing risk value from user(s) indicated, with the value from the matrix. The third group of entities stores data concerning supporting information on supply chain cost. The system relates information between tables with unique primary key named as “comp_id”. Next we will explain on functional and key components use for those 9 tables.

IV.3.1. Main function and key component of designed tables

The main function of the “company_info” table is to store general information of the company. Whenever users access the web application, the system provides a unique index of company_id and stores its general information into the table. The primary key of this table is “comp_id”. This table consists of three attributes company_id, typeofcompany and number of employee in the company. The “Share_holder” table is another table which holds information relevant to “company_info” table. This table consists of six attributes for comp_id, country1, share1, country2, share2, country3, and share3. However, table of “Share_holder” is used to store the countries of shareholders and their percent’s owners of the company. This information helps to classify group of users on making a decision. Besides, to risk factors of likelihood and impact for each risk and sub risk factors, four tables are relevant. There are the main perspectives which we aim to study of “Financial risk”, “Infrastructure risk”, “Human risk” and “Supply chain risk”. These entire tables also contain comp_id as their primary key associated with the values of likelihood and impact for each perspective.

However the table which is not created to update with user information rather to retrieve data for comparing is referred to Table “Template”. This table specially contains values of risk for three scenarios of: relocation, transferring and divestment. Those values used to compare and evaluate with the outcome of risk level indicated by user. Thus sub risk is the primary key of the table, while attributes of “relocation”, “transfer” and “divest” consist of indicated value (Impact and Likelihood) from user(s) corresponded to each key sub risk. While table “Risk Explanation” is provide information to explain and suggest users according to the related risk and sub risks issues. Therefore, this table is contained index of risk, sub risk and their explanations. Also Table “Cost” contains additional values providing users for cost analysis. The

minimum labor cost, watering cost per unit, electricity cost per unit, and cost of land associated with the selected country are contained. However, a structure of each designed table is illustrated on the Appendix.B: Structure of design table.

On the following section, steps to obtain the results from both static and dynamic will be constructed by using PHP and Java scripts language.

IV.4. Procedure in knowledge based system

To comprehend processes within knowledge based system, the procedure is developed and divided into the two stages of decision analysis. The first stage is risk evaluation algorithm with static analysis. The second stage is simulation model and cost calculation on dynamic analysis. Thus we will start to explain on procedure of static analysis. This procedure conducts the actions to evaluating risks. As we described on the static analysis in Chapter III (II.4.1) that there are twenty sub risks in the three main necessities of risk categories. However, to evaluate those risks practically, we demonstrate the procedure by categorizing into four groups, namely, human skill and performance, financial situation, supply chain, and infrastructure.

IV.4.1. Procedure on static analysis

The first analysis focuses on risk evaluation. In this part, the required values of impact and likelihood for 20 sub risks are needed. Those values are provided from the decision makers who are willing to evaluate their existing situation of plant. Afterwards, comparing those values with the values in the risk knowledge matrix, the suggested scenario will be introduced into one of the three scenarios among relocation, transferring or divestment situation. Thus we will explain step by step on the procedure to be analysed risks. The Figure IV.3 shows the procedure on evaluating risks.

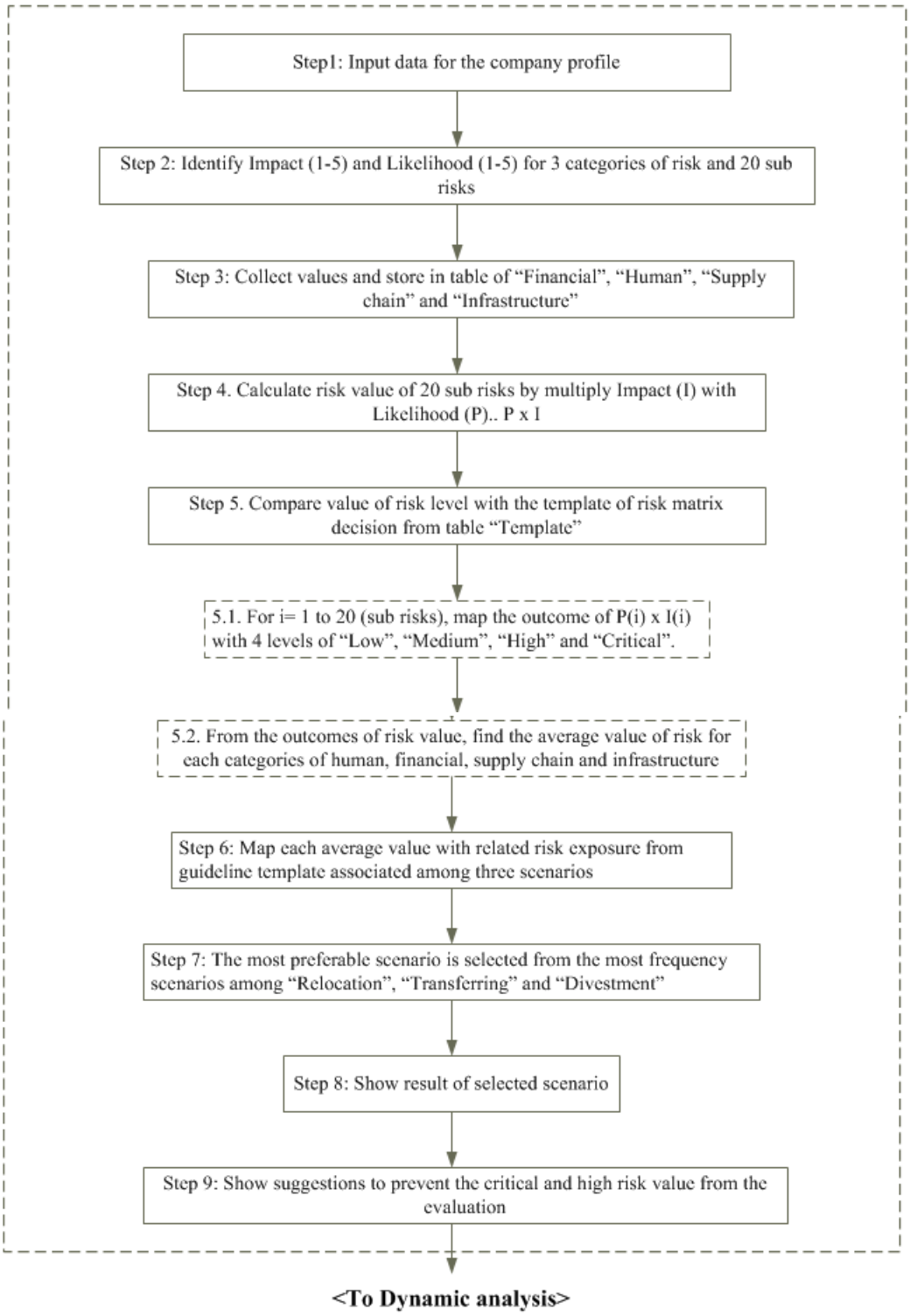


Figure IV.3: The procedure for static analysis

Step 1: This is the first step to fill data by decision maker(s) for the company profile of: manufacturing type, number of employees in the company and shareholders, i.e.,

Manufacturing type: Electronics manufacturing

Number of employees: 100 workers

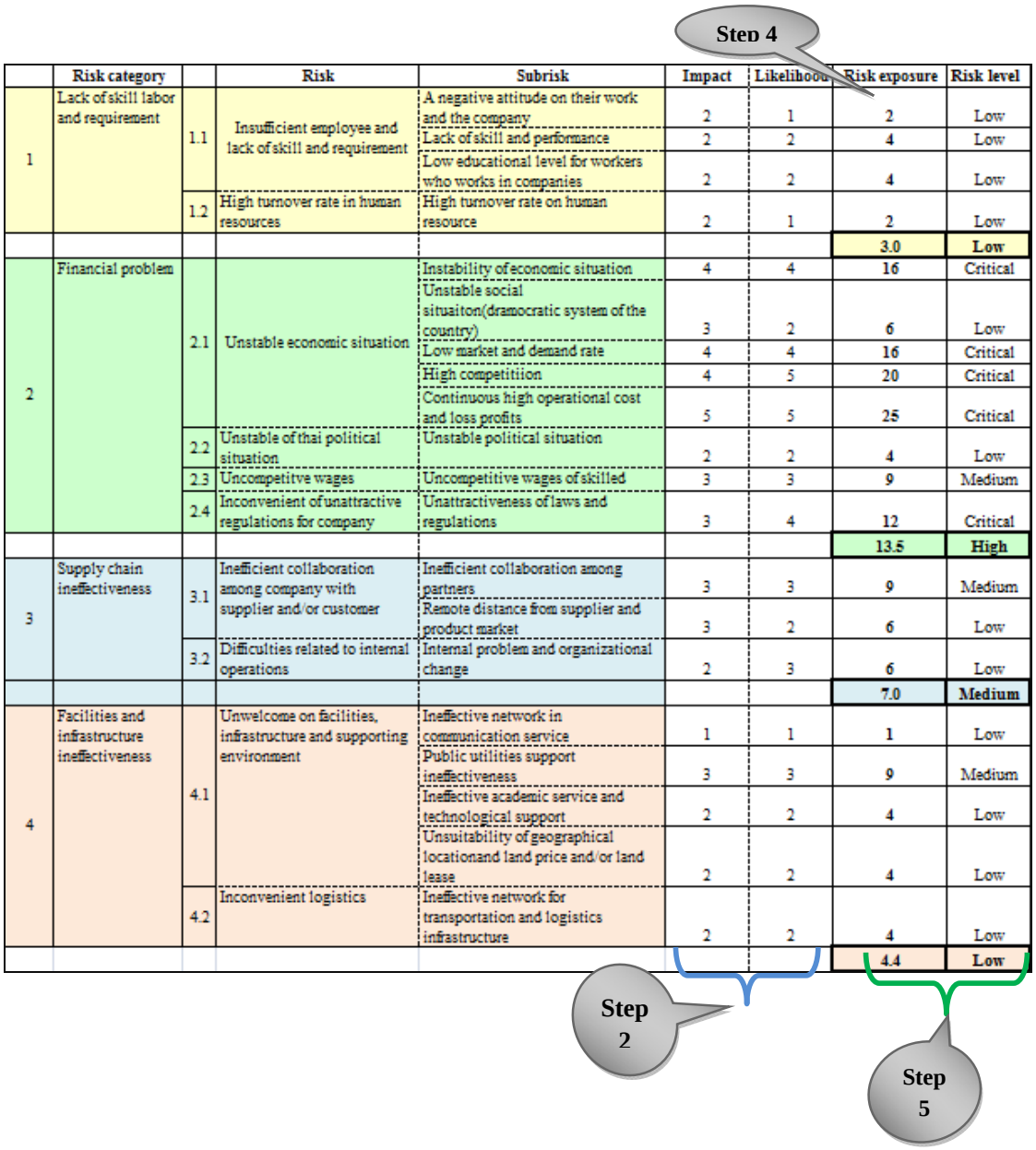
Shareholders: 100%, German

Step 2: This is also a step to fill data concerning the preference of the decision maker(s) to identify values of impact and likelihood for 20 sub risks, each value scores from 1 to 5 (see descriptors of 1 to 5 on chapter 3(3.4.1: Static analysis)). The values of impact and likelihood are obtained according to the experience of the decision maker(s). Table IV.3 presents sample values of impact and likelihood for the 20 sub risks.

Step 3: Those values are stored in the tables of financial, Human, Supply chain and infrastructure.

Step 4: This step is to calculate the value of risk exposure by multiply "Likelihood" with "Impact" (P x I). For example (see Table IV.3), risk exposure of the sub risk "*Lack of skill and performance*" is valued at "4". This value is calculated from "2" (Likelihood: P) multiply with "2" (Impact: I).

Step 5: For each category of risk, average those risk exposure. Then mapping the risk exposure with the four levels of risk which are "Low", "Medium", "High", and "Critical" (See the indicator of risk level on chapter III (Table 3.4)). The sample shows in Figure IV.4. According to the risk category of "Skill labor and requirement", the average of risk exposure is equal "*3*" which is evaluated into level of "*Low*" risk.



	Risk category		Risk	Subrisk	Impact	Likelihood	Risk exposure	Risk level
1	Lack of skill labor and requirement	1.1	Insufficient employee and lack of skill and requirement	A negative attitude on their work and the company	2	1	2	Low
				Lack of skill and performance	2	2	4	Low
				Low educational level for workers who works in companies	2	2	4	Low
		1.2	High turnover rate in human resources	High turnover rate on human resource	2	1	2	Low
							3.0	**Low**
2	Financial problem	2.1	Unstable economic situation	Instability of economic situation	4	4	16	Critical
				Unstable social situaiton(dramocratic system of the country)	3	2	6	Low
				Low market and demand rate	4	4	16	Critical
				High competitiion	4	5	20	Critical
				Continuous high operational cost and loss profits	5	5	25	Critical
		2.2	Unstable of thai political situation	Unstable political situation	2	2	4	Low
		2.3	Uncompetitve wages	Uncompetitive wages of skilled	3	3	9	Medium
		2.4	Inconvenient of unattractive regulations for company	Unattractiveness of laws and regulations	3	4	12	Critical
							13.5	**High**
3	Supply chain ineffectiveness	3.1	Inefficient collaboration among company with supplier and/or customer	Inefficient collaboration among partners	3	3	9	Medium
				Remote distance from supplier and product market	3	2	6	Low
		3.2	Difficulties related to internal operations	Internal problem and organizational change	2	3	6	Low
							7.0	**Medium**
4	Facilities and infrastructure ineffectiveness	4.1	Unwelcome on facilities, infrastructure and supporting environment	Ineffective network in communication service	1	1	1	Low
				Public utilities support ineffectiveness	3	3	9	Medium
				Ineffective academic service and technological support	2	2	4	Low
				Unsuitability of geographical locationand land price and/or land lease	2	2	4	Low
		4.2	Inconvenient logistics	Ineffective network for transportation and logistics infrastructure	2	2	4	Low
							4.4	**Low**

Figure IV.4: Sample calculation of the risk exposure.

Step 6: Mapping the value of average risk exposure from the previous step with the average risk exposure from Risk knowledge matrix. Thus the three scenarios which are relocation, transferring and divestment, are evaluated.

Step 7: Then, one of three scenarios is chosen according to the most adjacent value by comparing vales of average risk exposures with the Risk Knowledge Matrix (see Figure IV.5).

Step 8: Finally, the scenario which is the most frequency exposure is represented as the suggesting scenario. For example on Figure IV.5, the suggesting scenario of this sample is "*Divestment*".

	Risk category		Risk	Subrisk	Risk exposure	Risk level	Status
1	Lack of skill labor and requirement	1.1	Insufficient employee and lack of skill and requirement	A negative attitude on their work and the company	2	Low	
				Lack of skill and performance	4	Low	
				Low educational level for workers who works in companies	4	Low	
		1.2	High turnover rate in human resources	High turnover rate on human resource	2	Low	
					3.0	**Low**	**Divestment**
2	Financial problem	2.1	Unstable economic situation	Instability of economic situation	16	Critical	
				Unstable social situaiton(dramocratic system of the country)	6	Low	
				Low market and demand rate	16	Critical	
				High competitiion	20	Critical	
				Continuous high operational cost and loss profits	25	Critical	
		2.2	Unstable of thai political situation	Unstable political situation	4	Low	
		2.3	Uncompetitve wages	Uncompetitive wages of skilled labor	9	Medium	
		2.4	Inconvenient of unattractive regulations for company	Unattractiveness of laws and regulations	12	Critical	
					13.5	**High**	**Divestment**
3	Supply chain ineffectiveness	3.1	Inefficient collaboration among company with supplier and/or customer	Inefficient collaboration among partners	9	Medium	
				Remote distance from supplier and product market	6	Low	
		3.2	Difficulties related to internal operations	Internal problem and organizational change	6	Low	
					7.0	**Medium**	**Divestment**
4	Facilities and infrastructure ineffectiveness	4.1	Unwelcome on facilities, infrastructure and supporting environment	Ineffective network in communication service	1	Low	
				Public utilities support ineffectiveness	9	Medium	
				Ineffective academic service and technological support	4	Low	
				Unsuitability of geographical locationand land price and/or land lease	4	Low	
		4.2	Inconvenient logistics	Ineffective network for transportation and logistics infrastructure	4	Low	
					4.4	**Low**	**Transferring plant**
					Suggested scenario		**Divestment**

Figure IV.5: Sample result from the evaluation of risk

Step 9: Additionally, only the risk exposure in critical and high level of risk, the system provides suggestion to mitigate those risks for decision maker. The suggestions derive from table “Risk Explanation”.

IV.4.2. Procedure on dynamic analysis

From the previous section, risk evaluation on the existing situation of plant was conducted. In this section, to estimate the future cost of investment among two selected site locations, the supply chain cost based on SCOR processes are provided from the decision maker which are stored in the text file as input for the simulation model. Afterwards, outputs from running simulation are presented as one-year investment cost through the excel spreadsheet. To estimate the future cost, forecasting technique to derive inflation rate and demand rate change is needed to analyse the net present value (NPV). The Figure IV.6 explains approach on this dynamic analysis.

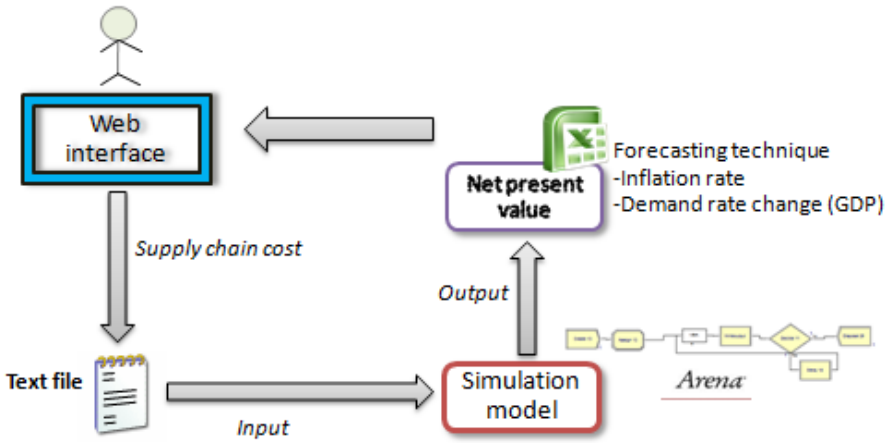


Figure IV.6: Approach of dynamic analysis

Thus the following steps, we describe approaches to obtain those outcomes by giving the sample of Thailand and China location. Figure IV.7 presents the procedure to analyse future cost of investment on dynamic analysis.

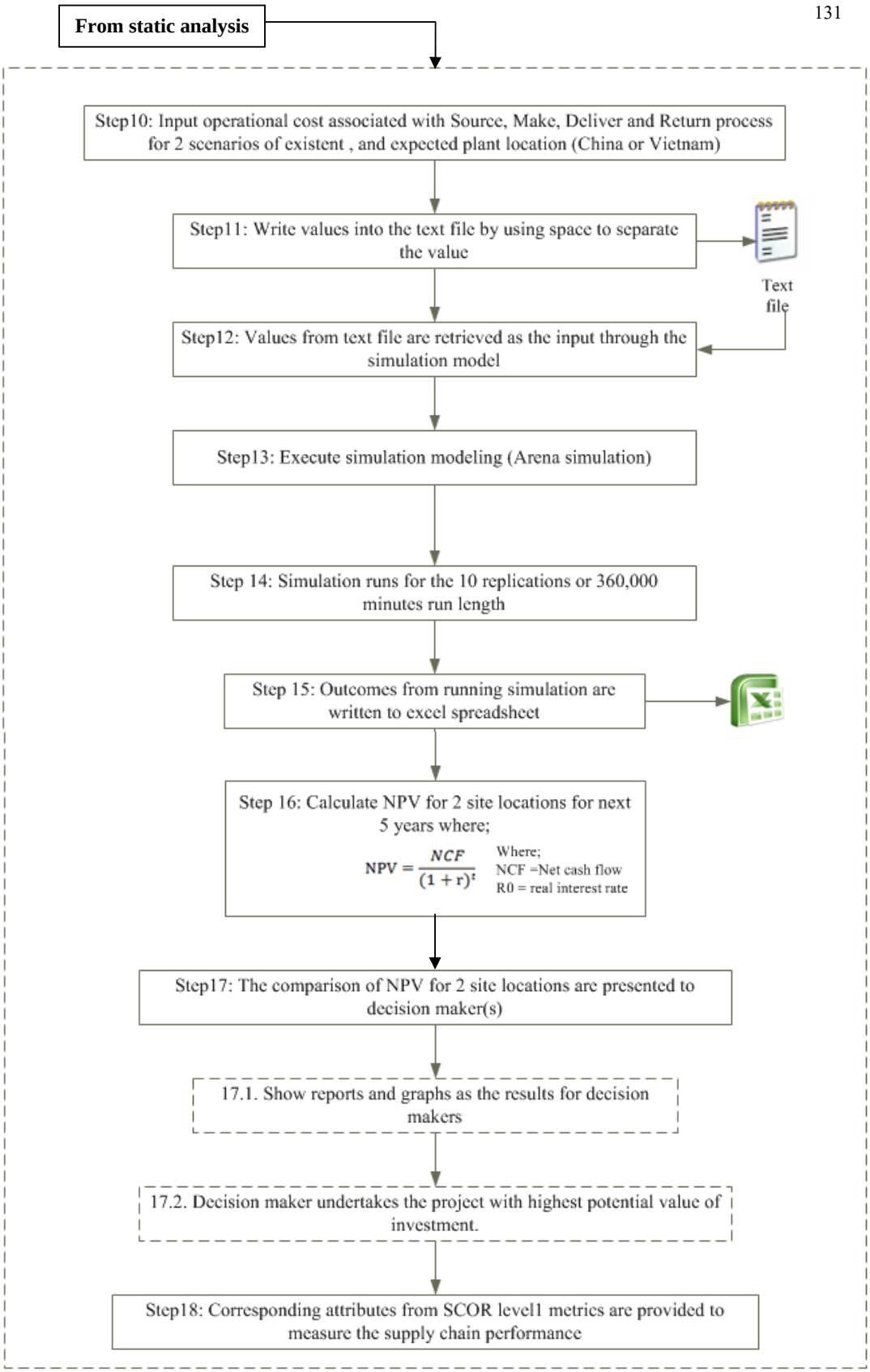
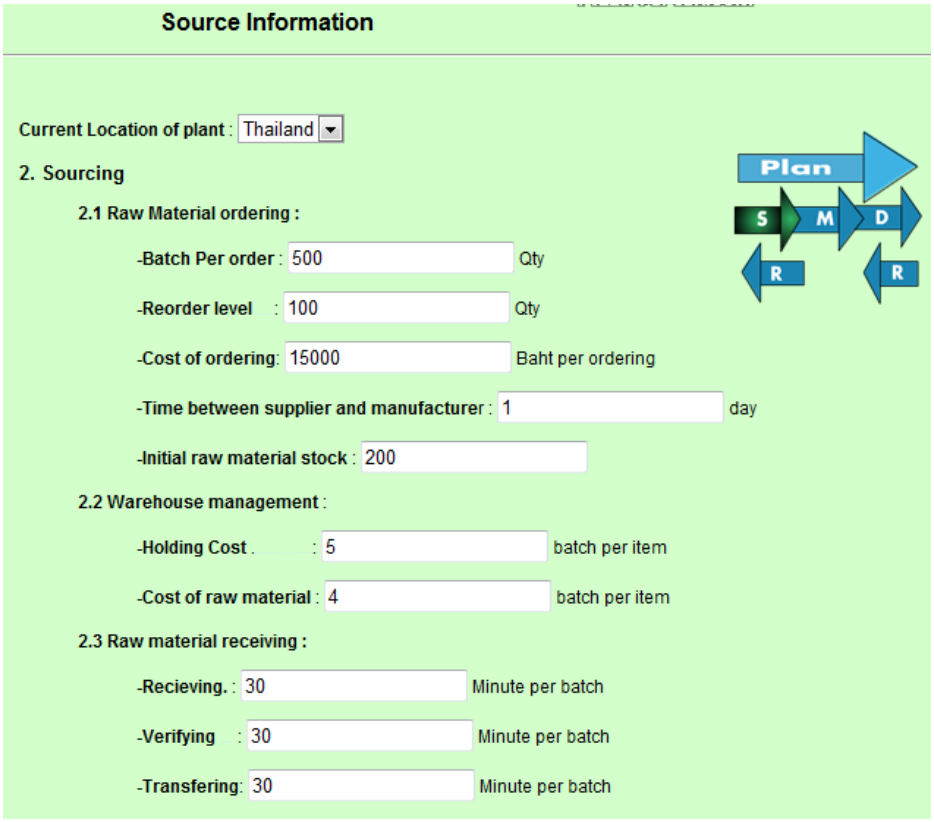


Figure IV.7: Procedure for dynamic analysis

Step 10: This step is to input parameters using for supply chain simulation through the interface. These input data are operational costs associated with Source, Make, Deliver and Return processes. The decision maker is required to complete those values of two sites for current location in Thailand and expected location by choosing between China and Vietnam site. However, this sample chooses the expected location in China. The Figure IV.8 shows sample input of "Source" cost based on SCOR through the interface.



The Figure IV.8: Sample input of "Source" cost from user interface

Step 11: Then, all input data are written into the text file as shown on figure below.

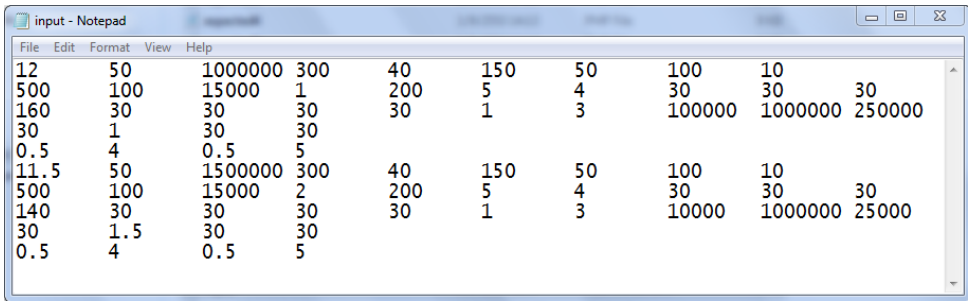


Figure IV.9. Input identified by user

Step 12: Then, those values are manipulated as the input through the model of supply chain simulation.

Step 13: Decision maker executes simulation model by this step. In order to visualize the interrelation among cost manipulation and simulation model, the supply chain SCOR model will be described in detail on the section IV.4.3 (Simulation model).

Step 14: Simulation runs for the 10 replications of the 360,000 minutes run length or 250 working days (one year).

Step 15: Finally, the outcomes from running simulation are written into excel spreadsheet as cost of *Source*, *Make*, *Deliver* and *Return* processes for the first year of investment. There are three sheets on the excel file. The first sheet shows in the Figure IV.10. It is used as the intial outcomes to estimate future cost of investment.

Output ---> 10 replication	**InProcess(Status=3)**	**1715200**
	FGinWH(status=4)	1598200
	FGShip(status =5)	1553500
	FGtoCus(Status=6)	1541100
	Count no. of delivery	2303
	ScrapMake	159
	No.of cus receiving FG	2285
	Count no.ordering RM	1147
	Sum orderRM	1719000
	AverageRM	12809
For 1 replication	InProcess(Status=3)	171520
	FGinWH(status=4)	159820
	FGShip(status =5)	155350
	FGtoCus(Status=6)	154110
	Count no. of delivery	230
	ScrapMake	16
	No.of cus receiving FG	229
	Count no.ordering RM	115
	Sum orderRM	171900
	FG complete in WH	159804
	FG complete ship	155334
	FG complete to Cus	154094
	FG complete Cus accepted	151012
	Current WIP	11716
	OnHandFG	4470
	Avg.InventoryRM	12809
	Current Source return volume	3438
	Current delivery return volum	3082
	Rejected Return RM	0.02
	Rejected Return FG	0.02
	Rejected Make	0.01

Source cost			
Shipment cost	count RM receive from sup.	171900	
+	Freight cost RM per item	5	859500
Ordering cost	No. of RM order Qty	115	
+	Ordering cost	1000	114700
Holding cost	Avg. inventory level	12809.09	
	Holding cost	5	64045.45455
Total Source cost			**1,038,245**
Make cost			
Direct mat cost	Material used qty	171520	
+	Material cost	10	1715200
Direct labor cost	no. of labor used*	10	
+	Labor cost per day	160	
	250 day per year	250	400000
indirect cost	utilities cost...per month (or year)	280000	
+	12 months per year	12	3360000
Additional cost	scrap cost per unit	7	
	Sum of scrap	16	111.3
Total Make cost			**5,475,311**
Delivery cost			
Freight cost FG		5	
Total no. of FG delivery		155334	**776,671**
Total Delivery cost			
Return cost			
Disposition of defective product cost	cost of rejected material	2	
+	count RM_receive from supplier)	171900	
	%RM_rejected	2.00%	6876
Return FG cost	Cost of rejected FG	2	
	No.of Rejected FG from cus	3082	6164
Total return cost			**13,040**

Figure IV.10: Outcomes from running simulation

Step 16: This process is to calculate NPV by estimating the net cash flow for next 5 years of two site locations as shown in Figure IV.11. The procedure is conducted on the second spreadsheet. Cells in the second spreadsheet are filled with formula used for net present value (NPV) calculation. To estimate the cash flow and obtain NPV, inflation rate and demand rate are also integrated to estimate the future cost of investment. Thus we will describe how to obtain those two values by using

forecasting technique and method to calculate NPV in the section IV.4.3.2 (Cost simulation).

	Year						
Thailand	**0**	**1**	**2**	**3**	**4**	**5**	**Total**
Total revenue	**11,325,916**	12,005,471.33	12,698,187.03	13,349,604.02	13,879,583.30	14,341,773.42	77,600,535.45
Demand rate		6.0%	5.8%	5.1%	4.0%	3.3%	
Initial investment cost	-						
Total expenditure	**7,303,267**	7,741,463	8,188,145	8,608,197	8,949,943	9,247,976	40,791,015.59
-source cost (ordering + holding+ transporting cost of material)	1,038,245	1,100,540.18	1,164,041.35	1,223,756.67	1,272,339.81	1,314,708.73	7,113,632.20
-Make cost (Direct mat cost + Direct labor cost + indirect cost + additional cost)	5,475,311	5,803,829.98	6,138,710.97	6,453,626.84	6,709,835.83	6,933,273.36	37,514,588.27
-Delivery cost (Shipped finished good cost)	776,671	823,270.73	870,773.45	915,444.13	951,787.26	983,481.78	5,321,427.85
-Return cost	13,040	13,822.15	14,620	15,370	15,980	16,512	89,343.12
Net CF	4,022,649	4,264,008	4,510,042	4,741,407	4,929,641	5,093,798	36,809,519.87
Interest rate (Thailand)	12%	12%	12%	12%	12%	12%	
Inflation rate (Thailand)		1.73%	3.03%	4.13%	3.93%	4.27%	
Real interest rate: (r-f)/(1+f)		10.092%	8.703%	7.554%	7.761%	7.417%	
NPV: NCF/(1+r)n	฿4,022,649.33	฿3,873,140.86	฿3,816,805.24	฿3,810,855.25	฿3,655,632.98	฿3,561,877.82	**฿22,740,961.49**

Figure IV.11: Net present value calculation for 5 years of investment plan

Step 17: Then the comparison of NPV for two site locations are presented to decision maker. The outcomes are showed in graphs and reports which describes values of supply chain cost and NPV as shown in Figure IV.12.

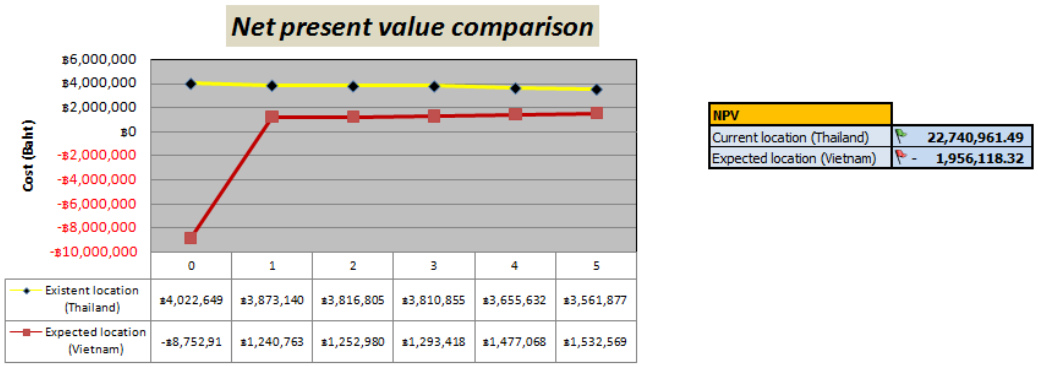


Figure IV.12: The comparison of NPV for two site locations

Step18: Since the supply chain cost is presented then supply chain performance is also measured which is conducted on the third spreadsheet. Standard SCOR level1 metrics are the corresponding attributes provided to measure the performance (see Appendix.C: Performance attributes and associated Level 1 and Level 2 metrics).

SCOR attribute and measurement

Performance attribute	Level 1 metric	Level 2 metric	Constraint factors	Performance measurement	
				Current	Expected
Reliability	Perfect Order Fulfillment	% of order delivered in full		**0.98**	**0.98**
Responsiveness	Order Fulfillment cycle time	Source cycle time		**2.38**	**2.33**
		Make cycle time			
		Deliver cycle time			
Flexibility	Upside supply chain flexibility, Upside supply chain adaptability,downside supply chain adaptability	Upside Make Flexibility (Upside Make Adaptability)	current on-hand WIP	**11,715.90**	**11,916.20**
		Upside Deliver Flexibility (Upside Deliver adaptability)	Current on hand FG	**4,470.00**	**3,800.00**
		Upside Source Return Flexbility (Upside source return adapability)	Current source return volume	**3,438.00**	**3,492.00**
		Upside deliver Return Flexbility (Upside deliver return adapability)	Current delivery return volume	**3,081.88**	**3,150.08**
Cost	Supply chain management cost, Cost of Goods sold	Cost to Source	Source cost	**7,113,632.20**	**4,810,875.08**
		Cost to Make	Make cost	**37,514,588.27**	**36,170,320.70**
		Cost to Deliver	Deliver cost	**5,321,427.85**	**3,261,709.02**
		Cost to Return	Return cost	**89,343.12**	**91,017.56**
Asset management	Cash-to-Cash Cycle time, Return on supply chain fixed assets, Return on working capital	Supply chain revenue		**77,600,535.45**	**52,878,421.76**
		Cost of Good sold		**37,514,588.27**	**36,170,320.70**
		Supply chain management cost		**40,791,015.59**	**36,140,331.09**

Figure IV.13: Comparison of SCOR attribute and measurement among two site location of plant

From Figure IV.13, not only NPV calculation are illustrated, but also performance in supply chain are measured and explains based on level 1 metrics of SCOR.

Consequently, the comparison on NPV and supply chain performance among two site location of Thailand and China are provided to decision maker. These information support the decision on FDIs' investment by providing them understand the existing situation of plant and future cost of investment for the 5 years plan. However, in order to visualize the interrelation among cost manipulation and simulation model, the supply chain SCOR model will be described in detail in the following section.

IV.4.3 Simulation model

This section describes how the simulation model works and executes the key activities used for calculation of NPV and measure performance in supply chain operations. There are two stages on simulation. First, the simulation model describes the supply chain activities. The outcomes obtaining from this simulation are represented in terms of supply chain cost. The second simulation model is cost simulation which conducted on excel spreadsheet.

IV.4.3.1 Supply chain simulation model

This simulation is performed by using Arena software application. The sub models which were broken down into activities are carried out as process elements based on SCOR. The sub models also associated with a participant include VBA blocks that communicate with corresponding Excel spreadsheet using VBA language.

As we described on the chapter III.4.2.1 (Supply chain simulatin framework) that our simulation model approach contains with three partners of supplier, manufacturer, and customer along the supply chain system. In this section, the simulation describes the proposed model in practical analysis. As shown in Figure IV.14, the illustration on process element based on SCOR for supplier and customer are illustrated. Besides, decompose processes for supplier activities are built. The processes are described on receiving, delaying and sending material to manufacturer. Additionally, process elements describing on the “schedule product delivering” and “receive” process element are also explained. There are three volumes for the schedule of customer demand as High, Medium and Low season.

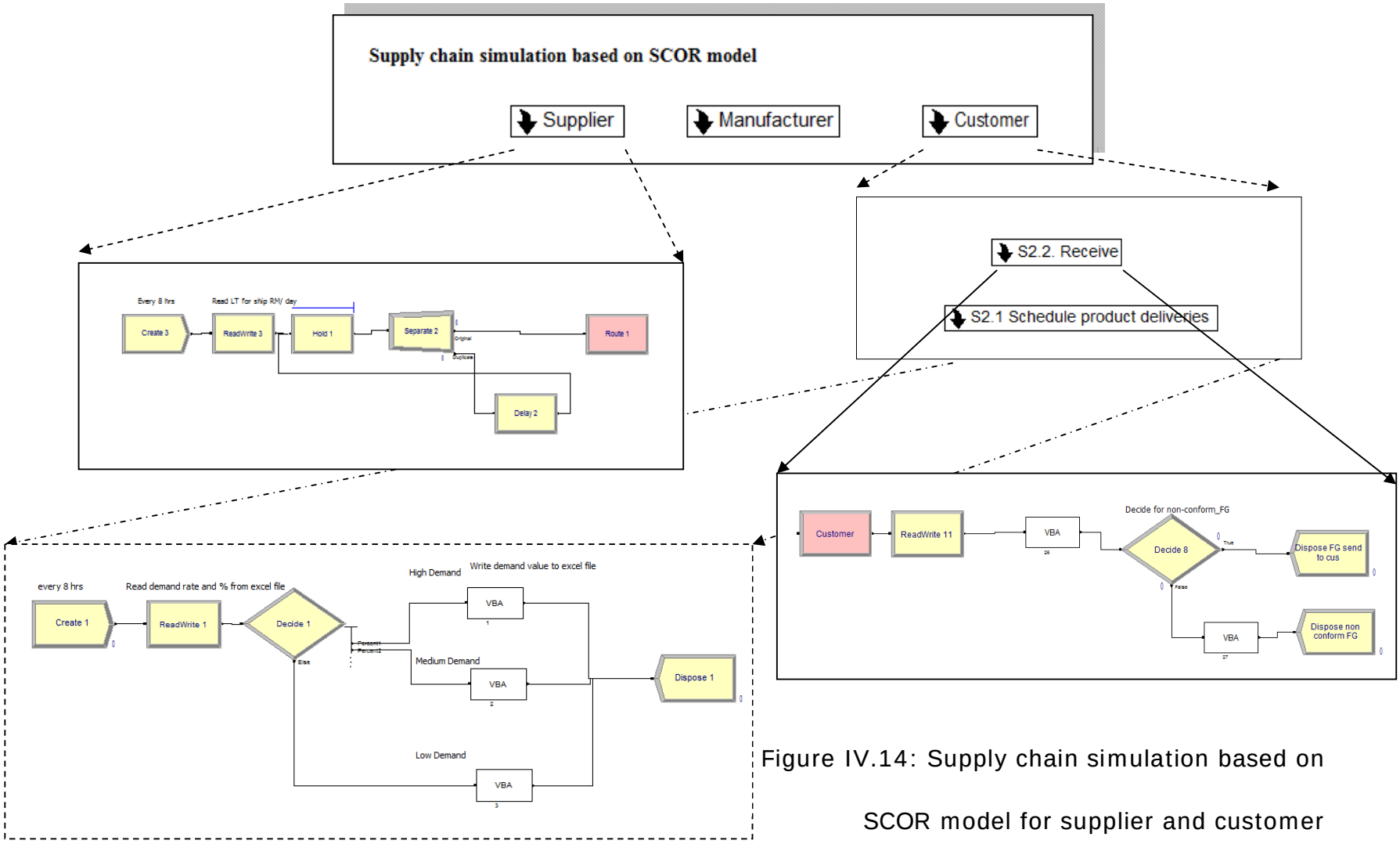


Figure IV.14: Supply chain simulation based on SCOR model for supplier and customer

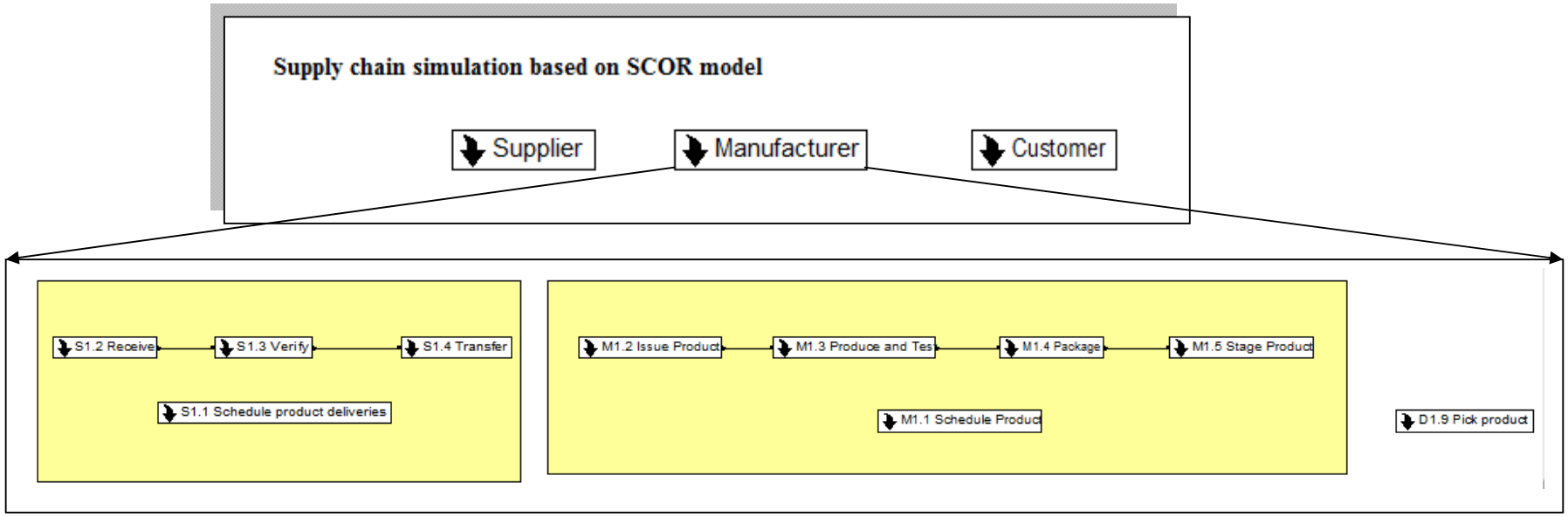


Figure IV.15: Supply chain simulation based on SCOR model for manufacturer

From Figure IV.15, the process elements for manufacturer represent the four basic processes of SCOR which are *Source*, *Make*, *Deliver and Return* processes. The model focuses on Make-to-Order (MTO) environment.

First, to simulate model of supply chain simulation, input data of supply chain and operational costs are provided to simulation at the starting run time, for example, demand quantity, lead time used along the supply chain system, or even transportation cost for *Source*, *Make*, *Deliver* and *Return* processes,. However, we did simulation runs for the 10 replications of the 360,000-minutes run length (or 250 working days of one year). During running the simulation, a separate summary report is generated in the excel file. This file contains outputs using for supply chain cost calculation and NPV analysis. These outputs from the simulation are provided as the initial cost of one year investment. However to estimate the future investment cost, analysis of net present value will be discussed in the following section.

IV.4.3.2. Cost simulation

From the previous section, values of *Source*, *Make*, *Deliver* and *Return* cost at time 0 were presented. To obtain the NPV for future cost of investment, it is necessary to integrate values of net cash flow and real interest rate with the influenced parameters of inflation and demand rate change as shown in the following formula.

$$\mathrm{NPV} = \frac{NCF}{(1+\mathrm{r})^t}$$

Where;

NCF = Net cash flow

r_0 = Real interest rate = (r-*f*) / (1+*f*)

f = Inflation rate

t = Time, year

However, the value of net cash flow and real interest rate, both are varied from time to time depending on capability to produce, customer demand and inflation rate. Thus our cost simulation applies forecasting technique of “Moving average” to estimate inflation and demand rate for next 5 years plan. To calculate NPV (see Figure IV.16), the five-year term (n) is fixed. Each year, the net cash flow and interest rate will be allowed to vary in this simulation. Conducting a simulation of the NPV, it is necessary to estimate to be as realistic as possible. So we include demand rate change (C5:G5) to adjust amount of the actual net cash flow (C12:G12) and integrate inflation rate (C17:G17) to obtain the real interest rate (C20:G20) for next 5 year plan. By using the technique of moving average, both forecasting values of demand and inflation rate are estimated and used for NPV analysis. Besides, forecasting approach to estimate those required values are given on the Appendix.D: Approach used on forecasting inflation and demand (GDP) rate.

	A	B	C	D	E	F	G	H
1								
2		Year						
3	**Thailand**	**0**	**1**	**2**	**3**	**4**	**5**	**Total**
4	Total revenue	**7,550,611**	8,003,647.55	8,465,458.02	8,899,736.01	9,253,055.53	9,561,182.28	51,733,690.30
5	Demand rate		6.0%	5.8%	5.1%	4.0%	3.3%	
6	Initial investment cost	1,300,000						
7	Total expenditure	**7,303,358**		8,188,247	8,608,304	8,950,054	9,248,091	33,049,963.94
8	-source cost (ordering + holding+ transporting cost of material)	1,038,336	1,100,636.55	1,164,143.27	1,223,863.82	1,272,451.22	1,314,823.84	7,114,255.07
9	-Make cost (Direct mat cost + Direct labor cost + indirect cost + additional cost)	5,475,311	5,803,829.98	6,138,710.97	6,453,626.84	6,709,835.83	6,933,273.36	37,514,588.27
10	-Delivery cost (Shipped finished good cost)	776,671	823,270.73	870,773.45	915,444.13	951,787.26	983,481.78	5,321,427.85
11	-Return cost	13,040	13,822.15	14,620	15,370	15,980	16,512	89,343.12
12	Net CF	-1,052,747	8,003,648	277,211	291,432	303,001	313,091	18,683,726.36
14	Interest rate (Thailand)	12%	12%	12%	12%	12%	12%	
17	Inflation rate (Thailand)		1.73%	3.03%	4.13%	3.93%	4.27%	
20	Real interest rate: (r-f)/(1+f)		10.092%	8.703%	7.554%	7.761%	7.417%	
21	**NPV: NCF/(1+r)n**	(฿2,352,747.03)	฿7,269,979.86	฿234,600.72	฿234,235.01	฿224,694.24	฿218,931.56	**฿5,829,694.35**

Figure IV.16: Spreadsheet simulates NPV for existent plant in Thailand

IV.5. Designed user interface for knowledge based system

Due to one of the main components constructing our system is referred to user interface. User interface allows the decision maker to operate interaction with the system, for example, input the values, evaluating on risk, or even accessing charts or graphic facilities. Thus this section, we present on the design and main functional uses of user interface for the knowledge-based decision support system on FDIs' investment. The two modules of static and dynamic analysis are mainly focused on the KBDSS of FDIs' investment. Regarding to the static analysis, it refers to evaluate existing risks of the situation of plant. The outcomes of suggested scenario and suggesting information on critical and high risk level are the main results from this analysis. The Figure IV.17 illustrates the interface of those providing outcomes.

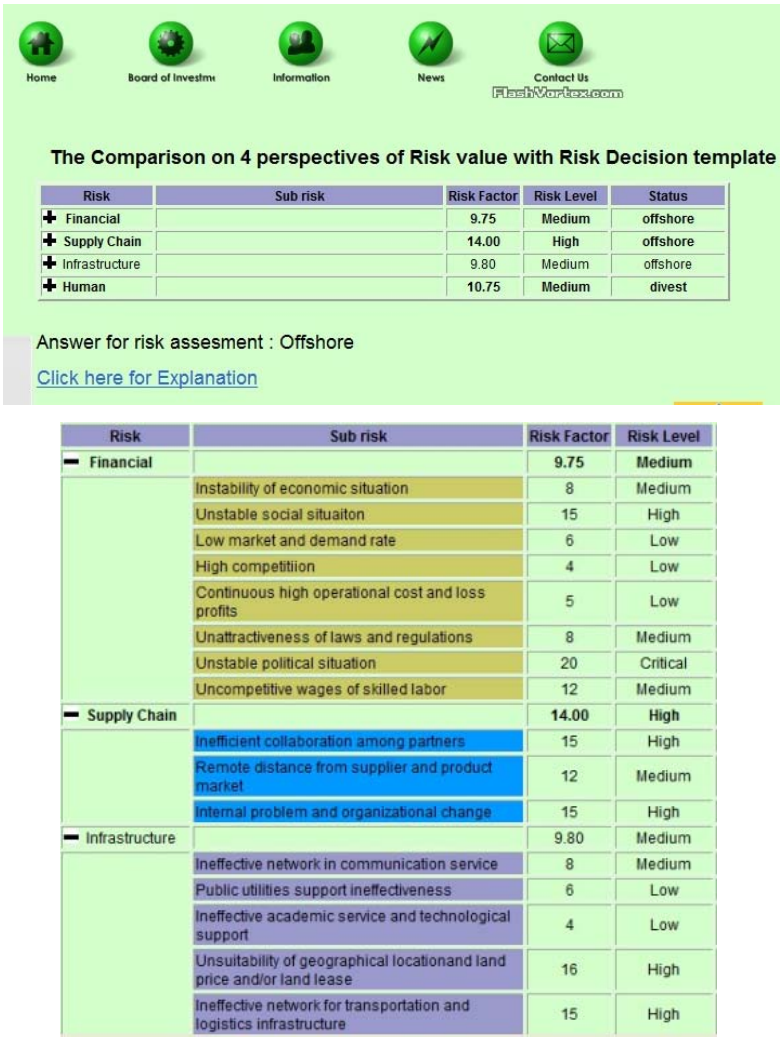


Figure IV.17: User interface on static analysis

In terms of dynamic analysis, it is in order to manipulate supply chain cost and evaluate NPV of future investment. The user interfaces obtaining supply chain parameters are required for the initial input to manipulate supply chain modeling. The user interfaces on dynamic anlaysis are shown in Figure IV.18.

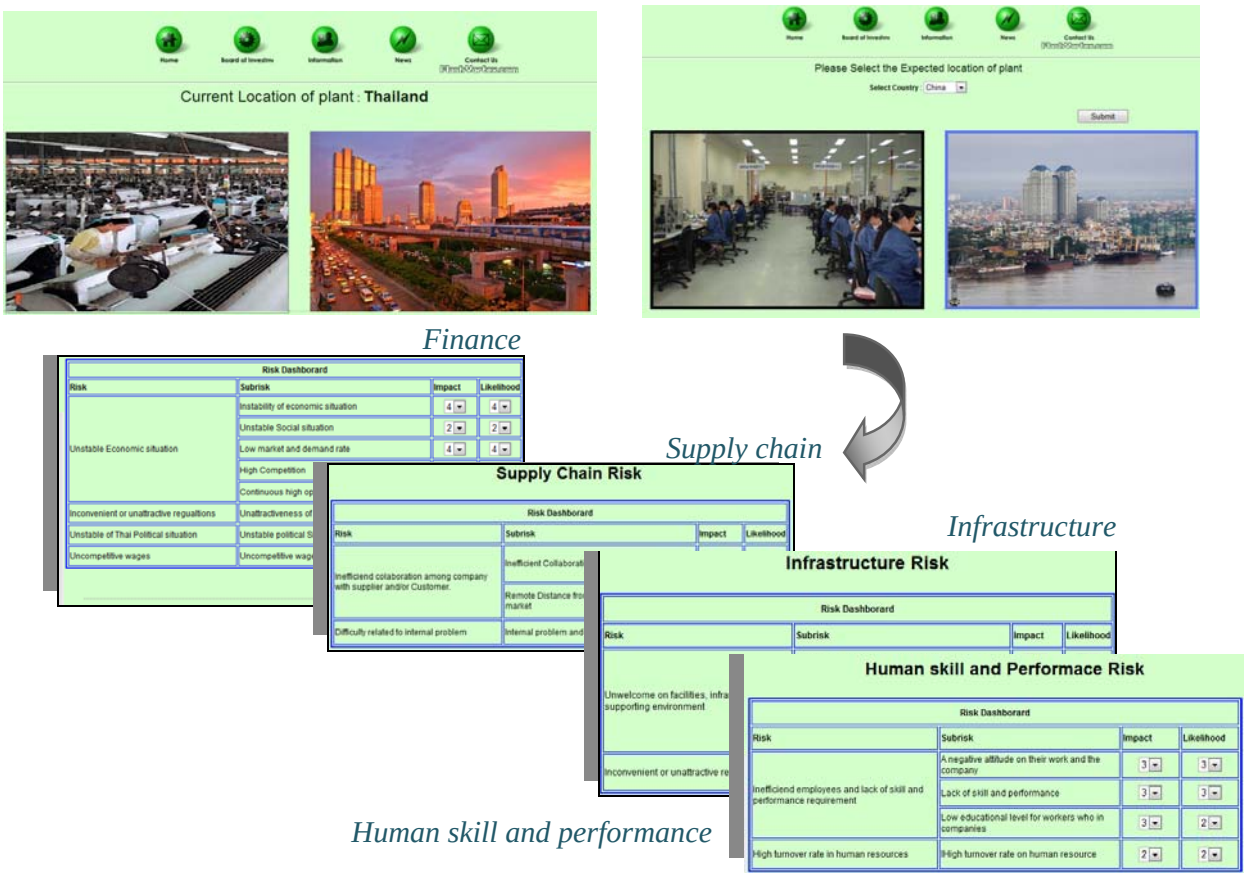


Figure IV.18: User interface on dynamic analysis

In addition, not only the major function required to obtain the results but also provide supporting information to investor as shown in the Figure IV.19. The KBDSS provide useful supporting information on the three main requirements of infrastructure, cost of doing the businesses and human resources, mainly from the three countries: China, Vietnam and Thailand.

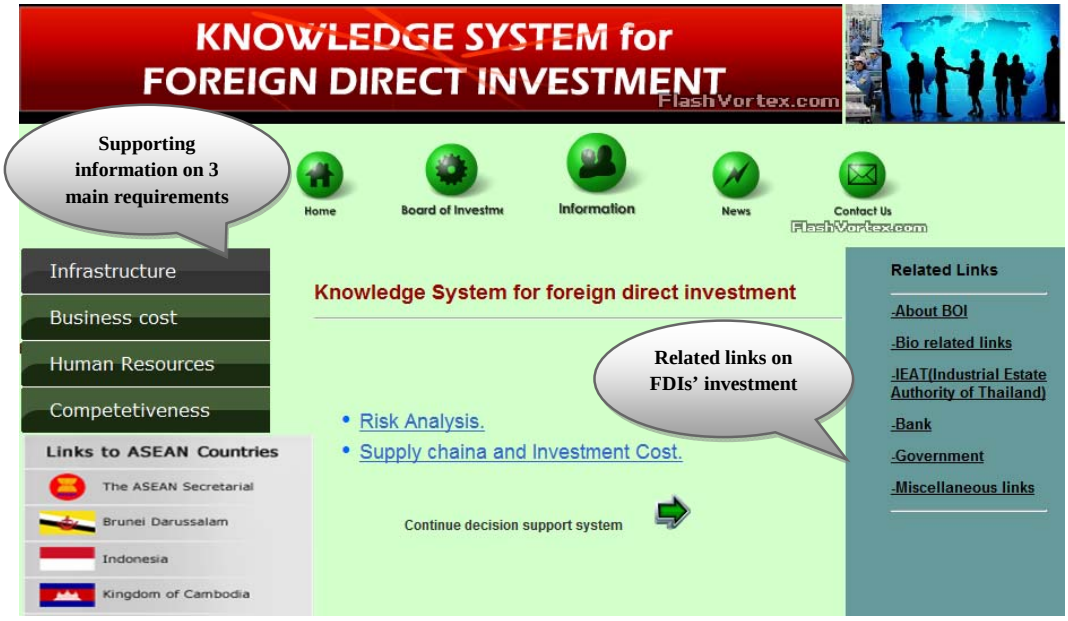


Figure IV.19: Main homepage of the KBDSS

IV.6. Conclusion

In summary, this chapter shows the application and obtained results from our proposed framework. The application of our knowledge based supporting system is mainly developed by integrating functions of the risk evaluation and the supply chain simulation according to the proposed methodology. This knowledge based system is performed on the web application using PHP and JavaScript language as the developing tool. However four components of: a user interface, database, model base, and a procedure, are the main parts required for constructing the system. Besides, the results from the knowledge based system can help decision makers who are facing with business crises, make a good decision on the investment of plant by suggesting the possible scenario of existent situation of plant and estimating supply chain cost of investment. Thus next chapter, we will apply the application of our research framework to a case study. The application will be demonstrated by using scenario from manufacturer in Lumphun Industrial estate area, Thailand.

Chapter V: Electronic Industry Application

V.1: Introduction

In this chapter we aim at validate a framework on investment of Foreign Direct Investments (FDIs) by interacting with Knowledge Based Decision Support System (KBDSS). This chapter demonstrates how the decision maker obtained the right decision to support the decision making of business in crisis by using KBDSS. The first part of this chapter, we will describe the background of the Northern Region Industrial Estate, Lumphun, Thailand, which is the area of our case study. However, the manufacturer in electronic sector is the main focus group of our case study. In the second part, the business situation of our case study will be represented in terms of the company profile, organizational structure and characteristic of supply chain and infrastructure. Afterwards, in order to validate the proposed framework, we will demonstrate the system by applying the KBDSS to the electronics company. A scenario of “Divestment” which described on shutting down of plant will be used to explain how the useful framework is applied on making decision. Finally, discussion on the result of risk evaluation and simulation of investment cost will be represented.

V.2: Background of Northern Region Industrial Estate, Thailand

At present the industrial estate authority of Thailand (IEAT) has established 34 industrial estates located in 15 provinces nationwide [Industrial estate overview BOI, Thailand 07]. One of those industrial estates is located in Northern part of Thailand which is a major industrial area of the Lumphun province. In 2008, the average income of the population in this area was reached 161,846 baht per person per year. This amount was the highest rank of the Gross Regional and Provincial Products (GPP) per capita of the North (Office of the National Economic and Social Development Board, June, 30 2009). From the recent evidence, GPP in 2009 of this area showed earning per capita from non-agriculture sector,

was higher almost 10% than agriculture sector (54,272 in Non-Agricultural and 5,550 in Agricultural sector). Moreover, earning from industrial labor wages is a key factor driving the province's economic growth.

The Northern Region Industrial Estate in Lumphun was established in April 1983, as a result of the Thai government policy to decentralize industry into rural regions. In 2008, there were at least 60 factories in this area, with around 20 factories operating in the general zone, and over 40 factories in the exporting processing zone. Industries in the general industry zone are focused on agribusiness, food, garment, metals, and other products. In the exporting processing zone, electronics factories are mainly based. In 2008, 60,000 workers were employed in this area. Of all workers, 80% work in electronics factories. Around 70% of all the workers working in the area are women, most of them aged between 18 and 25 years. Due to the global economic crisis, this situation has led to reductions of the workforce [Financial assistance of the European Union 09].

Recently, 924 factories were operated in the province [IEAT 10]. Of the total factories operated, seventy-five factories have been established in this industrial estate. As shown in Figure V.1, most manufacturing products or about 35 % are electronics, parts of machineries and equipments is 24%, food product is 15% and 26% is other type of manufacturing. 49,048 workers work in this area [Northern Region Industrial Estate 08].

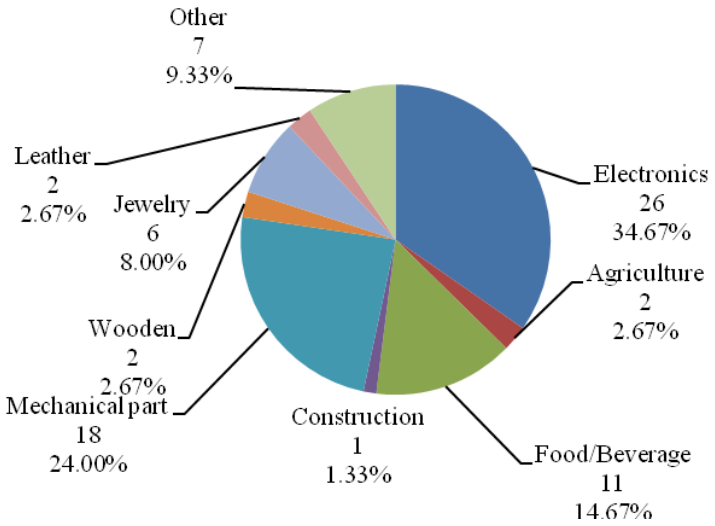


Figure V.1: Ratio in overall type of industries in Northern Religion Industrial Estate, Lumphun province, Thailand

Within the total amount, 28,541 workers work in electronic factories, which is over half of the entire workers in this area. Ratio of workforce on each type of industries in the area is show in Figure V.2.

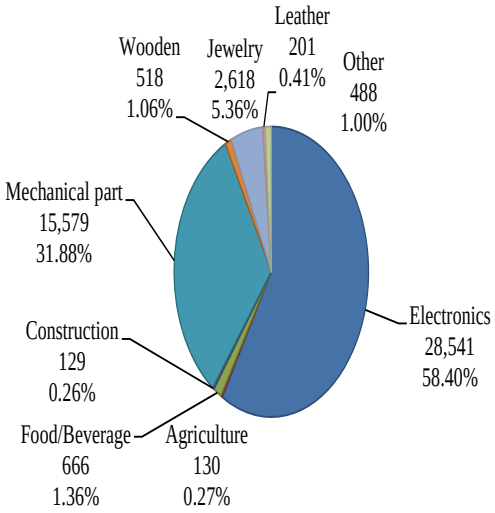


Figure V.2: Ratio of workforce on each type of industries in Northern Religion Industrial Estate, Lumphun province, Thailand

Considering on electronic sector, the main investors are Japanese, which is about half of the entire nationality operated in electronics area. While the investors from united state, South Korea, Switzerland and Taiwan are the secondary group. Furthermore, there are four joint venture companies with the Japan, which is also the most proportion, United State, South Korea, Netherland, Hong Kong, Singapore, China and Thailand.

From statistical data mentioned above, we have seen that electronic industrial is the major role operating businesses in this industrial estate area. Generally the influenced external factors that affect the electronics sector are as follows: (1) the structure of the electronics sector is oligopoly but its production's network is worldwide; (2) the multinational corporation has increased its investment in China; (3) the non-trade barriers on environment protection in importing countries have increased; and (4) the competition in the region to attract foreign direct investment has risen considerably. Besides, the natures of electronic characteristic are high technology, cost and investment. In addition skill requirement, continuous research and development, and intensive labor are needed. For these reasons, most of the electronics manufacturers in Thailand are depended on the Foreign Direct Investments (FDIs) in funding, implementing and technology transfer.

Thus in the next section, to understand the characteristic on the business crisis, we will explain the situation of our case study which is the electronic manufacturing sector.

V.3: Background of our case study

V.3.1: Case study characteristic and the company profile

The manufacturer which is our case study manufactured flexible circuits and assemblies to customers around the world from manufacturing base in Lumphun, Northern Thailand. However, headquarter which is located in the United state is the owner stakeholder. The factory is located on a Board of Investment (BOI), approved site within an export processing zone on the Northern Region Industrial Estate. The company first opened a manufacturing facility in Thailand in 1996 as part of a joint venture. In 1998, the company opened its own facility that also features many leading companies from around the world. The company had been involved in the flexible circuit industry for over 30 years and first opened in an export processing zone. Then the facilities also located in Mexico, Arizona, Minneapolis, UK, and China. This company has offices and representatives throughout the world with design and technical support available to help the customers design a flexible circuit that gave them a competitive advantage as shown in Figure V.3.



Figure V.3: Location of offices and representatives supporting the company

The manufacture of a flexible circuit is the main product introduces from the company. The manufacture of a Printed Circuit Board (PCB) involves many different processes and is quite different among each model. Figure V.4 shows the main product of PCB.



Figure V.4: Examples of Printed Circuit Board (PCB) from the case study

V.3.2: Structure of organization

The organizational structure of the company represents the president and Chief Executive Officer (CEO) was responsible for the company' global operations network and oversees operations at its four factory sites including production, supply chain, process engineering, quality facilities and other support functions. The general director is responded on each department unit. Most of the director and chief of the department were foreign workers. Besides, the total numbers of employees are more than 1000 people.

However, on January 2008, the company faced with business crisis since a fiscal first-quarter loss of $7.9 million, or 41 cents a share, including restructuring charges. That compared with a loss of $6.3 million, or 33 cents a share, a year ago. Net sales dropped to $20.8 million, from $26.0 million in the year-ago quarter. Thus its board would explore strategic alternatives, such as raising capital, a recapitalization and sale of the company [Reuters 08]. These situations led to overall lost in the profit margin of the company due to pricing and high operational costs and debts. Thus its board would explore strategic alternatives, such as raising capital, a recapitalization and sale of the company. In addition, we also sent the questionnaires to engineers who worked in this company, they said that boards of the company sent the noticed letters to all employees warning about the business situation and forced employees to resign. Besides, the payment terms cannot pay to the suppliers according to the defined schedule. Further no more shipment delivered to the customers. In terms of the infrastructure cost, the company was unable to pay utilities bills since the business faced with the crisis. However, at the beginning of the crisis, salaries were paid to employees 75% of total. Afterwards, no more payments allow to them.

V.3.3: Supply chain characteristic

The company exports products direct from Lumphun location site using Chiang Mai International Airport, a mere 30 minutes away. There are several product types and demand rate from customers. Since the main product is the flexible circuit using for mobile phone. Thus most of the customers are from Shanghai, China. Raw materials are provided from both local factories and foreign countries. In order to reduce inventory and increase the level of customization, the company has designed the production systems to produce a product only after it is ordered. Such system referred to Make-to-Order (MTO). However, considering on the strategy of Make to order system (MTO), relative factors are considered when evaluating the prospect of MTO.

- Firstly, “Customer patience” that means customer able to wait for a custom product to be manufactured and delivered or not. If not, the cost of losing the customer to the competition is the margin on the product, and causing to the customer may switch to the competition on the future purchases.
- Secondary, in case of holding cost of stocks are estimated to be a main cost in operation. MTO eliminates the problem of stock outs. Thus, this strategy becomes more attractive as reducing in relative large cost associated with overall costing.
- Thirdly, since the product is modular, the inventory costs from components can be reduced.
- Fourthly, manufacturing lead time is also importance since infeasible system causes longer lead time and customers are not willing to wait.

Due to demands from customers are high levels of variety, process of customer review on cost and finance are inefficient. Besides, the direct costs of a poor product start up include scrap, late deliveries, expediting the flexible circuit’s process includes design, mock up and prototyping. Thus process capability was not aligned with customer requirement. These situations had resulted to the turbulence on supply chain. In addition the prospect of MTO, disruption on supply chain directly affects to customization. Thus supply chain disruption as well the turbulence on business crisis, affected to crucial circumstances of the company. Afterwards the company failed to pay outstanding debt for its suppliers which led them stopped providing the material for manufacturing processes. Finally the company has announced that its subsidiary, as well has filed a rehabilitation petition under Thailand law. The petition was dated and filed on March 30, 2010[Business Wire 10].

V.4: System validation

In this section, we will apply the proposed KBDSS to the company which we explained the situation in previous. It is to provide the right information and support the decision on business crisis. Besides, our KBDSS is introduced to this company for validating our integrated framework by focusing on two issues i.e. risk evaluation and cost simulation.A scenario of “Divestment” which referred to withdrawal of plant is used to validating our framework with this company. We obtained firstly; the case study shows how to adopt the KBDSS for obtaining on the supporting information. Secondary, the obtained outcomes from each stage of analysis will be examined. We then apply obtained data to validate the system by sending the questionnaires to staffs who worked in this company. However, all required values are not allowed to provide from them. Therefore, we also discovered all requirements from the other reliable source such as, local organization of industrial estate, Thai government organizations and public agencies, chambers of commerce, and Ministry of labor. That information is needed to complete our validating system. Next we will clarify the scenario by applying real case to our KBDSS.

V.4.1: Static analysis: Risk Knowledge Matrix decision

The starting point of applying the system with the case study is that the decision maker determines general information of the company profile. On the previous section, we described about the case study, the share holder is only American. Besides, employees who worked in the company are more than 1,000 people. Thus, this step is in order to accumulate the background and status of the company which will be used as the referenced knowledge base compared with other. Figure V.5 is represented the interface to collect values of company profile.

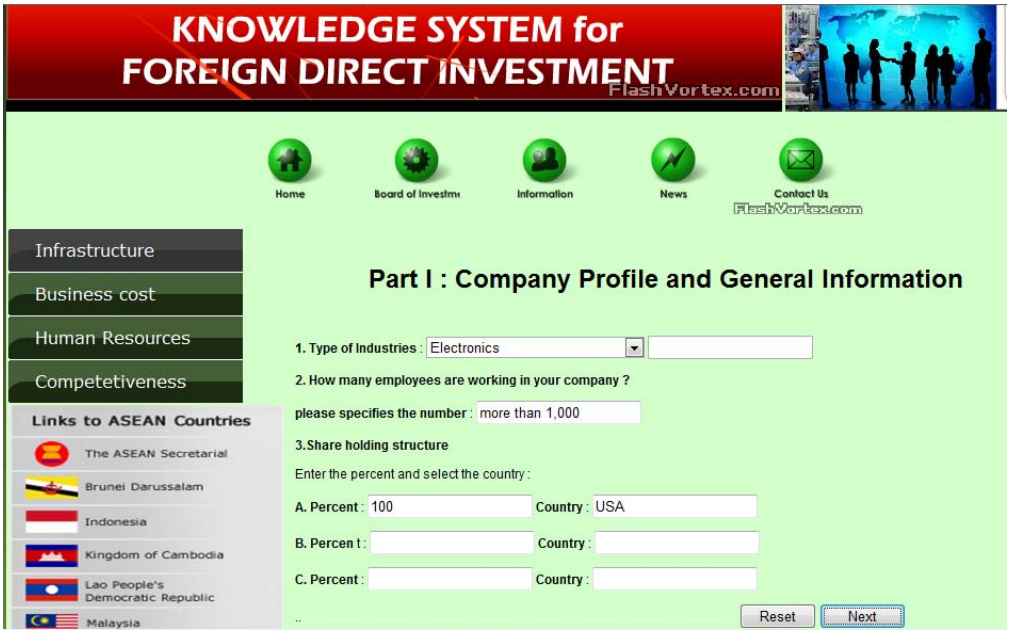


Figure V.5: Input values of the company profile

Thus, the first evaluation of risk focuses on financial and economic situation. The decision maker fills the value of impact and likelihood. All financial sub risks are identified. From the situation of the company, the decision maker ensures that the "Continuous high operational cost and loss the profits" is weighted as the most critical issue on this context see Figure V.6. The following risk dashboard displays those values of impact and likelihood corresponding to the risk and sub risk issues.



Figure V.6: Financial risk dashboard



Figure V.7: Supply Chain risk dashboard

In the supply chain point of view, the critical evaluation is mentioned on “Internal problem and organizational change”. The issue is provided impact at “4” and likelihood at “5” as shown in Figure.7. It is explained as the difficulties in communicaton and collaboration along the internal procedures and processes, for example, the review process on product design and price confirmation from customers are ineffectiveness, as well as uncertainty and delay of demand forecasting. The disruption is also resulted to inefficient collaborate among partners along the supply chain in the company.

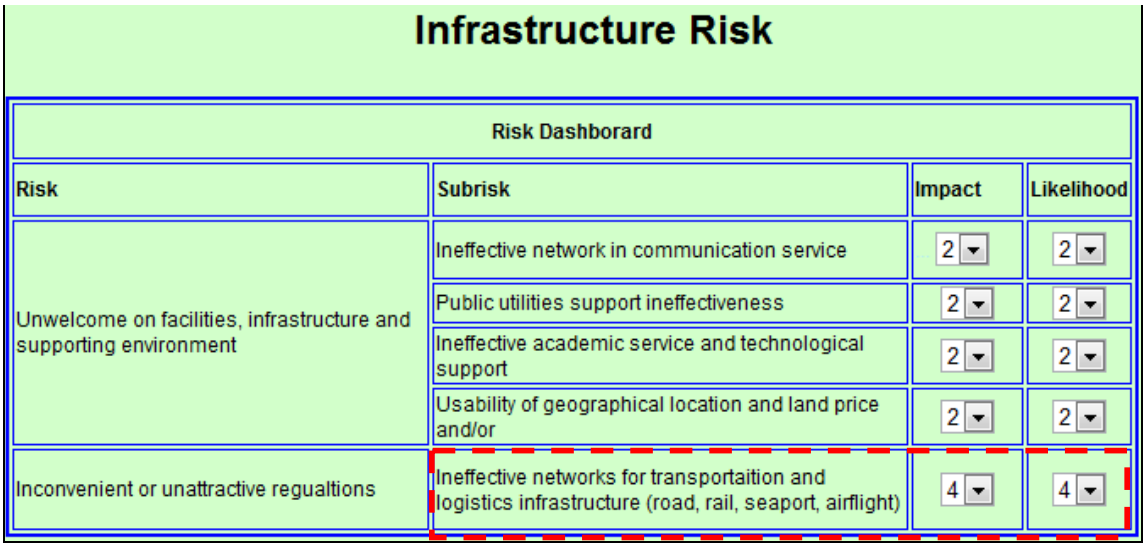
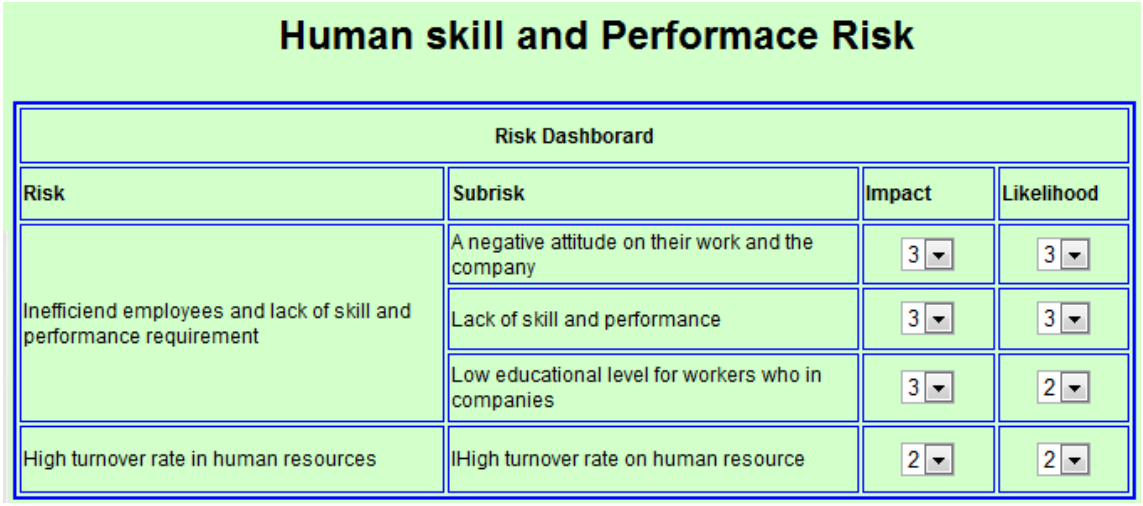


Figure V.8: Infrastructure risk dashboard

However, Figure V.8 shows networks of transportation and logistics infrastructure, for example, road, rail, port and air freight channel are claimed on inconvenient and sufficient

issues. This reason disrupts the distribution along supply chain network. Further, decision maker weights on this issue as major impact factors and probably occurring to the company.



Human skill and Performace Risk

Risk Dashborard			
Risk	**Subrisk**	**Impact**	**Likelihood**
Inefficiend employees and lack of skill and performance requirement	A negative attitude on their work and the company	3	3
	Lack of skill and performance	3	3
	Low educational level for workers who in companies	3	2
High turnover rate in human resources	IHigh turnover rate on human resource	2	2

Figure V.9: Human skill and performance risk dashboard

Consequently, the results show the comparison on the four perspectives by comparing with the risk value in the knowledge based system as shown on Table V.1. From the table, we have been noticed that the company has face on the critical of financial and economic situation. Since risk exposure shows as there are four of risk level in significant. However, supply chain and infrastructure are also crucial due to “Internal problem and organizational change”, “Ineffective network for transportation and logistics infrastructure” are also referred as critical in risk level to the case study.

	Risk perspective	Risk detail	Sub risk	Sub risk detail	Impact	Likelihood	Risk exposure	Risk level
1	Labor skill and performance	Lack of skill labor and requirement	Insufficient employee and lack of skill and requirement	A negative attitude on their work and the company	3	3	9	Medium
				Lack of skill and performance	3	3	9	Medium
				Low educational level for workers who works in companies	3	2	6	Low
			High turnover rate in human resources	High turnover rate on human resource	2	2	4	Low
2	Financial and their environment situation	Financial problems	Unstable economic situation	Instability of economic situation	4	4	16	Critical
				Unstable social situation (democratic system of the country)	2	2	4	Low
				Low market and demand rate	4	4	16	Critical
				High competition	4	4	16	Critical
				Continuous high operational cost and loss profits	5	5	25	Critical
			Unstable of Thai political situation	Unstable political situation	3	3	9	Medium
			Uncompetitive wages	Uncompetitive wages of skilled labor	3	3	9	Medium
			Inconvenient of unattractive regulations for company	Unattractiveness of laws and regulations	2	2	4	Low
3	Supply chain and Infrastructure situation	Supply chain ineffectiveness	Inefficient collaboration among company with supplier and/or customer	Inefficient collaboration among partners	3	3	9	Medium
				Remote distance from supplier and product market	3	2	6	Low
			Difficulties related to internal operations	Internal problem and organizational change	4	5	20	Critical
		Facilities and infrastructure ineffectiveness	Insufficient on facilities, infrastructure and supporting environment	Ineffective network in communication service	2	2	4	Low
				Public utilities support ineffectiveness	2	2	4	Low
				Ineffective academic service and technological support	2	2	4	Low
				Unsuitability of geographical location and land price and/or land lease	2	2	4	Low
			Inconvenient logistics	Ineffective network for transportation and logistics infrastructure	4	4	16	Critical

Table V.1: Results from risk evaluation

Thus system summarizes the outcomes by comparing risk exposure with the risk value in knowledge based system. Then the scenario is suggested the possible status plant to "Divestment" shown as the following Table (Table V.2).

	Risk perspective	Risk detail	Risk exposure	Risk level	Status
1	Labor skill and performance	Lack of skill labor and requirement	**7**	Medium	**Divestment**
2	Financial and their environment situation	Financial problems	**12.38**	Critical	**Divestment**
3	Supply chain and Infrastructure situation	Supply chain ineffectiveness	**11.67**	Critical	**Relocation**
		Facilities and infrastructure ineffectiveness	**6.4**	Low	**Divestment**
			Suggested scenario		**"Divestment"**

Table V.2: The suggested scenario of the case study

Thus, the KDBSS gives the suggesting information of critical and high risk value as shown in Figure V.10. From the case study, three critical risk categories: finance, supply chain and infrastructure show the risk exposure into three levels of risk for Critical, Medium and Low level. As we referred previous about the situation of the company, thus the most critical risk value is referred to financial problems and second is supply chain ineffectiveness. Lack of skills labor and the negative attitude of workers in the companies is also the third priority leading to the situation. Further, infrastructure effectiveness is accepted from decision maker having less influence to crisis in the company.

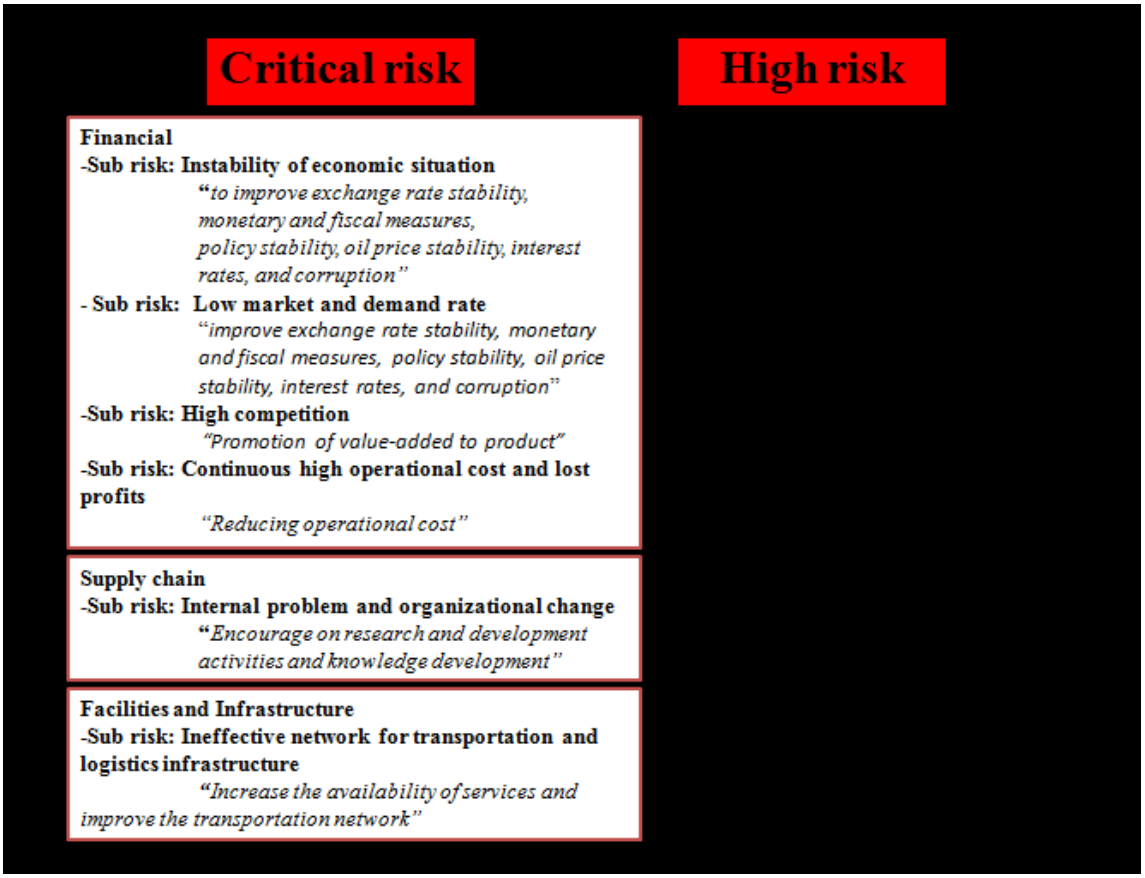


Figure V.10: Suggesting information on Critical and high risk value

This type of analysis is useful to suggest the possible situation of existing plant to the decision maker. Finally, the results from our case study, suggest to the situation of "Divestment" plant, which refers to closing plant or withdrawal of plant. Since the highest of risk level (See Table V. 1) focuses on the turbulence of financial and economic situation, which represents the critical level of sub risk from "instability of economic situation", "low market and demand rate", "high competition" and "operational cost and lost profits". Also the secondary of risk level refers on the supply chain ineffectiveness. The relative sub risks lead to the suggested situation mainly mentioned to the "internal supply chain problem and organizational change". However, the outcome of suggested situation of plant also ensures that our Risk Knowledge Matrix decision can use as the guideline knowledge on risk evaluation. Since from the recent evidence, the company has temporarily stopped the operations and no more employees work in the company. Besides, on March 30, 2010, the company filed with the Central Bankruptcy Court in Thailand, a voluntary rehabilitation petition under the Bankruptcy Act for Business Rehabilitation in accordance with Thailand Law [Financial News 10].

Afterwards, to continue the cost simulation on future investment, the decision maker will continue in the following part on cost simulation in dynamic analysis.

V.4.2. Dynamic analysis: Cost simulation

On this section, the cost comparison among two site location will be analysed. Then the decision maker starts with completing the values of operational processes based on process definition of Supply Chain Operations Reference Model (SCOR). The site location on existing plant, Thailand, is firstly identified. Afterwards, the secondary site location will be selected among the country of China and Vietnam. However, in this case study we select the Vietnam comparing with Thailand. Thus, the process of Plan, Source, Make, Deliver and Return, require parameters to complete simulation of each selected site location. As we described in previous, all those parameters are not allowed to provide from the case study. Then we discovered more on relative information from publishing articles and information provided from government, which are summarized in the table below.

Business cost	Thailand	Vietnam	Comparison
Labor worker			
Minimum labor wage ([MOL 09], [FIA Vietnam 10])	160 baht/day (130 USD/Month) (Lumphun province)	55 USD/Month	Thailand > Vietnam about 58% (2.4 times)
Working time ([BOI 10], [FIA Vietnam 10])	48 hours/week	48 hours/week	Equivalent
Utilities			
Average basic electricity tariff for industry (US dollar) [Puree 08]	5.09 $US	7.865 $US	Industrial electrical power in Vietnam is not satisfied comparing to Thailand
Water bill (for industrial production [Businee in Asia 10], [BOI 09]	0.46 USD/m3 (up to 201 m3) 10 Year deduct as tax incorporate	0.28 USD/m3 Varied depending on location	Thailand > Vietnam about 26% (1.64 times)
Land cost [IEAT 09	3,500,000 Baht/rai = 2,187 Baht/m^2	High land price land is now $2,000 (70,000 baht) per square meter	Vietnam > Thailand 96.87% (32 times)
Logistics transportation			
Port (major ports and terminal on basis of the	4 ports (Good) Rank 37	3 ports (Fair) Rank 89	Thailand have better sea freight network

amount of the cargo)			than Vietnam
International air transport network	Rank 41	Rank 76	Thailand have better airfreight network than Vietnam
Freight cost [Logistic Digest 10]	41.48 USD : Ton 20% of GDP Above 100kg: 7 ($US)/kg	20% - 25% of Vietnam's GDP Above 100kg: 15($US)/kg	Vietnam has more than 800 logistics businesses but most of them are small and medium-sized enterprises with limited capacity, expertise, and competitiveness.

Table V.3: Investment cost comparison on Thailand and Vietnam

- **Average of labor wage**: Vietnam is the cheapest labor rate in the South East Asia region followed by Cambodia and Thailand. Untrained Vietnamese workers pay rates about 65% cheaper than Thai wages. Since minimum wage of Thai labor in the case study area is 160 baht per day (130 USD/Month), Vietnam is 55 USD/Month. Although the figure is admittedly crude, it confirms that labor is cheaper in Vietnam than in neighboring countries. In practice, wage rates vary widely from company to company depending on the workers' experience, their skills and their ages [FIA 10].
- **Infrastructure:** The course of Thailand's electricity industry development has set forth a goal of greater efficiency, both on the supply side and demand side [BOI 10]. Comparing to Vietnam, it is rapidly catching up with its neighbors in terms of availability and cost of services. Still, enterprises in Vietnam complain about insufficient transport infrastructure, and excessively expensive electricity and telephone services [Vietnam Trade Office in the USA 10].
- **Logistics channel:** Thailand is a strategic location and serves as a gateway into the heart of Asia which is today the largest growing economic market. The country also offers convenient trade with China, India and the countries of the Association of Southeast Asian Nations (ASEAN), and easy access into the Greater Mekong sub-region, where newly emerging markets offer great business potential. According to a new market research report from Transport Intelligence. Laem Chabang port, located in the eastern part of Thailand, is one of the highest (tranding) growth rates in the

world. Besides, major international airports include Suvanabhumi, the new airport which can support of 3 million tons of cargo per year. In Vietnam, logistic inftrastructure is reported as «Fair » [CIA 10]. The demand for freight transport via air is expected to increase sharply. Two internation routes to China are available from Hanoi through Lao Cai and Dong Dan without cargo transfer. However, higher utilization of Lao Cai to Hanoi section is unable to respond to the increase demand and future requirements for cargo transfer at the China. Whereas Logistics 2009, high logistics costs are responsible for holding back the development of the Vietnamese economy. Logistics costs are estimated to be 20% - 25% of Vietnam's GDP, far higher than those in developed economies such as the US and higher than in other developing economies such as China. These high costs have hampered Vietnam's efforts to take advantage of its cheap labor resource and develop the national export economy. Overall, it can be said that the speed of infrastructure development in Vietnam is much slower than that in its neighbour and rival [Manila Bulletin 09]. In this case study, route from the company to China is the main logistics distance. In regard to location of plant among Thailand and Vietnam to China, distance is not much difference. Since distance from Thiland to China is approximately 2,248 km, while from Vietnam is approximately 2,461 km. The Figure V.11 shows the estimated distance from Thailand and Vietnam to China. Thus cost of the logistics network is a competitive factor to be considered for the case study.

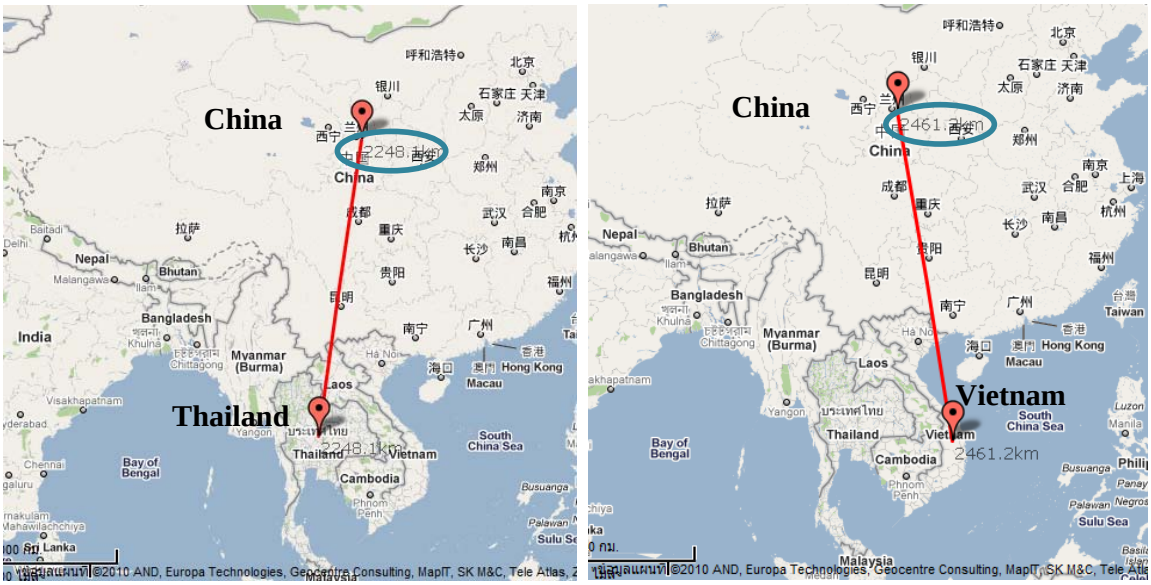


Figure V.11: Comparison between distance from Thailand and Vietnam to China

Consequently, to examine supply chain cost simulation, defining cost and parameters of Source, Make, Deliver and Return through the interface are obtained for the simulation. Those values are represented as shown in Table V.4.

PLAN	**Thailand**	**Vietnam**
Real interest rate (%)	**12%**	**12%**
Sales Price (Baht/unit)	**275**	**275**
Initial Investment cost (Baht)	**4, 000 ,000**	**5,500,000**
SOURCE		
Raw material ordering:		
- Batch order (Unit)	2,000	2,000
-Reorder level (Unit)	1,000	1,000
-Cost of ordering (Baht)	1,000	1,000
-Deliver Time between supplier and manufacturer (Day)	1	**2**
- Initial raw material stock	1,500	1,500

(Unit)		
Warehouse management:		
-Holding cost (Baht)	10	10
-Cost of raw material (Baht/unit)	125	125
Raw material receiving:		
Time of Receiving process (mins)	10	10
Time of Verifying process (mins)	10	10
Time of Transferring to Warehouse (mins)	10	10
MAKE		
Manufacturing process lead time:		
- Labor cost (Baht)	**160**	68
- Issue raw material to produce (mins)	10	10
- Produce and test (mins)	10	10
- Packaging (mins)	10	10
- Transfer to warehouse (mins)	30	30
Additional cost:		
%Scrap	0.01	0.01
-Scrap cost per item (baht)	5	5
Overhead cost:		
- Water (Baht)	25,200	20,000
- Electricity (Baht)	100,000	**154,520**
- Land (Baht)	200,000	393,740

DELIVER		
Deliver process per unit:		
- Delivery process (mins)	15	15
-Delivery time between manufacturer to customer (days)	1	**1.5**
Freight cost:		
- Freight cost of raw material (baht)	15	**35**
- Freight cost of good (baht)	22	**45**
RETURN		
Non-conforming material:		
- % non conforming material (%)	0.001	0.001
- cost of non-conforming material (baht)	5	5
Non-conforming good:		
-% non-conforming good	0.001	0.001
-Cost of non-conforming good (baht)	7	7

Table V.4: Parameters use for Source, Make, Deliver and Return on cost simulation

From the Table V.4, we estimate required values for model execution of Source, Make, Deliver and Return. However our estimation aims at analysing on cost of supply chain and infrastructure on two site location. Thus in terms of manufacturing processes, values are about similar. The exception is mentioned on labor cost. Regarding to the case study, minimum labor wage is 160 baht/day while labor wage of Vietnam turning to the Thai baht is approximately 68 baht per day. This amount is less than labor cost in Thailand for double. Besides, land cost in Vietnam is sharply high. Thus we assume land cost of Vietnam is 393,740 baht per month which is higher than Thailand almost twice. As well as the cost of electricity is quite expensive than Thailand what we assumed that Vietnam is 154,520 baht

per month which is higher than Thailand in half-price. Besides, the logistics channels are still insufficient in Vietnam. Thus we also determined logistic cost of Thailand is more preferable than Vietnam. For example, transit time from supplier to manufacturer and manufacturer to customer of Thailand are both 1 day which are 2 and 1.5 days respectively comparing to Vietnam.

Further, we put required value on Plan, Source, Make, Deliver and Return processes based on SCOR through the interface as shown in Figure V.12. Those values are required for both two site locations which in this case study is referred to “Thailand” and “Vietnam” sites. Thus in order to provide supply chain and investment cost for decision maker, our supply chain simulation is executed.

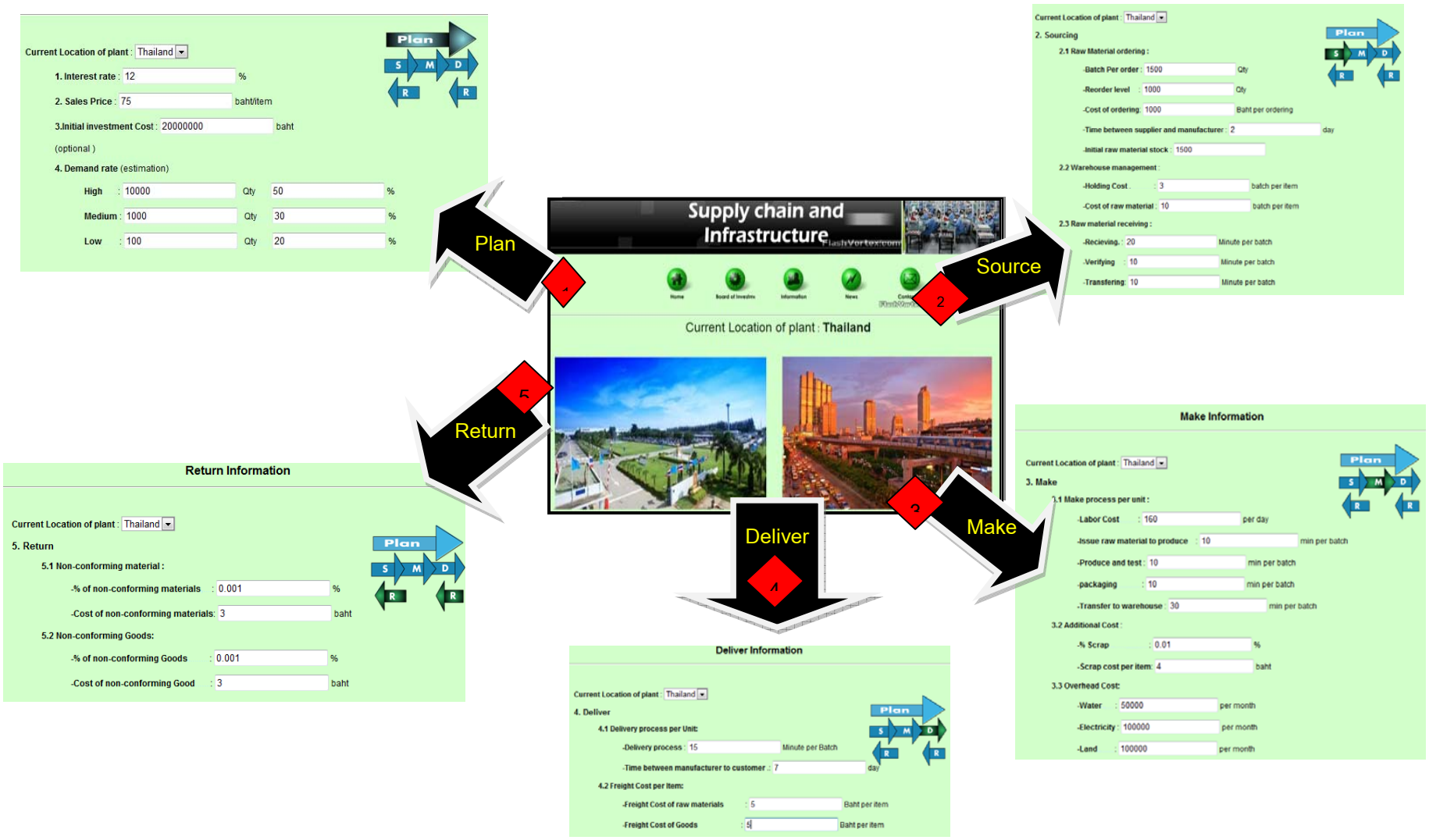


Figure V.12 User interface of supply chain cost.

The outcomes from running Arena software simulation are conducted to estimate the cash flow and NPV among two site locations, Thailand and Vietnam. The simulation runs for 10 replications of the 360,000 minutes run length or 250 working days of one year from Arena software simulation. Finally, the one-year outcomes are obtained to decision maker through excel spreadsheet. The Figure V.13 shows one-year supply chain cost of Thailand site.

Output -->10 Replication	InProcess(Status=3)	6808100
	FGinWH(status=4)	5717100
	FGShip(status =5)	5537000
	FGtoCus(Status=6)	5530500
	Count no. of delivery	1876
	ScrapMake	571
	No.of cus receiving FG	1874
	Count no.ordering RM	2380
	Sum orderRM	6816000
	AverageRM	22336.36364
For 1 replication	InProcess(Status=3)	680810
	FGinWH(status=4)	571710
	FGShip(status =5)	553700
	FGtoCus(Status=6)	553050
	Count no. of delivery	187.6
	ScrapMake	57.1
	No.of cus receiving FG	187.4
	Count no.ordering RM	238
	Sum orderRM	681600
	FG complete in WH	571652.9
	FG complete ship	553642.9
	FG complete to Cus	552992.9
	FG complete Cus accepted	552439.9071
	Current WIP	109157.1
	OnHandFG	18010
	Avg.InventoryRM	22336.36364
	Current Source return volume	681.6
	Current delivery return volum	552.9929
	Rejected Return RM	0.001
	Rejected Return FG	0.001
	Rejected Make	0.01

Source cost	**Cost Detail**		
Shipment cost	count RM receive from sup.	681600	
+	Freight cost RM per item	15	10224000
Ordering cost	No. of RM order Qty	238	
+	Ordering cost	1000	238000
Holding cost	Avg. inventory level	22336.36364	
	Holding cost	10	223363.6364
Total Source cost			**10,685,363.64**

Make cost	**Cost Detail**		
Direct mat cost	Material used qty	680810	
+	Material cost	125	85101250
Direct labor cost	no. of labor used*	500	
+	Labor cost per day	160	
	250 day per year	250	20000000
indirect cost	utilities cost…per month (or	325200	
+	12 months per year	12	3902400
Additional cost	scrap cost per unit	5	
	Sum of scrap	57.1	285.5
Total Make cost			**109,003,935.50**

Delivery cost		
Freight cost FG	22	
Total no. of FG delivery	553642.9	
Total Delivery cost		**12,180,143.80**

Return cost	**Cost detail**		
Disposition of defective p	cost of rejected material	5	
+	count RM_receive from supp	681600	
	%RM_rejected	0.001	3408
Return FG cost	Cost of rejected FG	7	
	No.of Rejected FG from cus	552.9929	3870.9503
Total return cost			**7,278.95**

Figure V.13 one-year cost of supply chain for site location in Thailand

From Figure V.13 output from 10 replication provides parameters, for example, work in process, finished good in warehouse, shipment and scrap quantity, which were used to manipulate into supply chain cost based on SCOR: Source, Make, Deliver and Return. However, to clarify each cost following the supply chain SCOR process, we also summarize those cost by comparing results amongThailand and Vietnam sites as following tables (Table V.4, V.5, V.6, V.7).

Source cost		Thailand		Vietnam	
Cost issue	**Cost detail**	**Parameter**	**Total cost**	**Parameter**	**Total cost**
Shipment cost	Count RM receive from supplier	681600		618800	
+	Freight cost RM per item	15	10224000	35	21658000
Ordering cost	No. of RM order Qty	238		217	
+	Ordering cost	1000	238000	1000	216900
Holding cost	Avg. inventory level	22336.36		21536.36	
	Holding cost	10	223363.6364	10	215363.6364
Total Source cost			**10,685,363.64**		**22,090,264**

Table V.4: Source cost of Thailand and Vietnam site

Firstly, Table V.4 shows the results from supply chain cost simulation between Thailand and Vietnam. « Source » cost are consisted of shipment cost from receiving raw material from suppliers, ordering cost of requesting for raw material and holding cost of raw material in stock. Comparing with among two site locations, source cost of Thailand is less than Vietnam, due to the sufficiency and availability of transportation and logistics in Thailand are more superior and cheaper freight cost than Vietnam site.

Make cost		Thailand		Vietnam	
Cost issue	**Cost detail**	**Parameter**	**Total cost**	**Parameter**	**Total cost**
Direct mat cost	Material used qty	680810		617930	
+	Material cost	125	85101250	125	77241250
Direct labor cost	no. of labor used*	500		500	
	Labor cost per day	160		68	
	250 day per year	250	20000000	250	8500000
Indirect cost	utilities cost per month (or year)	325200		568260	
+	12 months per year	12	3902400	12	6819120
Additional cost	scrap cost per unit	5		5	
	Sum of scrap	57.1	285.5	53	266
Total Make cost			**109,003,935.50**	617930	**92,560,636**

Table V.5: Value of Make process for Thailand and Vietnam

Secondary, in terms of cost from « Make » process (Table V.5), labor cost of Vietnam is less than Thailand about 2.5 times. Although, watering cost of Thailand is still expensive, however total cost of utilities is lower than Vietnam resulting from higher electricity and land cost. Besides the manufacturing cost from Vietnam is still below than Thailand. For this reason, producing in mass production is more beneficial toVietnam country because of the main cost is mainly related to « Make » process.

Deliver cost	Thailand	Vietnam
Freight cost FG	22	45
Total no. of FG delivery	553642.9	520867
Total Delivery cost	**12,180,143.80**	**23,439,006**

Table V.6: Value of Deliver process for Thailand and Vietnam

Thirdly, we have noticed that «Delivery» cost (Table V.6) among location on Thailand and Vietnam is more remarkable than others. Since Vietnam is insufficient on logistic infrastructure which leads to higher freight cost up to twice.

Return cost		Thailand		Vietnam	
Disposition of defective product cost	Cost of rejected material	5		5	
	Count RM receive from supplier)	681600		618800	
	%RM rejected	0.10%	3408	0.10%	3094
Return FG cost	Cost of rejected FG	7		7	
	No.of rejected FG from customer	553	3871	513	3594
Total return cost			**7,278.95**		**6,688**

Table V.7: Value of Return process for Thailand and Vietnam

Lastly, « Return » cost (Table V.7), it is not directly affected on making a decision. Since internal process among both sites are similar. Thus the final results can not distinguish Thailand from Vietnam site.

However those outcomes from running simulation are represented in terms of one-year calculation. Thus to forecast future cost of investment, we explained in chapter IV (IV.5.2: Cost simulation), forecasting technique used for inflation rate and demand rate help to estimate cost of investment in the next 5 years'plan. Those forecasting values are performed by technique of moving average. Regarding to the revenue, it is caused from demand rate change which is influenced by each year changing of Gross Domestic Product (GDP). Consequently, the outcomes and technique used of five-year forecasting value of inflation and demand rate are presented in Appendix.D. Those forecasting values of GDP rate change of Thailand from year 2011 to 2015 are 7.56 %, -17.19%, -12.26%, 3.22% and -22.92% (see Table V.8). In terms of inflation rate, the value is influenced on expected return of investment

which we obtain the Net Present Value (NPV) by integrating inflation rate with the real interest rate. Afterwards, NPV for 5 years of investment plan is calculated based on the assumption of forecasting values (Rate change of GDP, Inflation rate) and initial supply chain cost from simulation. The following Table (Table V.8) is explained how excel spreadsheet is conducted to obtain NPV of Thailand site.

	Year						
Thailand	**0**	**1**	**2**	**3**	**4**	**5**	**Total**
Total revenue	**151,368,535**	162,811,995.76	134,828,683.99	118,293,294.18	122,102,338.25	94,116,482.33	783,521,329.05
Demand rate change		7.56%	-17.19%	-12.26%	3.22%	-22.92%	
Initial investment cost	4,000,000						
Total expenditure	**149,659,229**	160,973,466	133,306,152	116,957,485	120,723,516	93,053,686	681,619,848.24
-source cost (ordering + holding+ transporting cost of material)	24,317,364	26,155,756.33	21,660,235.71	19,003,824.40	19,615,747.55	15,119,818.21	125,872,745.83
-Make cost (Direct mat cost + Direct labor cost + indirect cost + additional cost)	100,420,656	108,012,457.06	89,447,816.00	78,477,935.85	81,004,925.38	62,438,596.48	519,802,386.26
-Delivery cost (Shipped finished good cost)	24,913,931	26,797,423.65	22,191,616.46	19,470,036.61	20,096,971.79	15,490,745.86	128,960,724.87
-Return cost	7,279	7,829.24	6,484	5,688	5,872	4,526	37,677.66
Net CF	-2,290,694	1,838,529	1,522,532	1,335,809	1,378,822	1,062,796	101,901,480.81
Interest rate (Thailand)	12%	12%	12%	12%	12%	12%	
Inflation rate (Thailand)		1.73%	3.03%	4.13%	3.93%	4.27%	
Real interest rate: (r-f)/(1+f)		10.092%	8.703%	7.554%	7.761%	7.417%	
NPV: NCF/(1+r)^n	(฿6,290,694.04)	฿1,669,997.62	฿1,288,504.53	฿1,073,642.19	฿1,022,481.63	฿743,168.38	**(฿492,899.69)**

Table V.8: Net Present Value for 5 year of investment plan, Thailand site

Comparing to Vietnam site (see Table V.9), the rate change of GDP are 12.87%, 8.72%, 3.09%, 0.00% and 11.98% and inflation rate are 5.13%, 6.03%, 7.33%, 11.05% and 11.33%. Finally, comparing the Net Present Value (NPV) for next 5 years of investment plan, the figures show NPV of Thailand is **(492, 899.69)** baht and Vietnam is **5,001,191.60 baht**.

	Year						
Vietnam	**0**	**1**	**2**	**3**	**4**	**5**	**Total**
Total revenue	**140,530,052**	158,616,270.23	172,447,608.99	177,776,240.11	177,776,240.11	156,478,646.55	983,625,058.47
Demand rate		12.87%	8.72%	3.09%	0.00%	-11.98%	
Initial investment cost	5,500,000						
Total expenditure	**138,096,593**	155,869,625	169,461,456	174,697,815	174,697,815	153,769,017	812,823,305.25
-source cost (ordering + holding+ transporting cost of material)	22,090,264	24,933,280.57	27,107,462.63	27,945,083.23	27,945,083.23	24,597,262.26	154,618,435.55
-Make cost (Direct mat cost + Direct labor cost + indirect cost + additional cost)	92,560,636	104,473,189.85	113,583,252.01	117,092,974.50	117,092,974.50	103,065,236.15	647,868,263.00
-Delivery cost (Shipped finished good cost)	23,439,006	26,455,606.07	28,762,534.92	29,651,297.25	29,651,297.25	26,099,071.84	164,058,813.34
-Return cost	6,688	7,548.49	8,207	8,460	8,460	7,447	46,810.38
Net CF	-3,066,541	2,746,645	2,986,153	3,078,425	3,078,425	2,709,630	170,801,753.22
Interest rate (Thailand)	12%	12%	12%	12%	12%	12%	
Inflation rate (Vietnam)		5.13%	6.03%	7.33%	11.05%	11.33%	
Real interest rate: (r-f)/(1+f)		6.540%	5.635%	4.356%	0.855%	0.602%	
NPV: NCF/(1+r)n	(฿8,566,540.94)	฿2,578,045.37	฿2,676,039.57	฿2,708,801.47	฿2,975,299.67	฿2,629,546.46	**฿5,001,191.60**

Table V.9: Net Present Value for 5 year of investment plan, Vietnam site

NPV	
Current location (Thailand)	**(492, 899.69) Baht**
Expected location (Vietnam)	**5, 001, 191.60 Baht**

Table V.10: NPV comparison of Thailand and Vietnam

Finally, Table V.10 shows the NPV comparison among two sites location of: Thailand and Vietnam. Even though the NPV presenting of Vietnam is more preferable than Thailand, there are relevant parameters that decision maker had to recognize. Such parameters are for example, labor cost which are increasing continuously and capability of skill labor. While Vietnam is more preferable of labor wages and availability of labor workers, but infrastructure of logistics and transportation are still in development. Thus the decision makers need to consider in long term investment according to their manufacturing characteristics. Furthermore, we also compare supply chain performance by measuring attributes and metrics based on SCOR as shown in the following table (Table V.11).

SCOR attribute and measurement

				Performance measurement	
Performance attribute	**Level 1 metric**	**Level 2 metric**	**Constraint factors**	**Thailand**	**Vietnam**
Reliability	Perfect Order Fulfillment	% of order delivered in full		**1.00**	**1.00**
Responsiveness	Order Fulfillment cycle time	Source cycle time		**0.65**	**0.70**
		Make cycle time			
		Deliver cycle time			
Flexibility	Upside supply chain flexibility, Upside supply chain adaptability,downside supply chain adaptability	Upside Make Flexibility (Upside Make Adaptability)	current on-hand WIP	**109,157.10**	**85,453.20**
		Upside Deliver Flexibility (Upside Deliver adaptability)	Current on hand FG	**18,010.00**	**11,610.00**
		Upside Source Return Flexbility (Upside source return adapability)	Current source return volume	**681.60**	**618.80**
		Upside deliver Return Flexbility (Upside deliver return adapability)	Current delivery return volume	**552.99**	**513.40**
Cost	Supply chain management cost, Cost of Goods sold	Cost to Source	Source cost	**125,872,745.83**	**154,618,435.55**
		Cost to Make	Make cost	**519,802,386.26**	**647,868,263.00**
		Cost to Deliver	Deliver cost	**128,960,724.87**	**164,058,813.34**
		Cost to Return	Return cost	**37,677.66**	**46,810.38**
Asset management	Cash-to-Cash Cycle time, Return on supply chain fixed assets, Return on	Supply chain revenue		**783,521,329.05**	**983,625,058.47**
		Cost of Good sold		**519,802,386.26**	**647,868,263.00**
		Supply chain management cost		**681,619,848.24**	**812,823,305.25**

Table V.11: Comparison on SCOR attributes and metrics among two site location

From Table V.11, we have remarked that the speed at which a supply chain provides products to the customer of attribute or attribute“Reliability”, delivery cycle time is shown as an influenced factor consequence order fulfillment time of Thailand is beneficial than Vietnam. Besides, the effectiveness of an organization in managing cost associated with operating the

supply chain of Thailand is also better than Vietnam. However, the agility of a supply chain in responding to marketplace changes (“Flexibility”), concerning volume of work in process, finished good and return product, Vietnam is the better place.

Thus, the decision maker who decide in long term investment, need to consider the relative parameters of competitive advantage which depends on each country characteristic. For example, Vietnam encourages investors by providing workforce availability as well as low labor costs in the long term investment. Besides, during the last 15 years, Vietnam’s GDP has grown at 7.5% per year on average and last year recorded of GDP growth as 8.2%. This growth rate is the world’s highest rate behind China. Moreover Vietnam continues to be a top choice because of the work ethic of its people, the relatively low labor and other costs and because of highly attractive government incentives and an improving legal and business environment. Further, the Vietnamese government has promised to provide all necessary infrastructures, including roads, water systems, and electricity for factories in promoted industries since infrastructure in Vietnam is claimed from investors as still insufficiency.

However, when factors such as long term consistent government pro-business policies, rule of law, right to own land (as opposed to lease), tax incentives and quality of life for foreign executive managers, Thailand looks like a very good choice. Besides, most firms in Thailand have over 30 years of experience producing for Japanese, European and North American companies. Quality is understood and adhered to. ISO quality standards and just-in-time shipping are well understood and predictable logistics chains are the norm and more easily documented. Vietnamese suppliers have less experience supplying foreign vendors, foreign company would be their first aid helping them in manufacturing quality. Although suppliers from the Pearl River Delta area, the Shanghai and coastal areas will have more experience but time required to reach quality levels is a business cost that needs to be considered.

Although, the NPV from Vietnam is more preferable than Thailand, considering in long-term Return on Investment, profits in the early years in Vietnam has proved illusive for many companies. Thus investors should not expect a return on investment in the first few years. Instead, they should focus on long-term potential.

Thus, to validate our proposed framework on FDIs’ investment, outcomes from KBDSS provide decision makers regarding to future cost of investment and risks evaluation for company situation.

V.5: Conclusion

In summary, this chapter demonstrated how KBDSS uses to provide the right decision to support the decision making of business in crisis. Two major analyses that facilitate the demonstration are risk evaluation and supply chain cost simulation. Since the situation of our case in electronic company has faced with the business crisis, for example, continuous loss in profits, high operational cost and debts, lately the company stopped the operation. Then the case study helped to validate our framework by providing required parameters to demonstrate the system on those two main analyses. Thus the result from the first analysis of risk evaluation represented that the possible situation of the case study referred to “divestment” which is the current situation affected this company. Afterward, the comparison on future cost investment among Thailand and Vietnam is illustrated by using NPV. The value present returns on investment for 5 years’ plan which will help decision makers decide the suitable site location of manufacturing plants. Further, supporting information for FDIs’ investment are necessary, since the comparative advantage of each country attract foreign investors to invest on the country. In this case study, the benefit on labor cost of Vietnam is more preferable than Thailand, however, logistics and transportation cost of Thailand is more advantage. Thus to consider in long terms of investment concerning with the main characteristic of plant, is more advantage.

Conclusion and Perspectives

The ultimate goal of this research is to help foreign investors or manufacturers make the right decision on their businesses by providing a tool validate the decision. There are three main requirements of: 1) supply chain and infrastructure, 2) financial situation and 3) human skill and performance, which have to be considered on FDIs' investment. Along the supply chain network on FDIs' investment, there are also three partners which are also the key success factors to make sustainable businesses. Therefore, our study is organized into five chapters. Each chapter focuses on different point of views in the study. The explicit results from each chapter are described as follows:

The **first chapter** aims at analyzing the business crises context and the need of FDIs for funding and implementing technology in developing countries. We have found that, especially in the electronic manufacturing sector, businesses depend on foreign investors to support both funding and resources. However, effectiveness in supply chain and logistics are more beneficial to this sector, as the structure of the electronic product network is international, and most electronic products are directly exported to the parent companies or their subsidiaries. Besides, intensive labor is one of the main characteristic required for electronic companies. Moreover, in order to help them make a decision on FDIs' investment, discovering the potential factors affecting business crises is crucial and we will obviously tackle this question. The literature review related to the influenced factors on FDIs' investment and the survey of questionnaires also confirm the three main requirements of: supply chain and infrastructure, financial situation, and human skill and performance. However, we also found that among the three potential factors, meeting stakeholders' standard plays a major role in creating and improving competitive advantages. The responding stakeholders are firstly the government and private sector of the Industrial Estate Authority of Thailand, secondary, foreign investors and, thirdly, manufacturers.

The **second chapter** concentrates on the relevant theories based on three main requirements affecting the FDI's investment: supply chain and infrastructure,

financial situation, human skill and performance. We have found that there are several benefits for each theory and the specific aspects of each theory only cannot allow to answer the problematic. No research work produces any evidence of each benefit in each specific theory concerning business in crises. Besides, many influencing factors have been studied in the context of FDI. For this reason, we will propose integrated methodology to settle the problem.

Thus, to help foreign investors and manufacturers make the right decision on FDIs' investment. **Third chapter** aims at proposing an integrated framework with the appropriate methodology. Our methodology is composed by three main components which construct the research framework. We have discovered these components thanks to the three questions: "Who", "What" and "How". "Who" refers to the relevant stakeholders for FDIs' investment. "What" refers to the relevant stakeholders' needs from FDI's investment, and "How" refers to measuring their performance and capability for FDIs' investment. Afterwards, all components are represented as the guideline to construct our research framework. The proposed framework is presented according to the provided which focus on three perspectives: finance, supply chain and infrastructure, knowledge skill and performance. However, the strategies to be analyzed in our research framework can be categorized into static and dynamic analysis. In terms of static analysis, the Risk Knowledge Matrix decision represented the knowledge base system used to evaluate the occurrence of existing risks. Regarding dynamic analysis, the modeling of the supply chain simulation is constructed according to the Supply Chain Operations Reference (SCOR) model.

The **fourth chapter** shows the implementation and obtained results from our research framework. The application of our Knowledge Based Decision Support System (KBDSS) is mainly developed by integrating functions of the risk evaluation (static analysis) and the supply chain simulation (dynamic analysis) according to the proposed methodology. To demonstrate the implementation of the system, the sample scenarios are applied to represent obtained results. The results of the evaluation will be suggested among three scenarios of relocation, transferring or divestment of plant. Furthermore results from supply chain simulation are represented as the outcome which is used to estimate on future investment cost for foreign investors. Thus the KBDSS helps to provide a supporting tool for manufacturers or investors in decision

making on investments. Besides, results from the KBDSS can help decision makers who are facing business crises, make the right decision on investing plants by suggesting the possible scenario of the existing situation of plants and estimating supply chain cost of investment.

The **fifth chapter** concentrates on applying the KBDSS to a case study of a manufacturer in Lumphun Industrial estate area, Thailand. It aims at validating the proposed framework for the real case study. The outcome from evaluating risks and supply chain cost simulation are conducted among two site location of Thailand and Vietnam. The advantages of this knowledge based system will be provided as the supporting tool for manufacturers or investors in making decision of investments.

From our **perspective**, although this study showed the ability of the KBDSS to support the decision making FDIs. It can be improved in two aspects: Methodological aspect and Technical aspect. The methodological improvement concerns the use of knowledge. As the proposed knowledge base of the Risk Knowledge Matrix decision, the knowledge helps decision makers evaluating their existing risks in business. Thus this knowledge can be represented in depth in terms of ontology. It is in order to clarify the relationship between causes and effects (if “a” happens then leads to “b”), or discover the cause of the problem leading to business crisis among the situation of: relocation and divestment of plant. In this case, if the users found the unwelcome circumstances leading to the business crisis, then they can understand the situation and prevent as before happening. Thus, this ontology will help to represent the knowledge and their relationship factors in terms of knowledge utilization.

Further, in the technical point of view, the supply chain simulation which we developed by Arena software simulation, has been defined with the limitation of variable use due to the limit of evaluation mode (used for academic proposes). Thus to enhance the ability of the simulation, developing in the professional mode will help to enlarge the parameter used to measure supply chain performance. Besides, creating animation to illustrate the system will help decision makers understand the processes and characteristic of supply chain and logistics network.

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Appendix A:

Questionnaire

Part1: Company profile and general information Back Next

1. Type of industries.

- ☐ Electronics
- ☐ Part of machineries, equipment
- ☐ Food product
- ☐ Wooden product
- ☐ Other (Please fill)
- ☐ Jewelry and accessories
- ☐ Agricultural product
- ☐ Garment
- ☐ Construction

2. How many employees are working in your company?

- ☐ Less than 50 people
- ☐ 50-100 people
- ☐ 100-500 people
- ☐ 500-1,000 people
- ☐ More than 1,000 people

3. Shareholding structure

- ☐ ……% (Thai)
- ☐ ……% ……(Nationality)
- ☐ ……% ……(Nationality)

4. How many years has your company operated in the Lumphun industrial estate?

……..

5. What will be on your investment plan in the next 5 years?

☐ 5.1 Maintain the existing level of investment

Why ……..…..……..……..……

……..

☐ 5.2 Expand or transfer part or product to

☐ Thailand ☐ Other country (please fill) ……

How ……

……..

Why ……..……..……..……..……..

……..

☐ 5.3 Reduce the investment

How ……

……..

Why ……..……..……..……..……..

……..

☐ 5.4 Withdraw the investment

How ……

……..

Why . ……..……..……..……..

……..

Back Next

Part 2: Factor(risk) consquence on investment decisions lead to offshoring, transferring and divestment of manufacturing's situation

Please describe impact level (consequence) on the following factors that affect three investment decisions (Please give a score of 1-5)

(กรุณาให้ลำดับความรุนแรง (ระหว่าง 1 ถึง 5) ของผลกระทบเนื่องจากปัจจัยดังต่อไปนี้ ซึ่งส่งผลให้เกิดการตัดสินใจด้านการลงทุนทั้ง 3 เหตุการณ์ (ให้คะแนน 1-5)

Definitions: Three investment decisions	
Offshoring plant	The move of manufacturing process to low-cost labor-abundant locations by a combination of an investment abroad and subcontracting.
	Moving production facilities to low-wage countries
Transferring plant	Remain high technology process and expand processes that need laboring in other countries such as China, Vietnam , India etc.
Divestment plant	Withdraw the investment, a plant closure or downsizing

Score of consequence

Consequence	1	2	3	4	5
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
	Interuption does not impact	With minimal interuption	Some interuptions impact	Major impact	Significant effect

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Main issues

Aspect	Explanation	Offshoring	Transferring	Divestment
1. Labor workers	Negative attitude and work ethic, lack of ability to work of workers in companies			
2. Economic situation	Unstable market demand, competition, policy environment, domestic inflation rates.			
3. Infrastructure	Insufficient and ineffective of overall structure of transportation, public utilities, and telecommunication services.			
4. Supply chain	Lack of ability or insufficient on collaboration among supplier, manufacturer and customer			

Sub issues

	Issue	Offshoring	Transferring	Divestment
1	Financial problems such as the strong exchange rate of Thai baht, market risk, uncertainty on monetary policies, inflation and interest rates			
2	Unstable of thai political situation			
3	Inefficient collaboration among company with supplier and/or customer such as supplier unreliability, delay of delivery to customer, inaccurate sales forecast of demand variation.			
4	Difficulties related to internal operations such as operational and technical problem effecting product quality.			
5	Unwelcome on facilities, infrastructure and supporting environment, such as public utilities.			
6	Inconvenient or unattractive regulations for company.			
7	Inefficient internal collaboration, such as over inventory, production cost, information breakdown, problem effected due to product quality.			
8	Inconvenient logistics such as transportation channels for raw material and finished good delivery			
9	Inefficient employees and lack of skill and performance requirement			

10	High turnover rate in human resources			
11	Uncompetitve wages			
12	Other (Please fill)……..			
13	Other (Please fill)……..			
14	Other (Please fill)……..			
15	Other (Please fill)……..			

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Part 3: Explain on the probability or likelihood of risk occurrences result in the crises of manufacturing's situation

Please identify the frequencies of adverse occurrences result in the three investment decisions

(กรุณาระบุความน่าจะเป็น(ความถี่) ของเหตุการณ์ดังต่อไปนี้ ที่มีแนวโน้มก่อให้เกิดการตัดสินใจด้านการลงทุนทั้ง 3 เหตุการณ์)

Likelihood assessment-Guidance

Likelihood	1	2	3	4	5
	Rare	**Unlikely**	**Possible**	**Likely**	**Almost certain**
	Do not believe will ever happen	Do not expect to happen	May occur occasionally	Will probably occur	Will undoubtedly happen, possibly frequently

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	Issue	Likelihood		
		Offshoring	Transferring	Divestment
1. Labor worker	1. A negative attitude on their work and the company			
	2. Lack of skill and performance			
	3. High turnover rate on human resource			
	4. Low educational level for workers who works in companies			

		Offshoring	Transferring	Divestment
2. Economic situation	5. Instability of economic situation (low market and demand rate, exchange rate, interest rate, inflation rate)			
	6. Unstable social situation(dramocratic system of the country)			
	7. Unstable political situation(more transparency in managing country by the government)			
	8. Uncompetitive wages of skilled labor			
	9. Unattractiveness of laws and regulations			
	10. Low market and demand rate			
	11. High competition			
	12. Continuous high operational cost and loss profits			

		Offshoring	Transferring	Divestment
3. Infrastructure	10. Ineffective network in communication service			
	11. Ineffective networks for transportation and logistics infrastructure (road, rail, seaport, airfreight)			
	12. Public utilities support ineffectiveness			
	13. Ineffective academic service and technological support (R&D support)			
	14. Unsuitability of geographical location and land price and/or land lease			

		Offshoring	Transferring	Divestment
4. Supply chain	16. Inefficient collaboration among partners			
	17. Remote distance from supplier and product market			
	18. Internal problem and organizational change			

		Offshoring	Transferring	Divestment
5. Other	19. Others (Please fill).....			
	20. Others (Please fill).....			
	21. Others (Please fill).....			

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Part 4: Please rate √ your satisfaction level on the following issues
ท่านมีความพึงพอใจต่อรายการดังต่อไปนี้ในระดับใด

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	Issue	Strongly Satisfied	Satisfied	Moderate	Dissatisfied	Strongly Dissatisfied
1	**The satisfaction with infrastructure and utilities services**					
1.1	Transportation					
	· Sea freight	☐	☐	☐	☐	☐
	· Air freight	☐	☐	☐	☐	☐
	· Road	☐	☐	☐	☐	☐
	· Train	☐	☐	☐	☐	☐
1.2	Public utilities					
1.3	Prices of public utilities					
	· Electric power supply system	☐	☐	☐	☐	☐
	· Drainage system management	☐	☐	☐	☐	☐
	· Wages and gabages management	☐	☐	☐	☐	☐
1.4	Telecommunication and communication service					
	· Leased line	☐	☐	☐	☐	☐
	· Satellite	☐	☐	☐	☐	☐
	· Integrated Service Digital Network (ISDN)	☐	☐	☐	☐	☐
	· Asymmetric Digital Subscriber Line (ADSL)	☐	☐	☐	☐	☐
	· Wireless LAN (WLAN)	☐	☐	☐	☐	☐
	· Analog service	☐	☐	☐	☐	☐
1.5	Collaboration between research Institute and industrial sectors.					
	· University or academic institute	☐	☐	☐	☐	☐
	· Training center and R&D service	☐	☐	☐	☐	☐
	· Calibration center service	☐	☐	☐	☐	☐
	Suggestions:					
	.....					
2	**The satisfaction with labor force and employee**					
2.1	Number or adequacy of employee					
	· Labor worker	☐	☐	☐	☐	☐
	· Technician	☐	☐	☐	☐	☐
	· IT staff	☐	☐	☐	☐	☐
	· Engineer/ product design	☐	☐	☐	☐	☐
	· Local manager	☐	☐	☐	☐	☐
	· Foreign manager	☐	☐	☐	☐	☐
	Suggestions:					
	.....					
3	**Satisfaction with the services of governemtn agencies**					
	· Board of Investment (BOI)	☐	☐	☐	☐	☐
	· Industrial Estate Authority of Thailand (IEAT)	☐	☐	☐	☐	☐
	· Thai Customs Department	☐	☐	☐	☐	☐
	Suggestions:					
	.....					

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Part 5: Explain on the probability or likelihood of risk occurrences result the company.

Please identify the frequencies of adverse occurrences result in your company.

(กรุณาระบุความถี่ ของเหตุการณ์ดังต่อไปนี้ ที่เกิดขึ้นในบริษัทของท่าน)

Likelihood assessment-Guidance

Likelihood	1	2	3	4	5
	Rare	**Unlikely**	**Possible**	**Likely**	**Almost certain**
	Do not believe will ever happen	Do not expect to happen	May occur occasionally	Will probably occur	Will undoubtedly happen, possibly frequently

Back

	Issue	Likelihood
1. Labor worker	1. A negative attitude on their work and the company	
	2. Lack of skill and performance	
	3. High turnover rate on human resource	
	4. Low educational level for workers who works in companies	

		Likelihood
2. Economic situation	5. Instability of economic situation (low market and demand rate, exchange rate, interest rate, inflation rate)	
	6. Unstable social situation(dramocratic system of the country)	
	7. Unstable political situation(more transparency in managing country by the government)	
	8. Uncompetitive wages of skilled labor	
	9. Unattractiveness of laws and regulations	
	10. Low market and demand rate	
	11. High competition	
	12. Continuous high operational cost and loss profits	

		Likelihood
3. Infrastructure	10. Ineffective network in communication service	
	11. Ineffective networks for transportation and logistics infrastructure (road, rail, seaport, airfreight)	
	12. Public utilities support ineffectiveness	
	13. Ineffective academic service and technological support (R&D support)	
	14. Unsuitability of geographical location and land price and/or land lease	

		Likelihood
4. Supply chain	16. Inefficient collaboration among partners	
	17. Remote distance from supplier and product market	
	18. Internal problem and organizational change	

		Likelihood
5. Other	19. Others (Please fill).....	
	20. Others (Please fill).....	
	21. Others (Please fill).....	

Thank you for completing this questionnaire. I very much appreciate your help and time.
Please return by attached file via email to petchee@gmail.com

Appendix.B: Structure of Design table

Table: Company_info

Physical Name	Data Type	Req'd	PK	Notes
Comp_id	INTEGER	☑	☑	Comp_id identifies Company_info(auto increment)
Typeofcompany	VARCHAR(10)	☑	☐	Manufacturing type of company
Noofemploy	INTEGER	☑	☐	Total number of employee in the company

Table: Cost

Physical Name	Data Type	Req'd	PK	Notes
Country	VARCHAR(10)	☑	☑	Identification of selected country
Labor_cost	DOUBLE	☑	☐	Minimum standard of Labor cost per day
Water	DOUBLE	☑	☐	Standard cost of watering per unit
Electricity	DOUBLE	☑	☐	Standard cost of electricity per unit
Land	DOUBLE	☑	☐	Standard cost of land per square metre

Table: RiskExplanation

Physical Name	Data Type	Req'd	PK	Notes
Risk	VARCHAR(10)	☑	☑	Risk categories
Subrisk	TEXT(10)	☑	☑	Subrisk categories
Explanation	LONGTEXT	☑	☐	Explanation of risk prevention

Table: FinancialRisk

Physical Name	Data Type	Req'd	PK	Notes
Comp_id	INTEGER	☑	☑	Company_id
i1	INTEGER	☑	☐	Impact of subrisk1
L1	INTEGER	☑	☐	Likelihood of subrisk1
i2	INTEGER	☑	☐	Impact of subrisk2
L2	INTEGER	☑	☐	Likelihood of subrisk2
i3	INTEGER	☑	☐	Impact of subrisk3
L3	INTEGER	☑	☐	Likelihood of subrisk3
i4	INTEGER	☑	☐	Impact of subrisk4
L4	INTEGER	☑	☐	Likelihood of subrisk4
i5	INTEGER	☑	☐	Impact of subrisk5
L5	INTEGER	☑	☐	Likelihood of subrisk5
L6	INTEGER	☑	☐	Likelihood of subrisk6
i7	INTEGER	☑	☐	Impact of subrisk7
L7	INTEGER	☑	☐	Likelihood of subrisk7
i8	INTEGER	☑	☐	Impact of subrisk8
L8	INTEGER	☑	☐	Likelihood of subrisk8

Table: HumanRisk

Physical Name	Data Type	Req'd	PK	Notes
Comp_id	INTEGER	☑	☑	Company id
i1	INTEGER	☑	☐	Impact of subrisk9
l1	INTEGER	☑	☐	Likelihood of subrisk9
i2	INTEGER	☑	☐	Impact of subrisk10
l2	INTEGER	☑	☐	Likelihood of subrisk10
i3	INTEGER	☑	☐	Impact of subrisk11
l3	INTEGER	☑	☐	Likelihood of subrisk11
i4	INTEGER	☑	☐	Impact of subrisk12
l4	INTEGER	☑	☐	Likelihood of subrisk12

Table: SupplychainRisk

Physical Name	Data Type	Req'd	PK	Notes
Comp_id	INTEGER	☑	☑	Company id
i1	INTEGER	☑	☐	Impact of subrisk18
l1	INTEGER	☑	☐	Likelihood of subrisk18
i2	INTEGER	☑	☐	Impact of subrisk19
l2	INTEGER	☑	☐	Likelihood of subrisk19
i3	INTEGER	☑	☐	Impact of subrisk20
l3	INTEGER	☑	☐	Likelihood of subrisk20

Table: Shareholder

Physical Name	Data Type	Req'd	PK	Notes
Comp_id	INTEGER	☑	☑	Company id
country1	VARCHAR(10)	☑	☐	Shareholder of country1
percent1	INTEGER	☑	☐	Percent of shareholder1
country2	VARCHAR(10)	☑	☐	Shareholder of country2
percent2	INTEGER	☑	☐	Percent of shareholder2
country3	VARCHAR(10)	☑	☐	Shareholder of country3
percent3	INTEGER	☑	☐	Percent of shareholder3

Table: Template

Physical Name	Data Type	Req'd	PK	Notes
Subrisk	VARCHAR(10)	☑	☑	Subrisk identifies Template
Offshore	DOUBLE	☑	☐	Offshore is of Template
Transfer	DOUBLE	☑	☐	Transfer is of Template
Divest	DOUBLE	☑	☐	Divest is of Template

Appendix C: Performance attributes and associated Level 1 and Level 2 metrics (SCC 06)

Performance attribute	Performance attribute definition	Level 1 metric	Level 2 Metric	Calculation
Reliability	The performance of the sc in delivering: the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer.	Perfect Order Fulfillment	- % of order delivered in full - Delivery performance to customer commit date - Document accuracy - Perfect condition	-[Total no. of orders delivered in full]/[Total no. of orders delivered]x100% - [Number of order delivered in perfect condition]/[No. of orders delivered] x 100%
Responsiveness	The speed at which a supply chain provides products to the customer.	Order Fulfillment cycle time	- Source cycle time - Make cycle time - Deliver cycle time	[Sum actual cycle times for all delivered]/[total no. of orders delivered]
Flexibility	The agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage.	Upside supply chain flexibility, Upside supply chain adaptability, downside supply chain adaptability	- Upside Source Flexibility (Upside source adaptability) - Upside Make Flexibility (Upside Make adaptability) - Upside Deliver Flexibility (Upside Deliver adaptability) - Upside Source Return Flexibility (Upside source	- Current on-hand inventories (Raw material) - Current inventory on hand (WIP) - Current manufacturing order cycle time, - Current inventory on hand(FG) - Current source return volume - Current deliver return volume

			return adaptability) - Upside Deliver Return Flexibility (Upside deliver return adaptability)	
Cost	The costs associated with operating the supply chain	Supply chain management cost, Cost of Goods sold	- Cost to Plan - Cost to Source - Cost to Make - Cost to Deliver - Cost to Return	- source cost = (ordering + holding + transporting cost of material) - COGS = Make cost = (Direct mat cost + Direct labor cost + indirect cost + additional cost) - Deliver cost = (Shipped finished good cost)
Asset management	The effectiveness of an organization in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital.	Cash-to-Cash Cycle time, Return on supply chain fixed assets, Return on working capital	- Day sales outstanding - Inventory days of supply - Days payable outstanding	Supply chain revenue, Cost of goods sold, SC management costs, inventory

Appendix D: Approach used on forecasting inflation and demand (GDP) rate

D.1. Inflation rate forecasting

D1.1. Historical data

	Inflation rate (%)		
Year	**China**	**Thailand**	**Vietnam**
2003	-0.8	0.6	3.9
2004	1.2	1.8	3.1
2005	4.1	2.8	9.5
2006	1.8	4.5	8.3
2007	1.5	5.1	7.5
2008	4.8	2.2	8.3
2009	5.9	5.5	24.4

Source: CIA World Factbook (https://www.cia.gov/about-cia/index.html)

D1.2. Forecasting value by using moving average technique

	Inflation rate (%)		
Year	**China**	**Thailand**	**Vietnam**
2010	1.5	1.73	5.12
2011	2.37	3.03	6.02
2012	2.47	4.13	7.32
2013	2.70	3.93	11.05
2014	4.07	4.27	11.33

D.2. Gross Domestic Product (GDP) forecasting

D.2.1. Historical data

	Gross Domestic Product (GDP)	
Year	**Thailand**	**Vietnam**
2003	5.20%	6.00%
2004	6.70%	7.20%
2005	6.10%	7.70%
2006	4.50%	8.50%
2007	4.80%	8.20%
2008	4.80%	8.50%
2009	2.60%	6.20%

Source: CIA World Factbook (https://www.cia.gov/about-cia/index.html)

D.2.2. Forecasting value by using moving average technique

	Gross Domestic Product (GDP)	
Year	**Thailand**	**Vietnam**
2003	5.95%	6.60%
2004	6.40%	7.45%
2005	5.30%	8.10%
2006	4.65%	8.35%
2007	4.80%	8.35%
2008	3.70%	7.35%
2009	5.95%	6.60%