# CHAPTER 5
# ELECTRONICS INDUSTRY APPLICATION

## 5.1 Introduction

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

## 5.2 Background of Northern Region Industrial Estate, Thailand

The Thai BOI,[Board of Investment in Thailand, 2007] describe the creation of industrial estates in Thailand as*"... having established 34 industrial estates located in 15 provinces"*. One of those industrial estates is located in the Northern part of Thailand which is a major industrial area of the Lumphun province. The Office of the National Economic and Social Development Board reported that during 2008, the amount of Gross Regional and Provincial Products (GPP) per capita in this area reached 156,772 baht which was the highest rank of the Gross Regional and Provincial Products (GPP) per capita of the North. From the recent evidence, GPP in 2009 of this area showed earning per capita from non-agriculture sector, was higher by almost 10% than the agricultural 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 focused on agribusiness, food, garments, metals, and other products. In the exporting processing zone, electronics factories dominate. In 2008, 60,000 workers were employed in this area. Of all workers, 80% work in electronics factories. Around 70% of all the workers in the area are women, most of who are 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 5.1, most manufacturing products (or about 35 %) are electronics, parts of machinery and equipment 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].

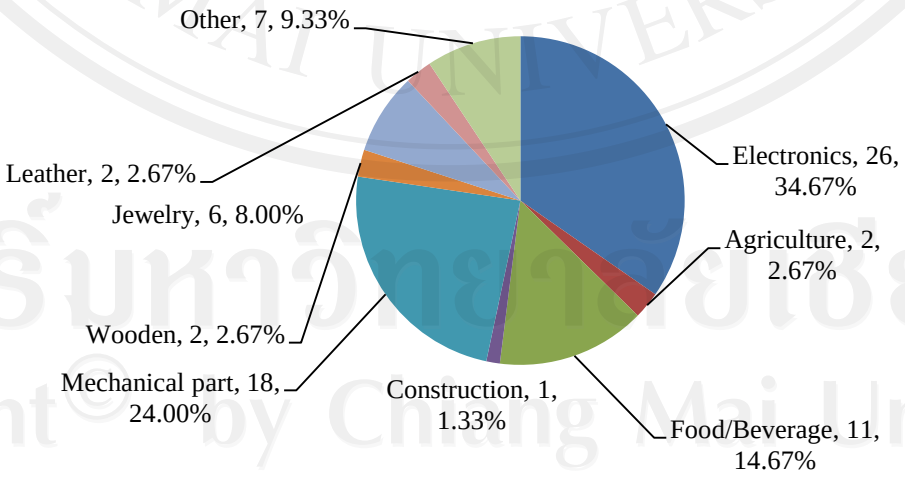



**Figure 5.1 Ratio in over all type of industries in Northern Region Industrial Estate, Lumphun province, Thailand**

Within the total amount, 28,541 workers work in electronics factories, which is over half of the entire workplace in this area. The ratio of workforce in each type of industry in the area is shown in Figure 5.2.

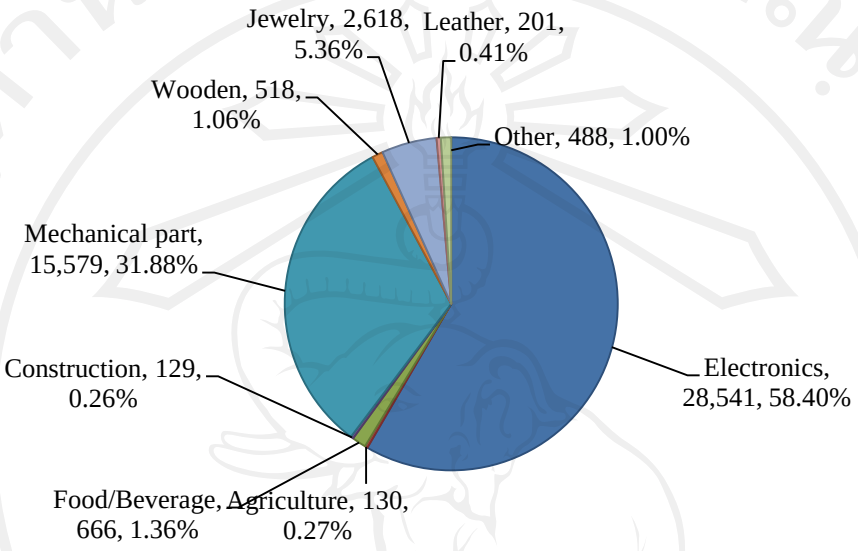



**Figure 5.2 Ratio of workforce on each type of industry in Northern Region Industrial Estate, Lumphun province, Thailand**

Considering the electronics sector, the main investors are Japanese, which are about half of the entire nationality operating in the electronics area. While the investors from the United States, South Korea, Switzerland and Taiwan are the secondary group.

From statistical data mentioned above, the electronics industry plays a major role in operating businesses in this industrial estate area. Generally the external factors that affect the electronics sector are as follows: (1) the structure of the electronics sector is an oligopoly but its production 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 FDI has risen considerably. Besides, the natures of the electronics industry are high technology and high cost of investment. In addition, the industry requires a skilled workforce, continuous research and development, and intensive labor. For these reasons, most of the electronics manufacturers in Thailand

depended on Foreign Direct Investments (FDIs) in funding, implementing and technology transfer.

Thus in the next section, to understand the characteristics on the business crisis, an explanation of the situation affecting the case study will be presented.

## 5.3 Case study background

### 5.3.1 characteristics and company profile of the case study

The manufacturer which produced flexible circuits and assemblies is based in Lumphun, Northern Thailand. However, the headquarters 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 a part of a joint venture. In 1998, the company opened its own facility that also features many leading companies 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 to design flexible circuits to gain competitive advantage, as shown in Figure 5.3.


**Figure 5.3 Location of offices and representatives supporting the company**

The manufacture of a flexible circuit is the main product introduced by the company. The manufacture of a Printed Circuit Board (PCB) involves many different processes and is quite different among each board produced. Figure 5.4 shows the main product of PCB.

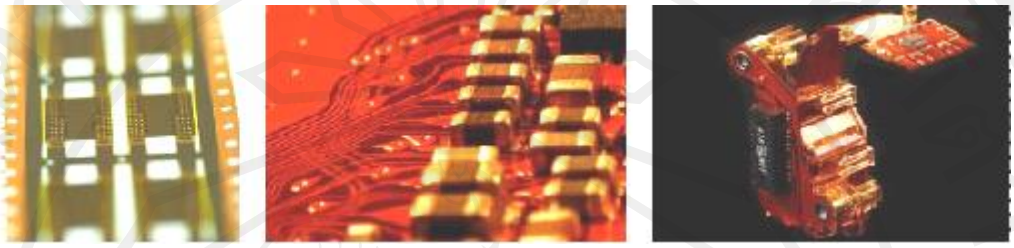


**Figure 5.4 Examples of Printed Circuit Board (PCB) from the case study**

### 5.3.2 Structure of organization

The organizational structure of the company represents the President and Chief Executive Officer (CEO) who are 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 responsible for each department unit. Most of the directors and chiefs of department were foreign workers. The total number of employees is more than 1000 people.

However, in January, 2008, the company was faced with a business crisis after a fiscal first-quarter loss of $7.9 million, or 41 cents a share, including restructuring charges, 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 2007. Thus, the managing director would explore strategic alternatives, such as raising capital, a recapitalization and sale of the company [Reuters 08]. These situations led to overall loss 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, the questionnaires were sent to engineers who worked in the company. They responded that senior management of the company sent the letters to all employees warning about the business situation and forced employees to resign. The payment terms could not pay the suppliers according

to the defined schedule. Further no more shipments were delivered to the customers. In terms of the infrastructure cost, the company was unable to pay utilities bills after the business was faced with the crisis. However, at the beginning of the crisis, salaries were paid to employees at a rate of 75% of the total. Afterwards, no more payments were paid to them.

### 5.3.3 Supply chain characteristics

The company exports products directly from Lumphun through Chiang Mai International Airport within a 30-minute drive. There are several product types and demand rates from customers. Since the main products are used for mobile phones, most of the customers are from Shanghai and 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 when it is ordered. Such a system is referred to as Make-to-Order (MTO). However, considering the strategy of Make to Order system (MTO), relative factors are considered when evaluating the prospect of MTO.

- Firstly, the chance of losing customers to the competition, since manufacturers cannot produce and deliver on time.
- Secondly, in the 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 in reducing the relatively 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 important since a longer lead time leads to customer impatience.

Because the demands from customers have high levels of variety, the process of customer review on cost and finance are inefficient. The direct costs of a poor product start up include scrap, late deliveries, expediting the flexible circuit's process including design, mock up and prototyping. Thus process capability was not aligned with customer requirement. These situations had resulted in turbulence in the

supply chain. In addition to the prospect of MTO, disruption on supply chain directly affects customization. Thus supply chain disruptions as well as the turbulence on business crisis, affect crucial circumstances of the company. Afterwards the company failed to pay debt to its suppliers which led them stop providing the material for the manufacturing process. Finally the company has announced that its subsidiary, has also filed a rehabilitation petition under Thai law. The petition was dated and filed on March 30, 2010[Business Wire 10].

## 5.4 System validation

In this section, the proposed KBDSS is applied to the company which was explained previously. It is to provide the right information and support the decision on the business crisis. KBDSS is introduced to this company for validating the 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 validate the framework with this company. The results are, firstly the case study shows how to adapt the KBDSS to obtain supporting information; secondly, the obtained outcomes from each stage of analysis will be examined. We then applied data to validate the system by sending the questionnaires to staff of the company. However, all required values were not provided by them. Therefore, requirements were from collected other reliable sources such as, local organizations of the industrial estate, Thai government organizations and public agencies, chambers of commerce, and the Ministry of Labor, to complete our validating system. Next the scenario is clarified by applying real data to the KBDSS.

### 5.4.1 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. The previous section, described that the majority shareholder is American with more than 1,000 employees. Thus, this step is to accumulate the background and status of the company which will be used as the reference knowledge base and compared with others. Figure 5.5 represents the interface to collect values of company profile.

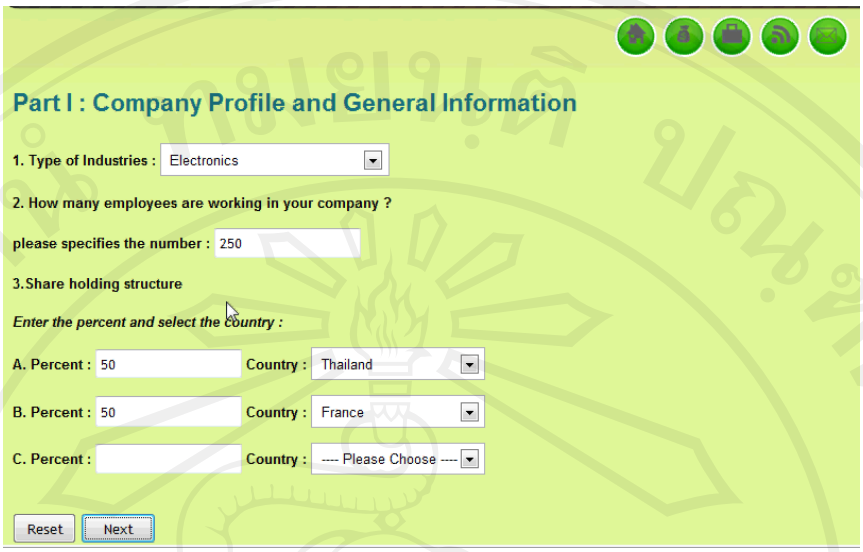



**Figure 5.5 Input values of the company profile**

Thus, the first evaluation of the risk focuses on the 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 of profits" is weighted as the most critical issue on this context (see Figure 5.6). The following risk dashboard displays those values of impact and likelihood corresponding to the risk and sub risk issues.

| Risk | Subrisk | Impact | Likelihood |
|---|---|---|---|
| Unstable Economic situation | Instability of economic situation | 4 | 4 |
| | Unstable Social situation | 2 | 2 |
| | Low market and demand rate | 4 | 4 |
| | High Competition | 4 | 4 |
| | Continuous high operational cost and loss profits | 5 | 5 |
| Inconvenient or unattractive regualtions | Unattractiveness of laws and regulations | 2 | 2 |
| Unstable of Thai Political situation | Unstable political Situation | 3 | 3 |
| Uncompetitive wages | Uncompetitive wages of skilled labor | 3 | 3 |

**Figure 5.6 Financial risk dashboard**


**Figure 5.7 Supply Chain risk dashboard**

From the supply chain point of view, the critical evaluation is mentioned on "Internal problems and organizational change". The issue is provided impact at "4" and likelihood at "5" as is shown in Figure 5.7. It is explained as difficulties in communication and collaboration among the internal procedures and processes. For example, the review processes on product design and price confirmation from customers are ineffective and uncertain as well as the delay of demand forecasting. The disruption also resulted to inefficient collaboration among partners along the supply chain in the company.

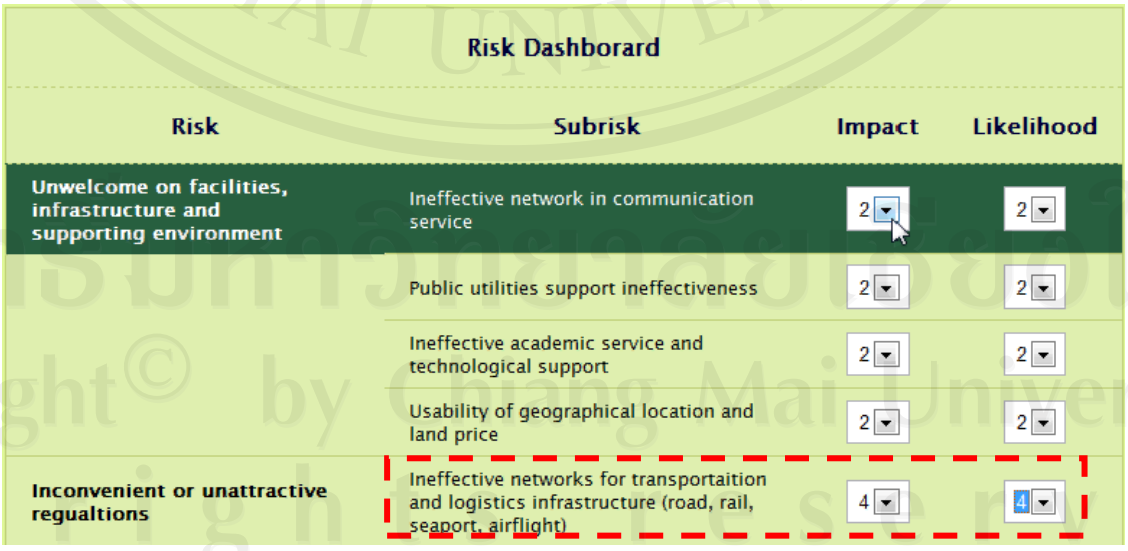



**Figure 5.8 Infrastructure risk dashboard**

However, Figure 5.8 shows networks of transportation and logistics infrastructure, for example, road, rail, port and air freight channels are claimed as inconvenient and insufficient. This reason disrupts the distribution along the supply chain network. Furthermore, the decision maker weight this issue as major impact factors and probability occurring.

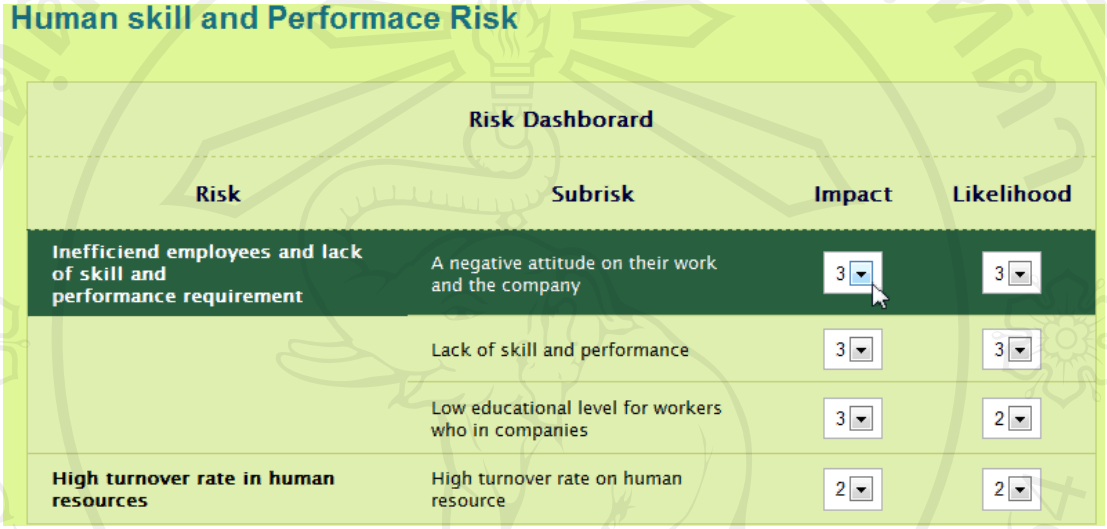



**Figure 5.9 Human skill and performance risk dashboard**

Consequently, the comparisons on the four perspectives of risk value in the knowledge based system are shown on Table 5.1. From the table, it is noticed that the company has faced a critical financial and economic situation. However, supply chain and infrastructure are also crucial because of “Internal problem and organizational change”, “Ineffective networks for transportation and logistics infrastructure” are also referred to as critical in the risk level of the case study.

**Table 5.1** Results from risk evaluation

| | 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 |
| | | | Instability 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 |

The system summarizes the outcomes by comparing risk exposure with the risk value in the knowledge based system. Then the scenario is suggested as the possible status of plant to “Divestment” shown in the following Table (Table 5.2).

**Table 5.2** The suggested scenario of the case study

| | **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 environmental 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”** |

Thus, the KDBSS gives information suggesting a critical and high risk value as shown in Figure 5.10. From the case study, three critical risk categories, namely finance, supply chain and infrastructure show the risk exposure in three levels of risk for Critical, Medium and Low level. As referred to previously, the most critical risk value is referred to as financial problems and the second is supply chain ineffectiveness. Lack of skilled labor and the negative attitude of workers in the companies is also the third priority leading to the risk level. Furthermore, infrastructure effectiveness having less influence on crisis in the company is accepted by the decision maker.


**Figure 5.10 Suggesting information on Critical and high risk value**

This type of analysis is useful to suggest the situation of existing plant to the decision maker. Finally, the results from the case study, suggest the situation of "Divestment" plant, which refers to closing plant or withdrawal of plant. The highest risk level (See Table 5.1) focuses on the turbulence of the 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 risk level refers to the supply chain ineffectiveness. The relative sub risks lead to the suggested situation mentioned by the "internal supply chain problem and organizational change". However, the outcome of the suggested situation of plant also ensures that the Risk Knowledge Matrix decision can be used as guideline knowledge on risk evaluation. From the recent evidence, the company has temporarily stopped operations and no more employees work at the company. 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 Thai Law [Financial News 10].

To continue the cost simulation on future investment, the decision maker will continue by producting a cost simulation using dynamic analysis.

### 5.4.2 Dynamic analysis: Cost simulation

In this section, the cost comparison among two site locations will be analysed. Then the decision maker starts by completing the values of operational processes based on process definition of the Supply Chain Operations Reference Model (SCOR). The site location of existing plant, Thailand, is firstly identified. Then, the secondary site location will be selected from China or Vietnam. However, in this case study Vietnam is compared with Thailand. Thus, the process of Plan, Source, Make, Deliver and Return, require parameters to complete the simulation of each selected site location. As described previously, all those parameters are not available from the case study. Further information from published articles and information provided from government sources are summarized in the table below.

**Table 5.3** Investment cost comparison between Thailand and Vietnam

| 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[a]], [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 $US | Industrial electrical power in Vietnam is not satisfied compared to Thailand |
| Water bill (for industrial production [Businee in Asia 10], [BOI 09] | 0.46 USD/m3 (up to 201 m3) 10 Year deduct as tax incorporate | 0.28 USD/m3 Varied depending on location | Thailand > Vietnam about 26% (1.64 times) |
| Land cost [IEAT 09 | 3,500,000 Baht/rai = 2,187 Baht/$m^2$ | High land price land is now $2,000 (70,000 baht) per square meter | Vietnam > Thailand 96.87% (32 times) |
| **Logistics transportation** | | | |
| Port (major ports and terminal on basis of the amount of the cargo) | 4 ports (Good) Rank 37 | 3 ports (Fair) Rank 89 | Thailand have better sea freight network than Vietnam |
| International air transport network | Rank 41 | Rank 76 | Thailand have better airfreight network than Vietnam |
| Freight cost [Logistic Digest 10] | 41.48 USD : Ton 20% of GDP Above 100kg: 7 ($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. |

- **Average of labor wage**: Vietnam has the cheapest labor rate in the South East Asia region followed by Cambodia and Thailand. Pay rates of untrained Vietnamese workers are about 65% cheaper than Thai wages. The minimum wage of Thai labor in the case study area is 160 baht per day (130

USD/Month), whereas Vietnam is 55 USD/Month. Although, wage rates are different from company to company, corresponding to workers' skill and performance and ages [FIA 10]. The wages rate in Vietnam is cheaper than neighboring countries.

- **Infrastructure:** The course of Thailand's electricity industry development in Thailand has set forth a goal of greater efficiency, both on the supply side and demand side [BOI 10[a]]. Compared to Vietnam, even though development of infrastructure is rapidly keeping up with neighbors, enterprises are still complain about insufficient infrastructure, for example, transportation, expensive electricity and inconvenience of telephone services [Vietnam Trade Office, 2008].

- **Logistics channel:** Explaining the geographical location of Thailand, the BOI [10[b]], reported that *"... (Thailand is) a strategic location and serves as a gateway into the heart of Asia…(with a)...large growing economic market,… convenient trade with China, India and the Southeast Asian Nations (ASEAN),…easy access into the Greater Mekong sub-region."* According to a new market research report from Transport Intelligence, Laem Chabang port, located in the eastern part of Thailand, has one of the highest (trading) growth rates in the world. Major international airports include Suvanabhumi, the new airport which can support 3-million tons of cargo per year. In Vietnam, logistic infrastructure is reported as «Fair » [CIA 10]. The demand for freight transport via air is expected to increase sharply. Although two international routes to China are available from Hanoi through Lao Cai and Dong Dan. The available logistic route from Lao Cai to Hanoi still remains insufficient in response to demand. High logistics costs affect the development of the Vietnamese economy which are estimated to be 20% - 25% of Vietnam's GDP [EyeforTransport 09].Further, the report inferred that *"High logistic costs have hampered Vietnam's efforts to take advantage of its cheap labor resource and develop the national export economy"* However, the development in Vietnam is sill lower than neighbors and rivals [Manila Bulletin 2009]. In this case study, the route from the company to

China is the main logistical distance. With regard to location of plants among Thailand and Vietnam to China, the distance is not much different, for example, distance from Thailand to China is approximately 2,248 km, and while from Vietnam is approximately 2,461 km. The Figure V.11 shows the estimated distance from Thailand and Vietnam to China, thus the cost of the logistics network is a competitive factor to be considered for the case study.

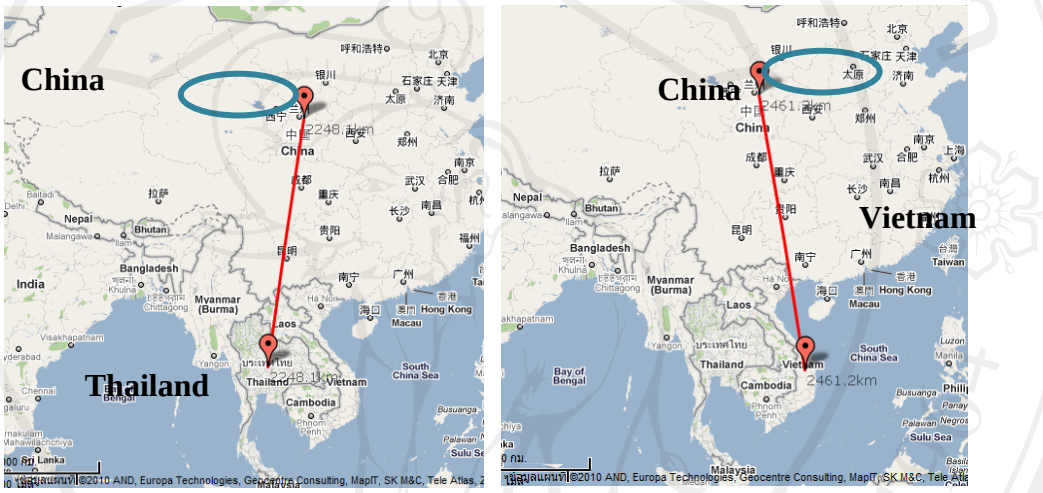



**Figure 5.11 Comparison between distance from Thailand and Vietnam to China (Adpated from Google Maps, 2011)**

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 5.4.

**Table 5.4** Parameters used for Source, Make, Deliver and Return on cost simulation

| **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 (Unit) | 1,500 | 1,500 |
| *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** |

**Table 5.4** (continued)

| **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 5.4, estimates the required values for model execution of Source, Make, Deliver and Return. However the estimation aims at analysing cost of supply chain and infrastructure on two site locations. Thus in terms of manufacturing processes, values are almost similar. The exception is labor cost. With regards to the case study, minimum labor wage is 160 baht/day in Thailand while the labor wage of Vietnam when exchanging to the Thai baht is approximately 68 baht per day, almost half of that of Thailand. The land cost in Vietnam is also high. Suppose the land cost of Vietnam is 393,740 baht per month, this is double the cost of Thailand. Meanwhile, the cost of electricity is also double in Vietnam than that of Thailand. In addition, the logistics channels are still insufficient in Vietnam, so the logistic cost of Thailand is determined as 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 when compared to Vietnam.

Furthermore, the required value was put on Plan, Source, Make, Deliver and Return processes based on SCOR through the interface as shown in Figure 5.12. Those values are required for both two site locations which in this case study are referred to “Thailand” and “Vietnam” sites. Thus in order to provide supply chain and investment costs for the decision maker, the supply chain simulation is executed.

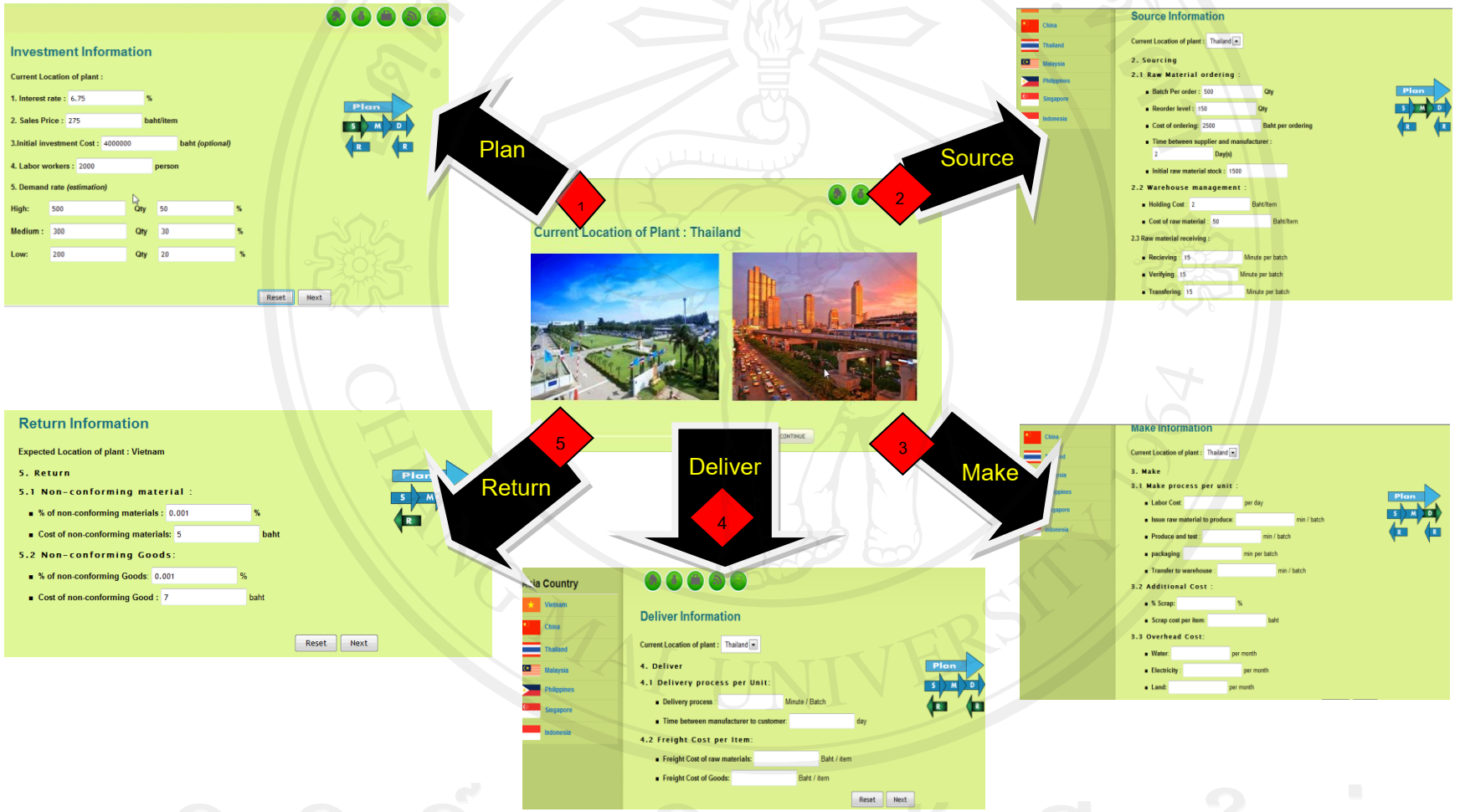



**Figure 5.12 User interface of supply chain cost.**

The outcomes from running the 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 within 360,000 minutes run length or 250 working days (one year) from the ARENA software simulation. Finally, the one-year outcomes are obtained for decision makers through an Excel spreadsheet. Figure 5.13 shows one-year supply chain cost of the 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 5.13 one-year cost of supply chain for site location in Thailand**

From Figure 5.13 output from 10 replications provides parameters, for example, work in process, finished goods in warehouse, shipment and scrap quantity, which were used to manipulate supply chain cost based on SCOR: Source, Make, Deliver and Return. However, to clarify each cost following the supply chain SCOR process, these costs are also summarized by comparing results among Thai and Vietnamese sites in the following tables (Table 5.5, 5.6, 5.7, 5.8).

**Table 5.5** Source cost of Thailand and Vietnam site

| **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** |

Firstly, Table 5.5 shows the results from supply chain cost simulation between Thailand and Vietnam. « Source » cost consisted of shipment costs from receiving raw material from suppliers, ordering costs of requesting raw material and holding costs of raw material in stock. Compared with two site locations, source cost of Thailand is less than Vietnam, due to the sufficiency and availability of transportation and logistics in Thailand being superior with cheaper freight cost than the Vietnamese site.

**Table 5.6** Value of Make process for Thailand and Vietnam

| **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** |

Second, in terms of cost from « Make » process (Table 5.6), the labor cost of Vietnam is 2.5 times less than Thailand. Although, water costs in Thailand are still expensive, the total cost of utilities is lower than Vietnam. Besides, the manufacturing cost from Vietnam is still lower than Thailand. For this reason, mass production is more beneficial to Vietnam because the main cost is mainly related to « Make » process.

**Table 5.7** Value of Deliver process for Thailand and Vietnam

| **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** |

Thirdly, it was noticed that «Delivery» costs (Table 5.7) among locations in Thailand and Vietnam are more remarkable than others. Since Vietnam has an insufficient on logistical infrastructure which leads to double freight costs.

**Table 5.8** Value of Return process for Thailand and Vietnam

| **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** |

Lastly, « Return » costs (Table 5.8), do not directly affect a decision making. Since internal process among both sites are similar. Thus the final results cannot distinguish the Thai from the Vietnamese site.

However those outcomes from running the simulation are represented in terms of one-year calculation. Thus to forecast future cost of investment, it was explained in chapter 4 (4.4.3.1: Cost simulation), that a forecasting technique used for inflation rate and demand rate help to estimate cost of investment over the next 5-year plan. Those forecasting values are performed by the use of a moving average technique. Regarding the revenue, it is caused from demand rate change which is influenced by the yearly change of Gross Domestic Product (GDP). Consequently, the outcomes and technique used for the 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 5.8). In terms of inflation rate, the value is influenced by expected return of investment shown by the Net Present Value (NPV) which is obtained by integrating inflation rate with the real interest rate. Afterwards, the NPV for 5 years of investment 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 5.9) explains how an Excel spreadsheet is produced to obtain NPV of the Thai site.

**Table 5.9** Net Present Value for 5 year investment plan, 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 | **(8492,899.69)** |

Compared to the Vietnam site (see Table 5.10), the rate of 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 the next 5 years of investment, the figures show NPV of Thailand is **(492, 899.69)** baht and Vietnam is **5,001,191.60** baht.

**Table 5.10** Net Present Value for 5 year of investment plan, Vietnam site

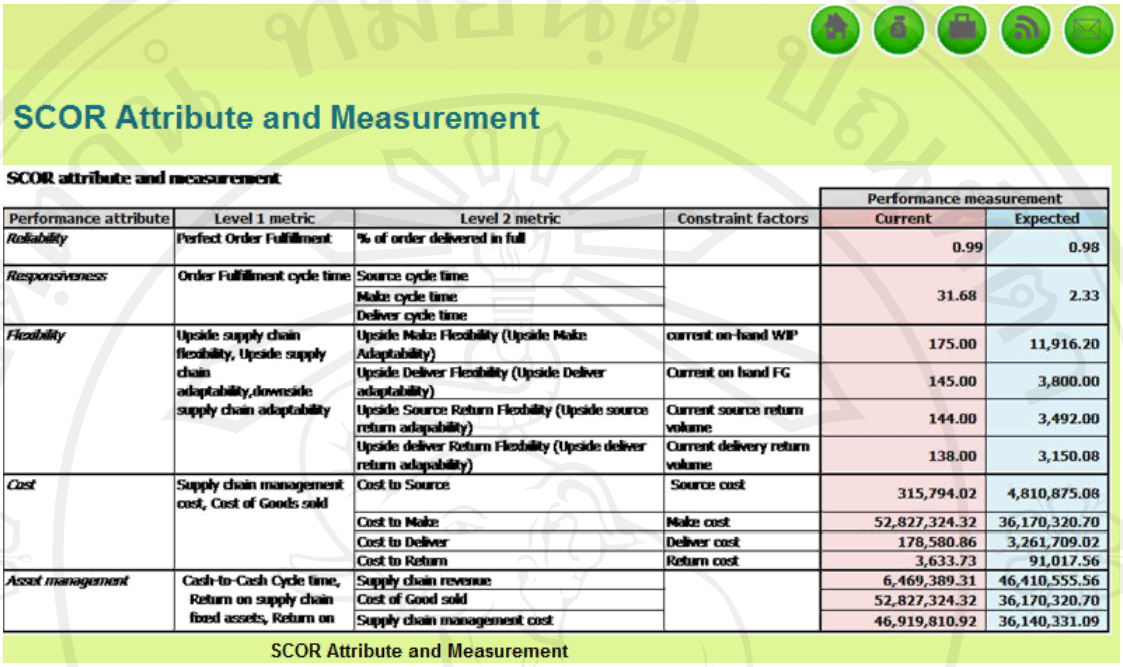
| | Year | | | | | | |
|---|---|---|---|---|---|---|---|
| **Vietnam** | **0** | **1** | **2** | **3** | **4** | **5** | **Total** |
| Total revenue | **140,530,052** | 158,616,270.23 | 172,447,608.99 | 177,776,240.11 | 177,776,240.11 | 156,478,646.55 | 983,625,058.47 |
| Demand rate | | 12.87% | 8.72% | 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 5.11** NPV comparison of Thailand and Vietnam

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

Finally, Table 5.11 shows the NPV comparison between two sites of: Thailand and Vietnam. Even though the NPV presents Vietnam as more preferable than Thailand, there are relevant parameters that the decision maker should recognize. Parameters such as labor cost, which are increasing continuously and the capability of skilled labor. While Vietnam is more preferable in terms of labor wages and availability of labor workers, infrastructure of logistics and transportation are still developing. Thus the decision makers need to consider long term investment according to their manufacturing characteristics. Furthermore, supply chain performance is also compared by measuring attributes and metrics based on SCOR as is shown in the following table (Table 5.12).

**Table 5.12** Comparison on SCOR attributes and metrics among two site location



SCOR Attribute and Measurement

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 | | 0.99 | 0.98 |
| *Responsiveness* | Order Fulfillment cycle time | Source cycle time | | 31.68 | 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 | 175.00 | 11,916.20 |
| | | Upside Deliver Flexibility (Upside Deliver adaptability) | Current on hand FG | 145.00 | 3,800.00 |
| | | Upside Source Return Flexibility (Upside source return adapability) | Current source return volume | 144.00 | 3,492.00 |
| | | Upside deliver Return Flexibility (Upside deliver return adapability) | Current delivery return volume | 138.00 | 3,150.08 |
| *Cost* | Supply chain management cost, Cost of Goods sold | Cost to Source | Source cost | 315,794.02 | 4,810,875.08 |
| | | Cost to Make | Make cost | 52,827,324.32 | 36,170,320.70 |
| | | Cost to Deliver | Deliver cost | 178,580.86 | 3,261,709.02 |
| | | Cost to Return | Return cost | 3,633.73 | 91,017.56 |
| *Asset management* | Cash-to-Cash Cycle time, Return on supply chain fixed assets, Return on | Supply chain revenue | | 6,469,389.31 | 46,410,555.56 |
| | | Cost of Good sold | | 52,827,324.32 | 36,170,320.70 |
| | | Supply chain management cost | | 46,919,810.92 | 36,140,331.09 |

SCOR Attribute and Measurement

From Table 5.12, the time to provide products to customers is referred to as "Reliability". Delivery cycle time is shown as an influenced factor of order fulfillment cycle time of Thailand and is more beneficial than Vietnam. The effectiveness of an organization in managing cost associated with operating the supply chain of Thailand is also than Vietnam. However, the agility of a supply chain in responding to marketplace changes ("Flexibility"), concerning volume of work in process, finished goods and return products, then Vietnam is the better place.

Thus, the decision maker who decides on long-term investment needs to consider the relative parameters of competitive advantage which depend on characteristics of each country. For example, Vietnam encourages investors by providing workforce availability as well as low labor costs in the long term investment Moreover, the benefits of people' work ethic, the relatively low-cost labor, and high stable economic growth[Hoang10],support Vietnam to be one of the best countries to invest in Asia. Furthermore, the government of Vietnam has promised to improve the infrastructure of: roads, water systems, and electricity for factories in promoted industries [Business-in-Asia 07] since the infrastructure in Vietnam is still claimed to be insufficient by investors.

However, Business-in-Asia [2005], noted that Thailand is a very good choice from the influencing 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".* Most firms in Thailand have over 30-years experience in producing for Japanese, European and North American companies. On the other hand, Vietnam is described as *"...Suppliers from Vietnam have less experience and needed helps from them in terms of quality of manufacturing"* [Business-in-Asia, 2005].

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

Thus, to validate the proposed framework on FDIs' investment outcomes from KBDSS provide decision makers with future cost of investment and risk evaluation for company situation.

## 5.5 Conclusion

In summary, this chapter demonstrated how KBDSS is used 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 the case in the electronics company has been faced with the business crisis, for example, continuous loss in profits, high operational cost and debts, the company has recently stopped the operation. Then the case study helped to validate the framework by providing required parameters to demonstrate the system based on those two main analyses. Thus the result from the first analysis of risk evaluation represented the possible situation of the case study referred to as "divestment" which is the current situation affecting this company. Afterward, the comparison on future cost investment among Thailand and Vietnam is illustrated by using NPV. The present returns on investment for the 5-year plan will help decision

makers to decide the suitable site location of manufacturing plants. Further, supporting information for FDIs are necessary, to elucidate the comparative advantage of each country in attracting foreign investors to the country. In this case study, the benefit of labor cost of Vietnam is more preferable than Thailand, however, logistics and transportation costs of Thailand are more advantage us. Thus to consider long term of investment concerned with the main characteristic of plant, is more feasible.