DISTRIBUTION CENTRE SELECTION MODEL IN EUROPE FOR A CERAMIC TILE COMPANY

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ผูกพันธ์ รัตนไพโรจน์กุล : แบบจำลองการเลือกที่ตั้งศูนย์กระจายสินค้าในยุโรป สำหรับบริษัทกระเบื้องเซรามิค. (DISTRIBUTION CENTRE SELECTION MODEL IN EUROPE FOR A CERAMIC TILE COMPANY) อ. ที่ปรึกษาวิทยานิพนธ์หลัก : ผศ.ดร.ปวีณา เชาวลิตวงศ์, 73 หน้า.

วิทยานิพนธ์นี้นำเสนอแบบจำลองการเลือกที่ตั้งศูนย์กระจายสินค้าในยุโรป สำหรับบริษัทกระเบื้องเซรามิค ที่จะไปทำตลาดใหม่ในประเทศเยอรมันนี เพื่อที่จะช่วยในการลดตัวเลือกของศูนย์กระจายสินค้า และให้ความสนใจเฉพาะทางเลือกที่เป็นไปได้ กระบวนการพัฒนาแบบจำลองประกอบไปด้วยสามขั้นตอนหลักได้แก่ (1) รวบรวมความต้องการและข้อกำหนดที่จำเป็นต้องใช้ประกอบการตัดสินใจ (2) วิเคราะห์และเปรียบเทียบตัวเลือกในเชิงคุณภาพ และ (3) วิเคราะห์และเปรียบเทียบตัวเลือกในเชิงปริมาณ โดยใช้หลักเกณฑ์ของบริษัทจริงพิจารณาร่วมกับทฤษฎีที่เกี่ยวข้อง แบบจำลองจึงถูกออกแบบเป็นขั้นเป็นตอนอย่างเป็นระบบแบบแผน

แบบจำลองได้ถูกพัฒนาขึ้นโดยใช้ข้อมูลของบริษัทกรณีศึกษา เพื่อแสดงเป็นตัวอย่างสำหรับการบวนการคัดเลือกของแบบจำลองให้ได้เห็นว่าสามารถนำไปใช้ได้จริงและเกิดประโยชน์ ผลลัพธ์จากการใช้แบบจำลองสามารถช่วยเหลือในการตัดสินใจ ลดเวลาในการตัดสินใจและก่อให้เกิดความได้เปรียบทางธุรกิจของบริษัท

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This thesis reports the details of the distribution centre location selection model for ceramic product new market in Germany in order to help reducing the alternatives and focusing on the plausible choices. It contains three process of model development (1) collect the requirements and constrains, (2) qualitative comparative analysis and (3) quantitative comparative analysis. Using the company criteria and applying relevant theories, the model is designed into systematical steps.

While develop the model, the case study of Thai Ceramic Company is applied to illustrate the process of selection model that is useful and practical. The result from the model helps to make a decision and gives business advantages to the company.

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Chapter 1

Introduction

1.1. Background and Problem Statement

The warehouses primarily serve along the supply chain as storage points between the origins of raw materials and the destinations for the final products consumption. Distribution centre is one of forms of warehouse that focuses on throughput where various products from manufacturers are combined into shipments of precise quantities for distribution according to customer needs (Wang & Adams, 2011). But nowadays, the distribution centre is also used for more benefit such as to smooth the flow in the supply chain and improve the customer service level to gain the business advantages.

In this case the Thai ceramic company plans to expand the export market; meanwhile exporting the ceramic tiles to Europe is limited. Because of the existing operation the trading partners in Europe. The company exports products directly from Thailand in huge lot size. So they have to have storage capacity to be large enough for at least one lot of products. This makes the company lost opportunity to sale for small and medium distributors. Moreover the lead time of product from the company storage in Thailand to the traders takes about 6-7 weeks. While other major competitors, mainly in Spain and Italy, take only three to seven days to distribute their products to their distributors. Thus they have more advantages in penetrating a wide range of market, new product introduction and high service level. Therefore the company plans to establish a warehouse as a distribution center in Europe in order to penetrate small and medium dealer market, reduce lead time and gain competitive advantage.

A good decision for the location of a supply chain improves the service level and the performance at lower cost. A defective located and sized facility makes efficient service obstacles and causes a cost increase (Azevedo & Ferreira, 2010). So

many companies become more focused on Distribution centres that are in the importance role for cost reduction, customer satisfaction improvement, and optimising their supply chain for the manufacturing, wholesale trade and distribution process. These make them pay more attention to the number and location of their distribution facilities.

To find an appropriate logistics approach and the number of distribution centres for the company's product, it needs to be segmented to find the effect when hold inventory in the supply chain against transportation cost. According product segmentation model adapted from Lovell et al. (2005), the products with low value density and low market volume should plan for regional stockholdings because too many warehouses cause too high holing inventory cost that the profit margin cannot cover the cost of storage and handling. The products with low value density and high market volume should use decentralised storage strategy with multiple distribution centre because many warehouses can increase the service level and the economies of scale can reduce the warehouse operation costs. The products with high value density and low market volume should use centralised storage strategy with global distribution centre and transport by air freight. Because the investment cost and the risk of establishing the warehouse is high, so it is safer and more beneficial to have one global distribution centre and ship by air freight. The products with high value density and high market volume should have more warehouses in the regional area in order to serve more customer and because the higher volume can create higher return on investment. The figure of product segmentation by volume throughput and value density is shown in Table 1;

Table 1 Product Segmentation by Throughput and Value Density

Volume Throughput	Low	High
High	**Decentralise** Multiple Distribution Centre Local Delivery	Regional Stockholdings
Low	Regional Stockholdings	**Centralise** Global Distribution Centre Airfreight

Product Value Density

Products of the company are ceramic tiles. The ceramic tile is categorised in low value density due to the weight that is high and the value is low compare to its weight as same as other construction products. And the market volume according to company's plan for entering the market is quite low. According product segmentation model adapted from Lovell *et al*. (2005), the products with low value density and low market volume should plan for regional stockholdings.

Because the company should concern for the transportation cost along with the inventory holding cost and customer service level, the regional warehouse is appropriate for this ceramic tile company. Due to the expected lead time of customer that should not more than seven days the transportation capability of regional warehouse can serve the customer within target market area. With low market volume of sales a regional warehouse is enough to cover the customer demand and the storage and handling costs are not too high. Although, the cost of transportation to customer is higher than multi distribution centre, the regional warehouse concerning the total cost of supply chain is suitable for this ceramic company.

There are many criteria for location consideration to be concerned because as Lu, C.-S. (2003) state that the international distribution centres should "provide a number of service attributes to shippers, such as storage, cargo tracking, inland transport service, customs clearance service, consolidation, packaging, labelling, assembly and documentation services. Some of these attributes can be expected to be

more important than others to customers, and not all customers attach the same importance to any particular attribute. To develop a distribution centre service responsive to customer needs, it is necessary to determine the individual importance of service attributes."

The distribution centre location decision making under the influence of unique condition of the ceramic tile business needs the specific selection process to serve the company's objectives. Because of the influence of the distribution of commodity resources, demand conditions, as well as transportation and other conditions, different layout options may make the different cost of the entire logistics system, so under the objective conditions, the correct selection of the specific location of distribution centres can effectively save the cost of whole logistics system and guarantee the balanced development of the logistics system (Dongliang et al 2010).

The location criteria that distribution centres factor into their site selection decision include, but are not limited to, market trends, proximity to customers, access to suppliers and vendors, transportation services and cost, telecom infrastructure, labour cost and availability, building and site acquisition and cost, quality educational institutions and training facilities, and regulatory factors (Cuomo, 2008).

Due to the company's strategy, the new market penetration aimed for expansion is Germany. Because of the high demand in ceramic tile consumption and the decreased trend of production, Germany tends to be a big potential market in Europe, according to world ceramic consumption report 2009. (Tile Edizioni, 2011)

However the location can have a long-term impact on the supply chain and the company's strategy. There are a lot of characteristics to be considered and prioritised. So the company needs a systematic selecting model to locate a distribution centre that creates an efficient distribution network.

1.2. Thesis Objective

The objective is to develop distribution centre selection model for ceramic product new market in Germany.

1.3. Research Scopes and Assumptions

1.3.1. Target Markets

The new target markets aimed by the company is Germany that is the countries that still have potential demand among the economic recession in Europe.

1.3.2. Customer

In this case, the customer means the dealers in Germany who make orders for products. It can be both from end customer order and their requirement to build their own stock.

1.3.3. Lead Time

In this research, lead time means a time from placing an order to delivery of the product to the customer. The breakdown of the existing lead time that takes about 6-7 weeks is shown in Table 2.

Table 2 Lead Time Breakdown (Thai Ceramic Co., Ltd.)

	Week1	Week2	Week3	Week4	Week5	Week6	Week7
Oder Received	→						
Stock Available Check	→						
Pick	→						
Consolidate	→						
Load	→						
Over Sea Transport	→						
Load	→						
Custom Clear	→						
Inland Transport	→						
Order Delivery	→						

After the distribution centre is established, the operation processes are cut off such as sea transportation and custom clear. And the expected process contain only

- Oder Received
- Stock Available Check
- Load
- Inland Transport
- Order Delivery

1.3.4. Potential Ports

Due to the properties of ceramic products that are heavy, high density and low product value density, the water transportation should be utilised. So the sea ports that are considered should not too far from the target market such as Port of Rotterdam (Netherlands), Port of Hamburg (Germany), Port of Antwerp (Belgium).

1.4. Methodology

As Renshaw (2002) states that the primary drivers of the site selection process are customer service level and operation costs. So the research methodology is to evaluate in both quality and quantity; (i) collect the requirements and constrains; (ii) comparative analysis; (iii) Feasibility for operation.

1.4.1. Collect the Requirements and Constrains

In collecting requirements and constrains for evaluation, the data sources that may be used in a case study can come from management interview, several documents (secondary data) and third party logistic company. The data that should be concerned are such as;

- estimates of space requirements (peak inventory levels) including safety stock
- required level of service (lead time)
- costs of warehousing and transportation
- infrastructure (roads with hard surface, railway tracks, sea port)
- Taxes and customs duties
- Laws and Regulations
- Costs of labor in the region

1.4.2. Qualitative Comparative Analysis

The main goal in site selection is to optimize customer service while minimizing costs associated with transportation, labor, real estate and taxes (Choomrit, 2005). For the most selection criteria the transportation cost is the most favorite factors but there are other aspects to be considered; the proximity to existing and new customers, the proximity to transportation routes, and the budget. Moreover other criteria are in concern; the truck driver supply, labor costs and availability, real estate costs, taxes, Incentives from the government, and utilities.

Before go through the cost analysis, the qualitative analysis is used to reduce the alternatives that cannot respond the company's objectives that want to reduce lead time to the existing and new target market. The criteria for comparative analysis such as;

1.4.2.1. Proximity to Market

Due to the company's objective that want reduce lead time to not more than 7 days, so the proximity to market is the most important qualification.

1.4.2.2. Road Transportation Connection

The high way access is very important not only because of it can improve the speed of customer due to the transportation time reduction but because the road transportation is also the most popular for inland freight in Europe, as shown in Figure 1 % total inland freight tonne-km in EU-27 (Source: eurostat.eu). So the location of distribution centre should access to highway system and have adequacy of highways and roads.

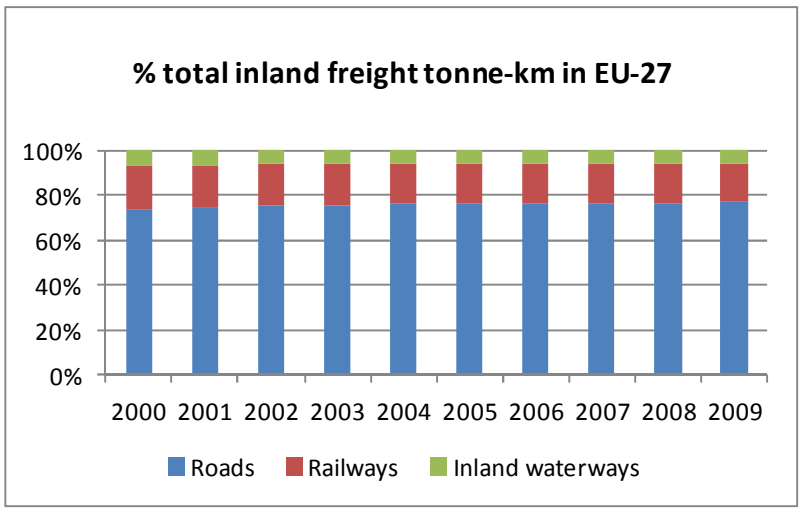

Figure 1 % total inland freight tonne-km in EU-27 (Source: eurostat.eu)

1.4.2.3. Opportunity for Expansion

The warehouse location should have opportunity to enlargement in the future not only in the space dimension but also the government restriction and support such as financial aid for project, tax abatement opportunities, transportation regulation.

1.4.3. Quantitative Comparative Analysis

The last step is to compare the operation cost between the each criteria and alternatives to make the more competitive advantage in pricing. The quantitative comparison is transportation costs, warehousing cost, taxes and customs formalities.

1.5. Research Schedule

Table 3 Research Schedule

	2011					2012		
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Information Gathering	→	→	→	→				
Research of theory and literature Review			→	→				
Evaluation and Analysis				→	→			
Conclusion and Recommendation						→		
Report Preparation and Examination							→	→

1.6. Expected Result

The research result is the decision making process to locate a potential area to be a distribution centre for ceramic product new market in Germany.

1.7. Expected Benefits

The potential area/zone recommended in the research result can give benefits to the company that can

- Reduce the lead time of product from the warehouse in Thailand to the customers in Germany to not more than 7 days
- Create opportunity to sale for small and medium distributors
- Gain advantage in time for new product introduction
- Improve service level.

Chapter 2

Theories and Literature Review

This chapter explains the theories and literature review related to the distribution centre selection criteria and the decision influences for location. The theories and literature review in this research covers 7 topics as follows:

- Roles of distribution centre and warehouse
- Types of warehousing
- Decision criteria for warehousing type selection
- Factor in the warehouse selection decision
- Other criteria for international site selection
- Distribution centre planning process
- Mathematical modelling for distribution centre location analysis

2.1. Distribution Center and Warehouse

The role of Distribution Center and Warehouse are (Baker *et al*, 2010);

- To hold the inventory produced from long production run. Because long production run can reduced production cost per unit by minimising the machine set up time
- To hold inventory to smooth the flow of production in the supply chain and enable an agile response to customer demand
- To hold inventory for large seasonal demands
- To hold inventory to help improve the customer service

- To hold inventory for transportation cost trade off by increasing the vehicle utilisation

- To facilitate order assembly

2.2. Types of Warehousing

There are two main types of warehousing operation that are company and public warehouse. There are many good reasons to choose either public or company warehousing. They both have advantages and disadvantages. The appropriate selection can maximise the benefit but it depends on company's strategy, warehousing plan, budget for investment, etc.

2.2.1. Company Warehouse

Company warehouse is a private warehousing owned, managed, operated and maintained by the company whose products or goods are stored in the building (Gourdin, 2006). Meanwhile, the warehouse facility itself could be happened to be privately owned or leased.

2.2.1.1. Advantages of Using Company Warehouse

2.2.1.1.1. Better Control

The company warehouse can be direct controlled by the management. The warehouse management system can be designed to compatible with the other company's functions to meet company's objectives.

2.2.1.1.2. Lower Cost

If the operating volume is high enough the operation cost of company warehouse is less than public warehouse due to the reduction of margin of profit and marketing cost.

2.2.1.1.3. Product and Marketing Information Feedback

The company warehouse can receive feedback from customers and community and send the information of sales to marketing department. And the information of defects from inspection tests can be sent to production department in order to develop the corrective measures quickly.

2.2.1.1.4. Sharing Office facilities

The company warehouse can let other relevant departments, such as sales and credit, share the office facilities. It also provides the opportunity for better communications between departments.

2.2.1.1.5. Base for Company Truck Operation

The company that own warehouse is better to operate its own truck fleet. The advantages are from effective scheduling to create truck utilization, freight reduction and haul saving.

2.2.2. Public Warehouse

Public warehouse is a type of warehouse operated by a third party that stores goods for multiple shippers (Gourdin, 2006) Any company can store products or goods in these warehouses on payment of rent. A company may have short-term or long-term contact. A license from the government is required to start warehousing to regulate the functions and operations. Mostly public warehouses are used by exporters, importers, manufacturers, wholesalers, etc.

2.2.2.1. Types of Public Warehouses

There are several types of public warehouses performing indifferent services. The examples of types of public warehouse are described below;

1. Commodity Warehouse: The commodity warehouses are built for special storing and specific commodities; rice, cotton, potatoes, tobacco, etc.

2. Bulk Storage Warehouse: The bulk storage warehouses have tank storage built for bulk liquid; chemicals, oil, etc. Their services may include mixing into new mixture.

3. Cold Storage Warehouse: The cold storage warehouses are primary used for perishable goods and special products that need preservation in low temperature; furs, some kinds of chemical, etc.

4. Household Goods Warehouse: The household goods warehouses are built for storing furniture and other household items. Their services may include fleets of moving vans to move the entire household.

5. General Merchandise Warehouse: The general merchandise warehouses are used to store and ship variety of materials. These warehouses can provide many type of warehousing as customer requirements except special temperature control or very specific features of facilities.

2.2.2.2. Advantages of Using Public Warehouse

2.2.2.2.1. Minimum Investment Risk

Buying or building warehouse is a long-term investment that often risky. Public Warehouse can be used without leasing or buying building, storage and handling equipment. Also the investment in labour hiring and training is not needed.

2.2.2.2.2. Lower Cost for Low Volume

The large public warehouse has more resource utilisation such as labour, equipment, space, etc. To establish company warehouse, the volume should high enough to provide steady employment and minimise the cost of operation per item.

2.2.2.2.3. Experimental Warehousing

Because public warehouse has less risk and more experience, the company should experiment the company's distribution system and public warehouse provides the opportunity to experiment for determination of contribution and value for company before starting its own facilities.

2.2.2.2.4. Overflow Warehousing

Public warehouse is suitable for overflow work that beyond the company's storage capacity. The high inventory that should be carried for peak demand and the exceed stock can be handled by outsourcing warehouse.

There are more other special types of warehouse catagorised by special functions or services that can be both company warehouse and public warehouse such as boned warehouse.

2.2.3. Customs Warehouse / Bonded Warehouse:

Customs warehouse or bonded warehouse, or tax warehouse called in EU, is one type of special warehousing that can be either company warehouse or public warehouse. It stores goods pending payment of duty under custom control (Benson, 1994).

Customs warehouses are used to delay the payment of duty and VAT. Till the time that products are delivered to the market concerned. Customs warehouses are operated jointly by Customs & Excise and have to be located in Customs-approved area built to their specifications. As goods stored in the warehouses, traders are allowed to operate some warehouse functions such as breaking bulk, sorting, sampling, repacking, etc. (Coyle, 1992)

2.3. Decision Criteria for Warehousing Type Selection

The use of warehouse reduce total distribution cost by utilising the carrier shipping the big lots and breaking into small lots at the distribution centre before sending to customers. The saving of freight cost from shipping the big lots directly to customer compared to small lots from distribution centre often more than the additional cost of warehouse operating (Jenkins, 1968).

It's important for the company to choose one of two main type of warehousing, either to use public warehousing or company warehousing. There are three criteria affected the decision, (Grant, 2006); (1) financial criteria (2) storage space criteria (3) and operating criteria.

2.3.1. Financial Criteria

2.3.1.1. Use of Capital.

The company warehousing needs large amount of capital for initial investment. While, public warehousing doesn't require the investment from the user. The investment costs include building land, material handling equipment, as well as hiring and training employees.

Depending on nature of business and return on investment, company warehousing operates in lower cost and generates more return in case that the sales are according to the plan.

2.3.1.2. Storage and Handling Cost

Public warehousing can provide exact storage and handling cost base on cases, pallets, weight stored and handle. And the company can forecast costs from different level of activities due to the costs charged pre activity.

Company warehousing is more difficult to determine the precise costs of storage and handling. But in long-term, the operating cost of company warehousing is

less than public warehousing for 15 to 25 per cent on the basis of 75 to 80 per cent of utilisation rate (Jenkins, 1968).

2.3.1.3. Taxes Benefits

Company warehousing can gain advantage from depreciation allowance on equipment and buildings in order to reduce taxes payable.

Public warehousing can gain advantage for some national taxes or VAT avoiding, because the company doesn't own property in a country. Besides, the user pays less in real estate taxes due to the sharing between the users of the public warehouse.

2.3.1.4. Economies of Scale

The economies of scale can reduce operation costs per unit stored and handled. Public warehousing tends to achieve the economies of scale more than the company that less in volume. The economies of scale can provide more efficient material handling equipment, warehouse management system, administrative and other expertise.

2.3.2. Storage Space Criteria

2.3.2.1. Space to Meet Requirement

Company warehousing is suitable for a stable level for product stored in balancing demand and production. On the other hand, public warehousing is suitable for seasonality of demand and production that user can rent as mush storage space as required to meet the peak demand or production.

2.3.2.2. Shortage of Space

Public warehousing is risk for the unavailability of space as the company required. The shortage of space can affect the logistics strategies and marketing strategies of the company.

2.3.3. Operating Criteria

2.3.3.1. Control

For company warehousing, the company can take control all warehouse function and easily to integrate into its total logistics system. Moreover, the company can modify the warehouse facilities in order to fit with its required special handling or storage that can't find in any public warehouses.

2.3.3.2. Flexibility

Flexibility is another major advantage of public warehousing. Due to the availability of short-term contract, the company can change the warehouse location to fit its purposes and strategy adjustment such as market place, mode of transport, volume of product sold, financial, etc.

The company that contracts many public warehousing in many countries for international distribution, has to deal with several different operators and monitor several contractual agreement.

However, the flexibility of public warehousing is limited in some locations for some special handling or storage that is the advantage of company warehousing.

2.3.3.3. Time Risk

By investing in company warehouse, it is expected to a life span of 20 to 40 years, but public warehousing can be switched often within 30 days. The risk of change in business, such as technology or sale volume, can be used to determine the facility solution.

2.3.3.4. Human Resources

Company warehousing can make better use of human resources. With the employee's ownership, they can take better care for products and specialise in handling and storage.

But the risk of company warehouse's employees is the labour dispute that public warehousing doesn't. As Jenkins (1968) stated that *"the courts have ruled that a labour union doesn't have right to picked a public warehouse when the union is involved in a labour dispute with one of the customer of that warehouse."*

2.3.3.5. Communication Problems

Communication problems tend to occur with the public warehousing more than company warehousing. Without standardisation in contractual agreement makes communication incompatible in management system.

2.3.3.6. Specialised Services

For some specialised services, public warehousing can offer more economically than company warehousing because of expertise and economies of scale;

- Broken-case handling
- Packaging for manufacturers' product for shipping
- Consolidation of damaged and recalled products for shipment to the manufacturer in truck load quantity
- Equipment maintenance and service
- Stock spotting product for manufacturers with seasonal product lines.
- Break-bulk service and combine with the order from different customers in the same market and ship with the same truckload.

2.3.3.7. Intangible Benefits

There are other intangible benefits from the customers' perception. The company warehouse represents the stability, dependable and continuity of business operation. Nevertheless, the speed of delivery and service level is the most concerned for customer satisfaction.

2.4. Factor in the Warehouse Location Selection Decision

According to Mulcahy (1994), there are five major factors that affect the operational cost factor influence in the decision.

1. *Transportation factors;* vehicle restrictions, access to good road, rail facilities, water way and high way, location of truck terminal, location of existing and future of venders and customers, etc.

2. *Land factors;* zoning restrictions and requirements, pollution laws, shadow laws, insurance and fire requirement, parking requirement, expansion capability, type of business neighbors, etc.

3. *Tax and Incentive factors;* insurance rates, inventory taxes, property taxes, re-location incentives, employee training programs, employee workers' compensation, free-trade zone status, etc.

4. *Labour factors;* availability of labour, educational level, medium income, number of workdays lost to work stoppages, number of holidays per year, percentage of union and nonunion employees, required amenities, attitude of community toward the business, availability of public transportation, community resources and services, etc.

5. *Utilities and Energy factors;* services and size of pipe of gas and water, quality and services of telecommunication and electricity power, etc.

2.5. Other Criteria for International Site Selection

There are more factors to be considered for country selected to be international warehousing Mulcahy (1994); (1) Value exported country's currency to host country's currency (2) Stability of the government (3) Stability of currency (4) Ability to take profits (5) Population attitude toward a foreign company (6) Government attitude toward a foreign company (7) Import and export regulations (8) Availability of required material handling equipment (9) Free-trade agreement between countries (10) Culture and customs of the host country

2.6. Distribution Centre Planning Process

By Donald J. Derewecki (2003) provide the five-step process to plan for a new distribution centre that improves supply chain effectiveness.

2.6.1. Step One: Determine the requirements the new facility must satisfy.

The primary requirement is space calculated from the inventory needs with a 20 percent deviation. The estimated volume of stock keeping units (SKUs) should include all critical design elements such as the associated cube, velocity, seasonality, and handling characteristics.

A distribution centre should be used to gain opportunities to balance receiving and shipping peaks. By coordinate with marketing department to forecast the customer needs, the order projection statistics also must be factored into design.

Moreover the company should think in terms of requirements five to seven years into the future to prevent additional investment and operational expenditures.

2.6.2. Step Two: Determine the feasible alternatives to satisfy the requirements.

In this step the alternatives that have any limitation or conflict to company constrain are cut off such as the availability of capital, information systems resources, acceptable levels of risk, requirements for flexibility, and uncertainty about the future direction.

2.6.3. Step Three: Analyse the viable alternatives, both qualitative and quantitative aspects.

In qualitative analysis the aspects to be considered in the process include:

- Flexibility for the operation adapts to changing operations requirements. The mechanized and/or automated components of the system can be upgraded and/or modified at reasonable expense
- Difficulty of implementation
- Difficulty of maintenance
- Evaluate the training need at start-up and ongoing operation
- The reliability of the warehouse management system
- User-friendliness of the information and material handling systems components

Derewecki suggests using computer simulation to evaluate for the quantitative analysis. But in case that the simulation cannot be used, he provides the static testing to determine which alternative best meets corporate financial requirements include the following guideline;

- Flows. There should not be any bottlenecks in the process or layout that restrict movement of materials move into, within, and out of the facility.

- Picking and storage modules. The picking modules should be enough and appropriately sized for the inventory profiles.

- Mobile equipment. It should contain the right types and capacities for each functional requirement and be enough equipment to meet peak requirements.

- Conveying and sortation equipment. It should have the right types and capacities in each zone.

- Staffing. Estimate the people required to run the operation.

- Capital budgets. Include facility-related costs, equipment, and information systems software and hardware.

- Comparative annual operating budgets. Include staffing, maintenance, utilities, and information systems costs.

2.6.4. Step Four: Make and document the rationale for decisions.

This step is to prepare the rationale and justification presentations for convincing the management committee.

2.6.5. Step Five: Implementation

The company have to coordinate with several departments including real estate, legal, finance, and human resources for project planning and control since construction to start-up and debugging.

2.7. Mathematical Modelling for Distribution Centre Location Analysis

In quantitative evaluation, the total cost function considers the three performances involved with transportation and storage of goods in distribution system. The three functions are the distribution centre, the transportation from plant to distribution centre, and the transportation from distribution centre to customer (Eilon, et al., 1971). Therefore the total cost function is;

$$C = F + G + H$$

Where F = cost of distribution centre in the system

G = transportation cost from plant to distribution centre

H = transportation from distribution centre to customer

2.7.1. Distribution Centre Cost

The costs of warehouse operation consist of;

- Rental Cost of space (including maintenance, energy charges)
- Inventory holding cost
- Handling cost
- Cost of administration
- Costs of other services

There are combined to the distribution centre cost function that is

$$F = a + f(W)$$

Where a = fixed costs of distribution centre

f(W) = variable costs of distribution centre which depend on the throughput, W.

The throughput is used to calculate the variable cost because it can refer to required space and handling cost. In some cases the inventory level and used area of storage are indicators instead. The different warehouse providers have different functions to calculate f(W).

2.7.2. Cost of Transportation

There are many factors affected the transportation cost such as

- Medium of transportation; ail, road, air, sea, etc.
- The size of carrier
- Typed of goods that affect the method of loading and unloading

The function of transportation cost from plant to distribution centre can be assumed as;

$$G = \beta_0 + \beta N d$$

Where β_0 = fixed costs per container or per vehicle

β = cost per unit distance to transport a container

N = total number of containers

d = distance of transportation. It can be in straight line or actual distance

The function of delivry cost from distribution centre to customers can be assumed as;

$$H = \sum_{i=1}^{m} (\alpha_i w_i d_i)$$

Where α_i = delivery cost per unit distance per unit

w_i = amount of goods delivery to customer i

d_i = distance of transportation from distribution centre to customer i

2.7.3. Single Distribution Centre Location for Deterministic demand

There are several methods to examine the feasible location of warehouse when the demands of customers are determined. The simply method that widely used to minimise the transportation cost is centre of gravity method. The centre of gravity method is to use by considering the distances between facilities, and the volumes of goods to be shipped between them. The co-ordinates of the centre of gravity are calculated by;

$$X_0 = \frac{\sum w_i X_i}{\sum w_i} \quad \text{and} \quad Y_0 = \frac{\sum w_i Y_i}{\sum w_i}$$

Where X_0 = X coordinate of center of gravity

Y_0 = Y coordinate of center of gravity

X_i = X coordinate of the location i

Y_i = Y coordinate of the location i

w_i = amount of goods delivery to facility i

An alternative method is to employ the weight of cost of goods transportation rates. The co-ordinates of the centre of gravity are calculated by;

$$X_0 = \frac{\sum \alpha_i w_i X_i}{\sum \alpha_i w_i} \quad \text{and} \quad Y_0 = \frac{\sum \alpha_i w_i Y_i}{\sum \alpha_i w_i}$$

Where α_i = delivery cost per unit distance per unit

X_0 = X coordinate of center of gravity

Y_0 = Y coordinate of center of gravity

X_i = X coordinate of the location i

Y_i = Y coordinate of the location i

w_i = amount of goods delivery to facility i

Chapter 3

Methodology

This chapter explains the details of methodology of distribution centre location selection model into 3 following topics;

- Concept of Model Creation
- Design of the Model's Steps
- Distribution Centre Location Selection Model

3.1. Concept of Model Creation

There are many theories for location selection of site and warehouse including supply chain strategy decision. The distribution centre location selection model is designed based on distribution centre planning process by Derewecki (2003). Because this process is suitable for the company due to steps that provided for the real business situation. The process starts with gathering required information then using the information to determine the feasible alternatives to satisfy the requirements. Besides, it contains guideline to analyse the viable alternatives both qualitative and quantitative.

Other theories of supply chain facilities design are such as product segmentation model of Lovell (2005), warehousing type decision of Grant (2006), mathematical modelling for distribution centre location of Eilon (1971). These have difference in scope for consideration that used to select the warehouse location and the results from each theory make the logistics system suitable for business and more efficiency. So using altogether systematically can narrow the alternatives that can be the right answer for the company.

3.2. Design of the Model's Steps

By considering, the product segmentation model of Lovell (2005) is the widest scope because it is to design the number of facilities required for the whole supply chain. So Lovell's model is the first step of distribution centre location selection model. Then the warehousing type decision of Grant (2006) is the second because the type of warehouse decision depends on financial criteria that the company should know the warehousing strategy, the number of warehouses, before making further decision. Moreover, the type of warehouse can clarify and get the direction for the company. Lastly, in order to narrow down the alternatives for step 2 of distribution centre planning process of Derewecki, to determine the feasible alternatives to satisfy the requirements, choices of scenario are set based on cost function according to mathematical modelling for distribution centre location of Eilon (1971).

3.2.1. Create Warehousing Strategy

According to Lovell (2005) before designing the supply chain and logistics network, the enterprise should set the strategy that make warehousing and transportation conformed to the value density of product and volume throughputs. The warehousing strategy results in an appropriate number of distribution centres and logistics approaches. So the first step of distribution centre location selection model is to design the warehousing strategy by adapted the Lovell's product segmentation model.

3.2.2. Choose Warehousing Type

After the company know the warehousing strategy and the number warehouse needed. The next step is to identify warehousing type because in warehouse selection process of Grant (2006), suitable type of warehouse for the company should be decided in order to take the advantages of the warehouse operation to maximise benefit and reduce cost.

So, the second step of distribution centre location selection model is to choose the warehousing type by finding the advantages of each type of warehouse that

according to company strategy and market situation in three aspects; financial, space and operation. Then selecting more specific type of warehouse is needed to be considered to gain more advantages for the company.

At this step, the data is needed to be collected and analysed. The data required for this step is business model and marketing strategy. Strategies of business model are such as product positioning, value chain structure and competitive strategy. Marketing information is such as annual demand forecast, location of customers, required service level. This information is analysed to make a decision for appropriate type of warehouse.

3.2.3. Design Warehousing Location Scenarios

The third step is to design warehousing location scenario based on Eilon's mathematics model for distribution centre location analysis. In this step, the scenarios are compared by using both quantitative and qualitative with acquired information to minimize scope of focus.

So, the data needed to be collected and analysed is logistics facilities, ports, transportation distance and costs. Then scenarios are analysed and compared to each other in both qualitative and quantitative.

3.3. Distribution Centre Location Selection Model

In summary, the distribution centre location selection model for ceramic product new market in Germany has four major steps for making a decision that are;

- Create Warehousing Strategy
- Choose Warehousing Type
- Design Warehousing Location Scenarios

Figure 2 The distribution centre location selection model

Chapter 4

Data Collection

This chapter explains the details of data collection for making decision according to the distribution centre location selection model into 3 following topics;

- Business model for new market in Germany
- Marketing plan for new market in Germany
- Ports

4.1. Business Model for New Market in Germany

From management interview with Mr. Somkul Boonma, International Trading Manager of Thai Ceramic Company Limited, the company sets business strategy to expand ceramic tile market in Europe. Mr. Boonma (2012) stated that to enter the medium retailers in Germany, with company should carefully plan for product quality, positioning, brand image, and supply chain integration that the distribution centre is one of those important keys for business success.

4.1.1. Value proposition

The company found the opportunity in ceramic tile market Germany that is the most interesting. Due to the economic recession in Europe, Germany still has strong economy. Though the domestic ceramic consumption is decreased, the import value still stable and tend to increase because of the reduction of production trend.

Compare to France that is the leader of ceramic tile importer in Europe, Germany is the second with a bit lower. But the market situation France is more competitive due to positions of major competitors that are in Italy and Spain that closer

to France. Besides, the sharp decrease in demand of France from economic crisis shows the threat of the market instability.

4.1.2. Market segment

The ceramic tile products are segmented by the usability such as wall tile, floor tile, swimming pool tile, or other special purposes. The segments that company wants to expand the market are floor tile and wall tile of the experiences and world-class standard of design and production. The company aims to the medium to high segment of floor and wall tile products that is more profitable. With the high product quality, innovative design and high service mind, these are strengths for product introduction into the new market.

4.1.3. Value chain structure

The company wants to strengthen the value chain structure by improving the distribution channel to customers. By having the distribution centre, the company can gain opportunity to sale in small and medium shops. Moreover the value of service in value chain can increase due to the reduction of lead time of product and service solution provided.

4.1.4. Positioning

The company attempts to change the perception of European customers from an Asian producer to a world-class producer by attending many international exhibitions and events in many countries such as Spain, France, Italy, etc. (Thai Ceramic Co., Ltd.)

Although, the company's brand perception is a global brand, the products are positioned a bit lower pricing than other competitors in the same segment.

Because the ceramic tiles are often sold in high volume, the total price of purchasing makes significant difference for customers' decision making.

4.1.5. Competitive Strategy

The competitive strategy is to serve the high quality products with responsive services to customers. These include the innovativeness of design to create fashionable products or uniquely new and marketable that is very attractive to customers. The precise forecasting strategy is also needed by using the effective and experienced market vision. Moreover the lean product introduction process is implemented.

The company's supply chain strategy is to set up a distribution centre for products that are in medium to high segment because they are not only more beneficial but the inventory is also not too much volume. The inventory turnover of products often is high because of its cost that is high so the dealer won't like to keep it too long.

4.2. Marketing Plan for New Market in Germany

For developing the marketing plan, Mr. Suphakit Jongsadjanulux, Sale Executive Assistant, Export Department of Thai Ceramic Company Limited, stated that the company estimates the annual demand from the new market by discussing with the existing customers and creates marketing strategy by gathering information from international events such as company road show, etc.

4.2.1. Expected of Annual Sales

From the company's forecast for the new target market sales, there are four potential medium-distributors in Germany that are Weimex GmbH, Auer Fliesen GmbH, Heinrich Taxis GmbH, and Knief & Co. GmbH. The annual demand forecast in square meter is shown in Table 4.

Table 4 Annual Demand Forecast of New Target Market in Germany (square metre)

Product Group	Weimex GmbH	Auer Fliesen GmbH	Heinrich Taxis GmbH	Knief & Co. GmbH
Overall Result	24,618	7,985	21,143	24,618
Extra	3,283	-	-	-
Deluxe	-	1,138	2,276	3,414
Empress	4,513	6,848	11,519	6,576
Granite	161	-	586	221
Mosaic	11,333	-	-	9,025
Glazed Porcelain	318	-	1,081	514
Glass Tiles	21	-	42	63
Outsource	1,700	-	4,560	3,955
White Body	3,288	-	1,080	850

4.2.2. Required level of service (lead time)

The company set the other level of service as the period of lead time from customer order placing to product delivering. The required lead time from the company is maximum seven days.

By benchmark with other major competitors, mainly in Spain and Italy, they can deliver products within three to seven days to their customers. Thus in order to compete with other competitors, the company requires at least the same lead time as them. The locations of the four of target market are shown in Figure 3;

Figure 3 Location of New Target Market

4.2.3. The required advantages the company

The company wants the experimental warehousing that can test the market and logistics system. And the result is used to evaluate for setting up the strategy to expand the market, increase the capacity or outsource.

The positioning of products is not the low price ceramic tile. The company's expected product perception is in fashionable with medium to high price. So the quality of services and delivery is importance following with the cost of operation.

4.3. Ports

The port selection is also an important factor affected the logistic cost. There are many criteria that the company concerns about such as facilities, proximity to market, availability of transportation, etc. So the company prefers some ports of choice that are deep-sea ports which are quite big and busy.

The advantage of busy ports is that products won't waste more time waiting for full-container consolidation. The big ports are also fully provided with facilities, transportation networks and logistics brokers that can facilitate the company's business such as transportation modes, logistics planning, custom clearance and etc.

According to the company's requirement, there are three potential ports close to the market, on which the company focuses, that are Port of Rotterdam (Netherlands), Port of Hamburg (Germany) and Port of Antwerp (Belgium). The locations of them are shown in Figure 4;

Figure 4 Location of Potential Ports

4.3.1. Port of Rotterdam

The Port of Rotterdam is the largest logistic and industrial hub in Europe, located in the city of Rotterdam, Netherlands. With the advantages of the extensive network of transportation modes such as rail, pipeline, road and sea, goods are delivered fast, efficiently and competitively.

The port of Rotterdam offers excellent rail transport connections for transporting large quantities of cargo over long distances, to most of Europe's important industrial areas. By the Betuwe Route, cargo railway link to Germany, It takes less than 12 hours for destinations in Belgium and Germany.

For road transportation, there are many logistics companies to carry the goods to the front door of the customers. The A15 motorway is the core of the port's road transport system, which creates excellent connections to the national motorway system.

The port of Rotterdam is also the strong link for every type of break-bulk before importing into Europe.

4.3.2. Port of Hamburg

The Port of Hamburg is the largest port in Germany in the city of Hamburg, Germany, on the river Elbe. It is the second-busiest port in terms of TEU throughput in Europe after the port of Rotterdam.

The port of Hamburg is located in the leading logistics locations in Northern Europe. In this area, there are well over 1,000 storage and logistics companies with a wide range of storage-related services: Customs clearance, commissioning, quality controls, labelling and packing or distribution to the relevant destination.

For transportation modes, this is very quick and flexible in freight distribution. The port of Hamburg is an important transhipment centre in Europe. The port railway network connects the terminals to railways in Germany and throughout Europe. The highway system links Hamburg to the neighbouring industrial region as well as to international business centres.

4.3.3. Port of Antwerp

The port of Antwerp, in Belgium, is the largest warehouse storage capacity in Europe. It's located in the inland location that is more central location in Europe than the majority of North Sea ports.

There are numerous logistics and distribution centre companies in and around Antwerp, offering a whole range of efficient, advanced services as added value activities such as customs clearance, repackaging, labelling, quality control etc. This concentration of service providers and the high degree of flexibility ensure that an appropriate response can always be found to every transport requirement, even the most specialised and unique.

The logistics of Belgium are reflected in the presence of numerous European. The port of Antwerp is very centrally advantageous located within the European network. All the neighbouring countries can be reached quickly and easily by road from the port. Intermodal operators run frequent shuttle services, connecting the Port of Antwerp with the European hinterland. Antwerp has 5 rail freight terminals and all

the large shipping container terminals in the port have their own rail terminal offering direct connections to the main economic centres of Europe.

Chapter 5

Data Analysis and Results

This chapter explains the details of data analysis and results into 8 following topics;

- Order winners and qualifiers
- Company warehouse or public warehouse
- Select type of public warehouse
- Transportation scenario
- Cost analysis
- Sensitivity analysis
- Analysis results
- Cost comparison results

5.1. Order Winners and Qualifiers

According to the products perspective of the company's target market that are fashionable goods so order winning criteria should be brand image, Innovativeness, time to market and price. And order qualifying criteria needed to maintain products in the market are product quality, packaging, variety and availability. These get along with the company's strategy that is to set up the distribution centre. However the company should trade off between the time to market and the cost of warehousing. The first decision is to select the type of warehousing between public and company own.

5.2. Company Warehouse or Public Warehouse

According to Grant (2006), the company should use three criteria to make a decision whether to use public warehousing or company warehousing; (1) financial criteria (2) storage space criteria (3) and operating criteria.

5.2.1. Financial Criteria

5.2.1.1. Use of Capital.

Because the company wants to experiment the distribution centre system in Germany, so it doesn't need as huge investment as warehouse building or buying. Moreover, nature of business of commodity products the profit margin is low so return on investment depends on volume. So the company should have high volume of sales enough before invest in its own warehouse.

Hence, for the capital aspect, public warehouse is more appropriate to this company that required low Initial startup cost.

5.2.1.2. Storage and Handling Cost

For the initial test of distribution system in Germany, the company needs the storage and handling cost to be identified exactly from any different level of activities to evaluate the value gain from logistic improvement and calculate for return on investment. So the public warehouse is suit for this company in order to know the cost exactly and able to forecast the expenses.

5.2.1.3. Taxes Benefits

For Taxes benefits aspect, public warehouse can provide more advantages to the company than company warehouse. Because public warehouse, such as bonded warehouse, can postpone VAT until the goods shipped to customers.

5.2.1.4. Economies of Scale

Because of low volume sales, the company should use public warehousing to gain advantages from economies of scale.

5.2.2. Storage Space Criteria

5.2.2.1. Space to Meet Requirement

Because of unknown of exactly demand of new market, the space requirement can be fluctuated. So it'd better to use public warehousing in order to prepare for unstable demand.

5.2.3. Operating Criteria

5.2.3.1. Control

Due to the company doesn't want to control the warehouse and it's better to let public warehouse that has more expertise control the warehouse functions and distribution in the local area.

5.2.3.2. Flexibility & Time Risk

The company needs the flexibility, so the short-term contract of public warehouse is more appropriate than own the warehouse that contain the time risk before it's feasible. The company can change the warehouse location to support the strategy that depended on market situations, cost of warehousing, transportation, etc.

5.2.3.3. Human Resources

Due to the inexperience in personnel and labour union in European country, the company should reduce risk by using the public warehousing that has more expertise in human resource management.

5.2.3.4. Specialised Services

For using public warehouse, the company can utlise some expertise of services, that more economically because of and economies of scale. For example, the service to break-bulk, combine with the order from different customers in the same market and ship with the same truckload can reduce the transportation cost.

5.3. Select Type of Public Warehouse

The type of public warehouse suitable for ceramic tile is general merchandise warehouse, because the product doesn't need special handling or controlled temperature. Moreover the warehouse storage and material handling equipments are in common to the other general lines of products.

For more specific type of warehouse that gain advantages for the company is customs warehouse. Because the major opportunity is the company can delay the payment of duty and VAT until the products delivered to customers. Moreover the company can use stocks to be buffers for unexpected demand from other countries nearby.

5.4. Transportation Scenario

According to mathematical model for distribution centre location analysis of Eilon (1971), the total cost function considers from the warehousing costs, the transportation from plant to warehouse and the transportation from distribution centre to customer. So the company should set the cost based scenarios for location selection to minimise the cost and optimise the delivery time.

5.4.1. Low Cost Warehousing

The first scenario is to find the warehouse that has the lowest cost of operation. With low warehousing cost, there may be many facilities to be traded off such as service quality, distance from port and/or market, accessibility to highway, expertise in administration, etc. If the warehouse location is far away from port and customers, not

only the cost of transportation increases but also the time to markets. For that reason, the warehousing cost should be low enough to be attractive for investment.

However, this scenario is the least interesting because for the warehouse location selection, the transportation distance is concerned more than the cost of warehouse. Since the major proportion of logistic cost is transportation cost and much more than warehousing cost. Including the characteristics of ceramic products, they make the indifference in warehousing cost for general merchandise warehouse due to the general treatment. (Greenhalgh, 2011) Moreover in the future trends, the transportation cost tends to increase due to the fuel cost and when market volume expanded. Lastly, the chosen type of warehouse that is custom warehouse is the limitation of warehouse location selection because the customs warehouses are mostly established near ports or industrial estates.

5.4.2. Customer Centric

The second scenario is to find the warehouse close to markets. The benefit of warehouse that is close to market is the lower cost of break-bulk carriers. And the transportation from port to warehouse in a big lot size is more cost effective. Moreover, the transportation cost from distribution centre to customer and delivery time is less than other scenarios with the best time to market. Nevertheless, the warehousing cost of distribution centre that is close to the city centre is often higher due to the cost of land.

5.4.3. Port-Centric

The third scenario is to find the warehouse close to the port or port-centric. The advantage of warehouse that is close to port is the lower cost of warehousing and transportation form port to warehouse than moving items miles away to warehouses. The port centric zones tend to be more secure.

Another significant advantage of port centric is the availability of port facilities. Trucks have a direct access to retrieve and deliver containers. Since trucks do not require to break bulb of the containers due to weight restrictions of local roads. There is thus the potential to take full advantage of the weight limits of container loads and have more freight loads being carried.

Port-centric is also lower freight handling costs in the supply chain. Port-centric logistic zones can maximize the efficiency of transloading facilities, and the utilisation of containers that they are able quickly repositioned to loading locations. Moreover using 'DC bypass' and cross-docking method, the products can be conglomerated with other customers' goods in the same or nearby district and shipped together to reduce the transportation cost.

The most advantage of warehouse that is close to port is for the future market expansion beyond Germany because products can be quickly shipped to the port and distributed to all over Europe.

Though there are many advantages in using port-centric warehousing. Nevertheless, the limitation of port-centric warehouse is the distance from target market that most of the customers should be within 600 km delivered directly by trucks. According to company's target customers within Germany, all of them aren't too far away from potential ports for one-day delivery. The duration from port to each customer is shown in Table 5.

Table 5 Duration of Transportation from Port (hours)

Customers \ Port of	Rotterdam	Hamburg	Antwerp
WEIMEX GMBH	2:59	2:58	2:49
Auer Fliesen GMBH	8:16	7:37	7:40
HEINRICH TAXIS GMBH	5:33	5:54	4:53
KNIEF & CO. GMBH	3:47	1:09	4:11

5.5. Cost Analysis

Actually, the cost analysis should be the comparison of cost of the whole supply chain for each strategy. However, there is some information that is still unavailable for calculating the whole supply chain cost. Hence, these are the cost comparison of the major expenses in international logistic used to be compared such as transportation cost, warehousing cost, tax and customs duties.

5.5.1. Taxes and customs duties

For custom duties of company's products, European Commission (2012) catagorise them in two groups of harmonized code that are 6907 and 6908. These are authorized in Netherland, Belgium and Germany so the port decision won't affect the custom duties.

6907 is for the group of products that are unglazed ceramic flags and paving, hearth or wall tiles; unglazed ceramic mosaic cubes and the like, whether or not on a backing. The custom duty for the third country is 5.00 %.

6908 is for the group of products that are glazed ceramic flags and paving, hearth or wall tiles; glazed ceramic mosaic cubes and the like, whether or not on a backing. The custom duty for the third country is 7.00 %.

For value added taxes (VAT), according to The German VAT law implemented by the Federal Parliament based on the EU VAT Directive, German tax law is administered by the 16 federal states (Bundesländer) with standard rate 19% (since Jan 2007) (TMF Group, 2009).

5.5.2. Warehousing Cost

The warehouse cost is compared by using cost of handling and cost of space because the almost public warehouse charge for operation cost based on activities occurred in warehouse.

The handling cost is varied by the amount of goods sold. The amount of ceramic tile per pallet is approximate 70 m^2/pallet by average. (Jongsadjanulux, 2011) The estimated amount of pallets transported to each customer is shown in Table 6.

Table 6 Amount of Pallets Transported to Customers per Annual

Customer	sale (m2)	Pallets
WEIMEX GMBH	24,618	352
Auer Fliesen GMBH	7,985	114
HEINRICH TAXIS GMBH	21,143	302
KNIEF & CO. GMBH	24,618	352
Total	78,365	1,120

The cost of space requirement is estimated by using target inventory turnover rate and forecasting peak inventory demand including safety stock. Due to the positioning of product in medium-high position, company's products are catagorised in fast moving good with 2-week turnover. So the required space is about 43 pallets with including 20% allowance the required space is 56 pallets.

So the supplier selection process should these data of total goods transported and space required for calculating the total warehousing cost. For example the average of annual rental cost of warehouse in Hamburg is 67 Euro/m^2, Antwerp is 45 Euro/m^2 and Rotterdam 40-60 Euro/m^2. Then the transportation cost should be added for logistic cost comparison, supplier selection and feasibility study.

Moreover, the warehouse supplier charges the management fee for other document operation such as customs clearance etc. The management fee would be

charged in percentage of total cost such as 10% of warehouse operation cost. This cost should be added to evaluate the total warehousing cost.

5.5.3. Transportation Cost

The transportation cost is compared by using transportation activities. Because the almost transportation activities happen in Germany so it depends on supplier selection to find the lowest price per ton-km. The transportation activities (in ton-km) is calculated by amount of good transported (in ton) multiply by distances (in kilometre).

The weight of ceramic tile is approximate 13 kg/m^2 by average (Jongsadjanulux, 2011). The estimated weight of good transported to each customer is shown in Table 7.

Table 7 Weight of Good Transported to Customer per Annual

Customer	sale (m2)	weight (kg)
WEIMEX GMBH	24,618	320,039
Auer Fliesen GMBH	7,985	103,811
HEINRICH TAXIS GMBH	21,143	274,857
KNIEF & CO. GMBH	24,618	320,039
Total	78,365	1,018,747

5.5.3.1. Centre of Gravity Method

The centre of gravity can be calculated by using co-ordination refer to latitude and longitude of each customer's location (and port) and volume of good transport as shown in Table 8.

Table 8 Co-ordination and Volume of Good Transport of Each Customer's Location

	X	Y	Weight (ton)
WEIMEX GMBH	7.72447	51.79406	320,039
Auer Fliesen GMBH	11.99127	48.33045	103,811
HEINRICH TAXIS GMBH	9.26439	49.05718	274,857
KNIEF & CO. GMBH	8.83301	53.04121	320,039
Port of Rotterdam	4.48451	51.90472	1,018,747
Port of Hamburg	9.99415	53.54426	1,018,747
Port of Antwerp	4.41170	51.22952	1,018,747

The results of centre of gravity calculation between customers and the port are shown in Table 9.

Table 9 Centre of Gravity when Using Different Port

	X	Y
CG1 (Using port of Rotterdam)	6.70374	51.49961
CG2 (Using port of Hamburg)	9.45856	52.31938
CG3 (Using port of Antwerp)	6.66734	51.16201

Then, the distance between each centre of gravity and their customers and port is figured as shown in Table 10.

Table 10 The Distance between each Centre of Gravity and Customers and Port

	CG1	CG2	CG3
WEIMEX GMBH	116	156	131
Auer Fliesen GMBH	662	666	625
HEINRICH TAXIS GMBH	404	495	371
KNIEF & CO. GMBH	269	138	307
Port	194	170	199

Finally, the total transportation activity of each centre of gravity in ton-km is calculated as shown in Table 11.

Table 11 Total Transportation Activity of Each Centre of Gravity in ton-km

	CG1	CG2	CG3
WEIMEX GMBH	37,125	49,926	41,925
Auer Fliesen GMBH.	68,723	69,138	64,882
HEINRICH TAXIS GMBH	111,042	136,054	101,972
KNIEF & CO. GMBH	86,091	4,165	98,252
Port	197,637	173,187	202,731
sum	500,617	472,471	509,762

According to the total transportation activity in ton-km, the CG2, the centre of gravity of Port of Hamburg has the lowest result, 472,471 ton-km, that is lower than the centre of gravity of Port of Rotterdam 5.6% and lower than the centre of gravity of Port of Antwerp 7.3%. This leads to the lowest cost among other centre of gravities.

5.5.2.3. Port Centric

The transportation activity of port centric method uses the calculation of weighed distance between each warehouse in port centric area and customers. The distance between port and customers is figured as shown in Table 12.

Table 12 Distance between Port and Customers

Customers \ Port of	Rotterdam	Hamburg	Antwerp
WEIMEX GMBH	294	306	284
Auer Fliesen GMBH.	849	787	789
HEINRICH TAXIS GMBH	567	616	511
KNIEF & CO. GMBH	388	116	437

Assuming the distance from port to the warehouse in port centric area is not more than 10 kilometers. The total transportation activity of each warehouse in port centric area in ton-km is calculated by weighed data from Table 4 as shown in Table 13.

Table 13 Total Transportation Activity of Each Port in ton-km

ton*km	Port of Rotterdam	Port of Hamburg	Port of Antwerp
WEIMEX GMBH	94,092	97,932	90,891
Auer Fliesen GMBH	88,135	81,699	81,907
HEINRICH TAXIS GMBH	155,844	169,312	140,452
KNIEF & CO. GMBH	124,175	37,125	139,857
Port (10 km from port)	10,187	10,187	10,187
Sum	472,434	396,255	463,295

According to the total transportation activity in ton-km, the Port of Hamburg has the lowest result, 396,255 ton-km, that is lower than the activity of Port of Rotterdam 16.1% and lower than the activity of Port of Antwerp 14.5%. This leads to the lowest cost among other port centric areas.

Comparing the transportation activities of the warehouse at the centre of gravity of port of Hamburg, 472,471 ton-km, with the warehouse in port centric area, 396,255 ton-km, the port centric has less activity for 16.1%. So the port centric area of Hamburg is the best area for warehousing in concern of transportation activities.

5.6. Sensitivity Analysis

The sensitivity analysis is discussed about the uncertainty of customers. The variation of demand is one of important factors that affect the model result. For example, when the demand change the centre of gravity is changed so the calculation for new solution of location should be reconsidered.

According to the company's annual demand forecast for the new target market sales in Table 4 and the location is shown in Figure 5. As the demand of each customer changed, it can affect the result of calculation that Port of Hamburg is the least transportation activity.

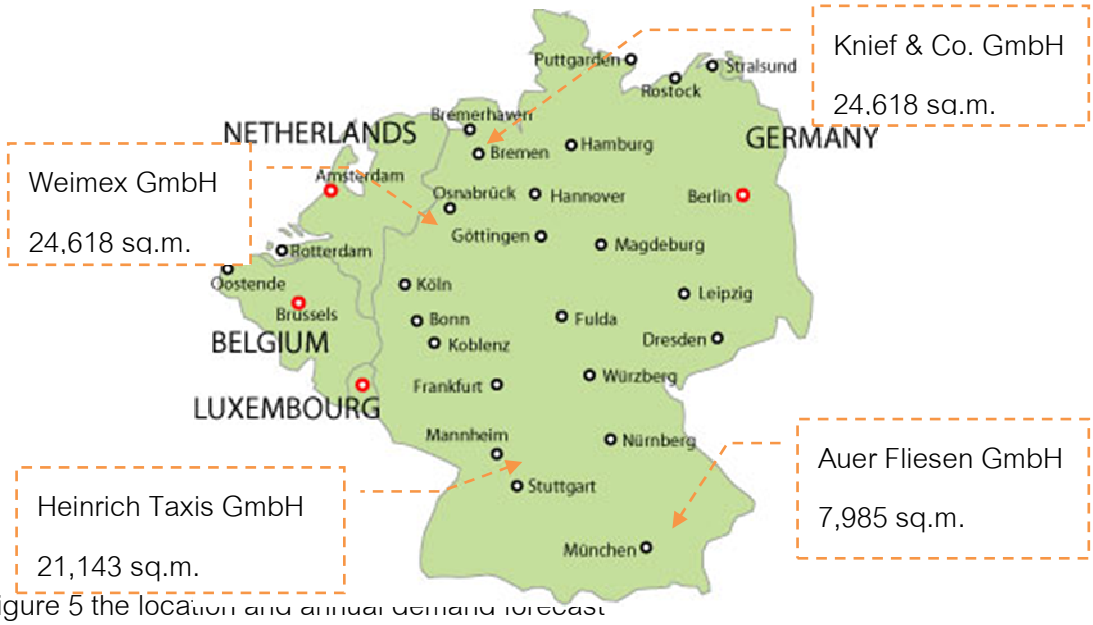

Figure 5 the location and annual demand forecast

So the sensitivity analysis is to analyse the transportation activity difference between port of Hamburg and port of Rotterdam and Antwerp while each demand is set to change to increase for 25% as shown in Figure 6.

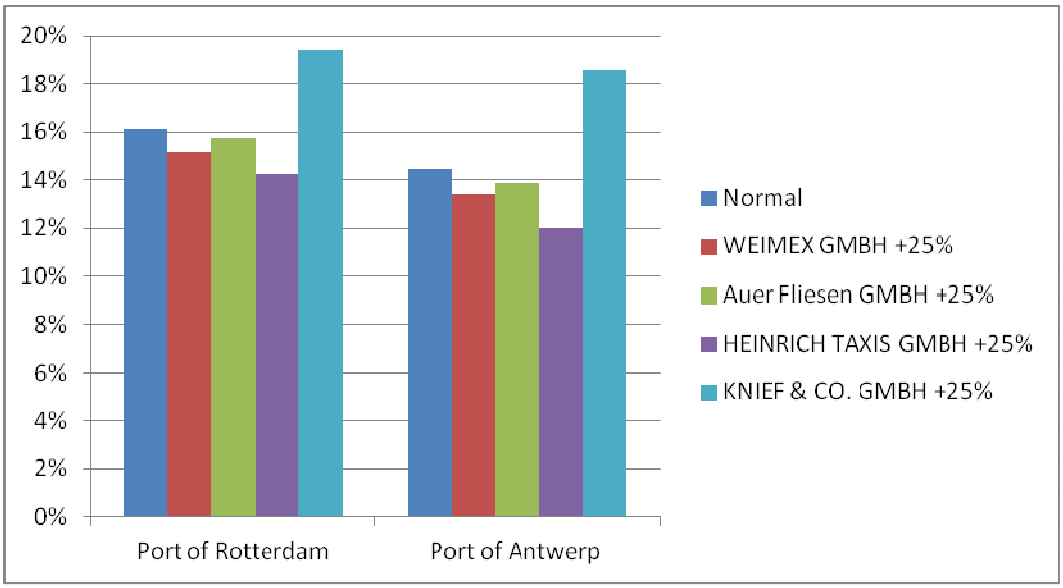

Figure 6 sensitivity analysis of demand change

From Figure 6, it's only KNIEF&CO. GMBH that the transportation activity difference increases as the demand increase. Moreover, the Heinrich Taxis GMBH is the most sensitive to the result because the transportation activity difference is lower more

than other customer demand change. However, the transportation activity of port of Hamburg is still the lowest among others.

The first possible situation that the transportation activity of port of Hamburg is higher than port of Antwerp; the demand of Heinrich Taxis GMBH should increases more than 200% of the annual forecast and others demand are the same. This case is too extreme to happen within 5 years. However, the warehouse location should be re-considered when there is unexpected situation with serious effect occurred.

The sensitivity analysis result shows that the most effective variable for transportation activity is the customer who is the nearest to other ports. As the model bases on transportation activity in ton-km, the port should be close to the customer with the highest demand. The demand change of this zone should be monitored because it can affect the model result and lead to be disadvantages of the company in term of cost and services.

5.7. Analysis Results

The analysis result for regional stockholding facility using the business strategy, product characteristic and positioning to consider the appropriate type of warehouse using criteria as financial, space requirement and operating criteria, the characteristics of required distribution centre for new target market in Germany of Thai Ceramic Company are;

5.7.1. Warehouse Type

The type of warehouse that is suitable for ceramic tile is customs warehouse which is public warehouse. Because of the company business strategies, marketing plan and products, public warehouse can gain advantages from economies of scale, flexibility for unknown of exactly demand, risk reduction from lower investment and their experience in personnel and labour union in European country. The customs warehouse can gain advantages from VAT postponement and future market expansion to other countries nearby.

5.7.2. Transportation Scenario

The transportation scenario that is suitable for the company is port-centric because of two main reasons, the availability of port facilities and agencies, and lower freight handling costs in the supply chain. As the appropriate type of warehouse for the company, many customs warehouses are available in port-centric area. Nevertheless, due to the low volume of throughputs of the company, using port-centric for transportation scenario can gain advantages from economies of scale and lower freight handling costs in the supply chain.

5.7.3. Selected Ports

The ports of choice that company preferred are deep-sea ports which are quite big and busy due to the concerned criteria of facilities, proximity to market, and availability of transportation. According to the company's requirement, there are three plausible potential ports that are Port of Rotterdam (Netherlands), Port of Hamburg (Germany) and Port of Antwerp (Belgium).

5.8. Cost Comparison Results

The port and warehouse selection does not affect taxes and customs duties because European Commission authorized in Netherland, Belgium and Germany are the same. Moreover, because of customs warehouse, the value added taxes (VAT) are paid only according to The German VAT law.

In term of warehousing cost, it's hardly to find information and quantitative data for comparison. However from the interview of Andrew Greenhalgh, Regional General Manager at Norbert Dentressangle Warehouse in UK, the main factor that makes difference in warehousing cost in general merchandise warehouse is the treatment of handling and keeping. For the characteristics of ceramic tile products, the treatments are general in handling and keeping compare with other fragile ceramic products (Greenhalgh, 2011).

The transportation cost compared by using transportation activities in ton-km is calculated by amount of good transported (in ton) multiply by distances (in kilometre). Using customer centric scenario, the total transportation activity result of centre of gravity of Port of Hamburg has the lowest result. Using port-centric scenario, the total transportation activity result of the Port of Hamburg has the lowest result. The comparison result of transportation activity between the lowest of two transportation scenario is the distribution centre in port centric area has less activity than in customer area.

Chapter 6

Conclusion

This chapter shows the conclusion of the research which can be divided into 4 following topics:

- Conclusion of the research
- Limitation of the system
- Problem and obstacle during the research time
- Suggestion for further studies

6.1. Conclusion of the Research

This thesis reports the details of the distribution centre location selection for ceramic product new market in Germany that is developed based on the case study of Thai Ceramic Company that is inexperience in warehousing operation in Europe. The objective of this research is to develop the distribution centre location selection model for ceramic product new market in Germany. The researcher has applied many theories in order to create the specific location selection model such as decision criteria for warehousing type selection, factor in the warehouse selection decision, distribution centre planning process and mathematical modeling for distribution centre location analysis. The distribution centre location selection model for ceramic product new market in Germany has four major steps for making a decision that are (1)create warehousing strategy, (2)choose warehousing type, (3)design warehousing location scenarios and (4)process supplier selection. The result from the model applied to Thai Ceramic Company is to select supplier that can provide public warehouse that is customs warehouse in port-centric area.

6.2. Limitations of the Model

- This selection model is designed for ceramic tile imported from Thailand to Germany. In case of others product, the model should be reconsidered since the step of product segmentation by value density and volume throughputs.

- There is single distribution centre in this case study. In case of multiple warehouses, the transportation scenarios and the cost comparison in the model would be changed according to mathematical model for multiple distribution centres.

- Warehouse, transportation, law and regulations are concerned in the operation of brokers or agencies. According to the assumption that the suppliers charge for management fee for other services.

- Transportation cost varies to transportation activities excluding other fixed cost. Fixed costs are such as initial rental fee, loading and unloading cost etc. the researcher assumed that suppliers of transports are charged for total distance of delivery. Though excluding fixed costs to the cost calculation affects the accuracy, but the results do not change due to the long distances from port to customers.

- Specific warehousing and transportation cost per unit are unavailable.

6.3. Problems and Obstacles in Conducting Research

- The cost comparison is limited by the information that some companies cannot give the internal information that is necessary for doing research.

6.4. Suggestions for Further Studies

The further studies are supplier selection process and feasibility for operation that is to compare the benefit between the existing sale practices with the new ones. The existing sale practice is Free On Board (FOB) that the company loads the goods on board the ships nominated by partners. And the new one after setting up the distribution centre is Delivered Duty Paid (DDP) that the company is responsible for delivering the goods to the partners' stores in Europe, including cost of duties, taxes and customs formalities. The operation cost is calculated from inventory costs, in bound and out bound transportation costs, duties, taxes and customs formalities.

For future market expansion to other countries, because this model bases on assumption that transportation activity reflect the transportation cost because the transportation cost in Germany is the same for allover country. So this model can be used for the future expansion as long as the transportation cost is the same in one country or nearby boundary or indifferent in transportation cost between countries. Otherwise, the transportation cost should be calculated for exactly result for cost comparison.

References

Azevedo, S. and Ferreira, J. Decision making for distribution centres location in CEP sector: a case study [Online]. 2010. Available from: http://www.ijmsem.org/upfiles/Download/2010091119422836269 .pdf [2011, July].

Baker, P., Croucher, P., and Rushton, A. The Handbook of Logistics & Distribution Management 4th Edition, London ; Philadelphia : Kogan Page, 2010.

Benson, D. Transport and Logistics, New York ; London : Woodhead-Faulkner, 1994.

Boonma, S. International Trading Manager, Thai Ceramic Company Limited, Interview, 10 June 2011.

Choomrit, N. Location Decision in Distribution Centers [Online]. 2005. Available from: http://as.nida.ac.th/ornet/conf05/paper_orconf48/_22_Ninlawan_location%20decision.pdf [2011, July].

Coyle, J.J., Bardi E.J., and Langley C.J. (2003) The Management of Business Logistics - 7th ed., Mason, Ohio : South-Western/Thomson Learning, 2003.

Cuomo, A. Development Profile for Warehouse/Distribution/Logistics Center Sites [Online]. 2008. Available from: http://www.esd.ny.gov/BusinessPrograms/Data/BuildNow/BNNY_Warehouse-Profile-082608.pdf [2011, July].

Derewecki, D.J. GRAND OPENINGS: PLANNING A NEW DISTRIBUTION CENTER [Online]. 2003. Available from: http://www.grossassociates.com/articles/design.htm [2011, July].

Dongliang, H., Yihong, R., and Xiuquan, X. The Application of GA in the location of Third-party logistics center [Online]. 2010. Available from: http://www.pomsmeetings.org/ConfProceedings/015/ FullPapers/015-0941.pdf [2011, July].

Eilon, S., Watson-Gandy C.D.T., and Christofides N. Distribution Management: Mathematical Modelling and Practical Analysis, London : Griffin, 1971.

European Commission. TARIC measure information SECTION XIII ARTICLES OF STONE, PLASTER, CEMENT, ASBESTOS, MICA OR SIMILAR MATERIALS; CERAMIC PRODUCTS; GLASS AND GLASSWARE [Online]. 2012. Available from:

http://ec.europa.eu/taxation_customs/dds2/taric/measures.jsp?Lang=en&SimDate=20120208&Taric=6908100000&LangDescr=en [2012, January].

Gourdin, K.N. Global logistics management: a competitive advantage for the 21st century, Malden, MA; Oxford: Blackwell Pub., 2006.

Grant, D.B., Lambert, D.M., Stock, J.R., and Ellram, L.M. Fundamentals of Logistics Management - European ed. London ; Boston : McGraw-Hill, 2006.

Greenhalgh, A. Regional General Manager, Norbert Dentressangle Warehouse, UK, Interview, 6th December 2011.

Jenkins, C.H. Modern Warehouse Management, New York McGraw-Hill, 1968.

Jongsadjanulux, S. Sale Executive Assistant, Export Department, Thai Ceramic Company Limited, Interview, 10 June 2011.

Lovell, A. Supply Chain Segmentation: Managing Diversity Through Tailored Supply Chains [Online]. 2005. Available from: https://wisoanmeldung.uni-koeln.de/media/showPub/id/1359 [2011, July].

Lu, C.-S. Market segment evaluation and international distribution centres, Transportation Research Part E: Logistics and Transportation Review 39(1), 2003: 49-60.

Mulcahy, D.E. Warehouse Distribution and Operations Handbook, New York : McGraw-Hill, 1994.

Renshaw, F.W. Natural Site Selection for Distribution Centre Site Selection [Online]. 2002. Available from: http://www.werc.org/assets/1/workflow_staging/Publications/536.PDF [2011, July].

TMF Group German VAT [Online]. 2009. Available from: http://www.tmf-vat.com/vat/eu-vat-rates.html [2012, January].

Wang, B.X., Adams, T.M., Warehousing and Distribution Centers [Online]. 2011. Available from: https://ceprofs.civil.tamu.edu/bwang/CVEN672/Warehousing-DC-Chapter-Wang-Adams.pdf [2011, July].

Appendices

Appendix A

Company Background

Thai Ceramic Co., Ltd. is established specifically for this purpose on September 24th, 1979, the company is a subsidiary of The Siam Cement PLC (SCG), renowned and respected as a leader in Thailand construction materials industry.

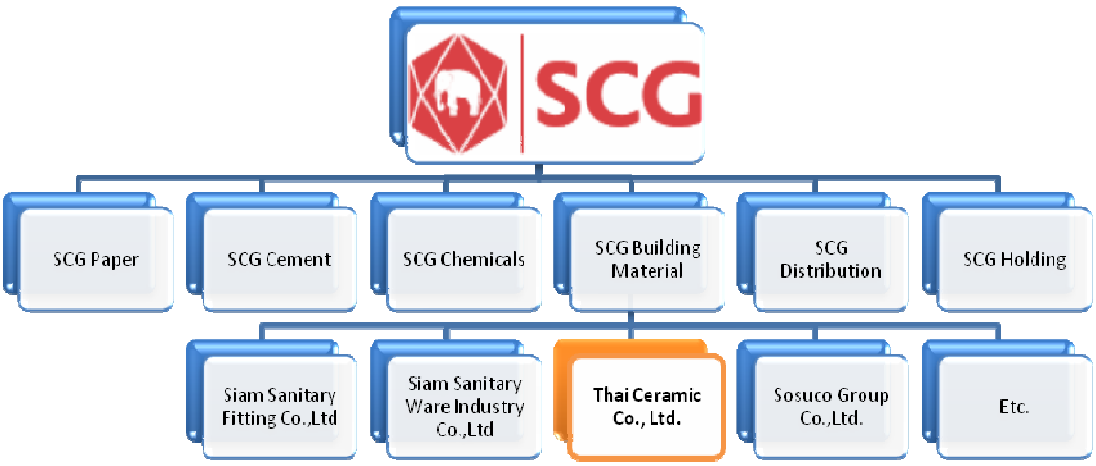

Figure 7 Thai Ceramic Co.,Ltd is a subsidiary of SCG

Appendix B

Products

The company focuses on development in technology, production, product research and design. All processes are carried out under the closest scrutiny, or quality assurance system, to ensure maximum quality and to answer all the different tastes and styles of customers in Thailand and more than 50 countries around the globe.

The company divides products into main six categories;

Glazed Floor Tiles

We offer extensive selections of sizes and designs as well as textures, such as anti-slip matt and semi-matt to satisfy the requirements of different areas and spaces.

Glazed Wall Tiles

A number of different techniques are employed to create a wide palette of colours, patterns and textures setting new trends to give customers the chance to create their own decorative style.

Glazed Porcelain Tiles

These tiles are fired high temperatures to keep them durable with very low water absorption and, the same time attractive in a wide assortment of designs, colors and surfaces for both floor and walls.

Fully Vitrified Homogeneous Tiles (Granito Tiles)

These "through body" porcelain tiles are so tough and durable they can support weights of over 560 kg./square cm. An advanced process produces tiles that have superiors almost identical to natural stone though out.

Mosaic Tiles

These small durable tiles come in a wide range of shapes and glazes, including crystal, metallic and 24k gold mosaic, to let you create just any design you want on floors or walls.

Glass Tiles

Transparent crystal mosaic tiles that glitter with the light to create the shining glint of jewellery facets. It's not just the surface covering but also discreet value.

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Appendix C

Markets

In year 2010, the sales are 56% for domestic market and 44% for export market to every region around the world as shown in Figure 8.

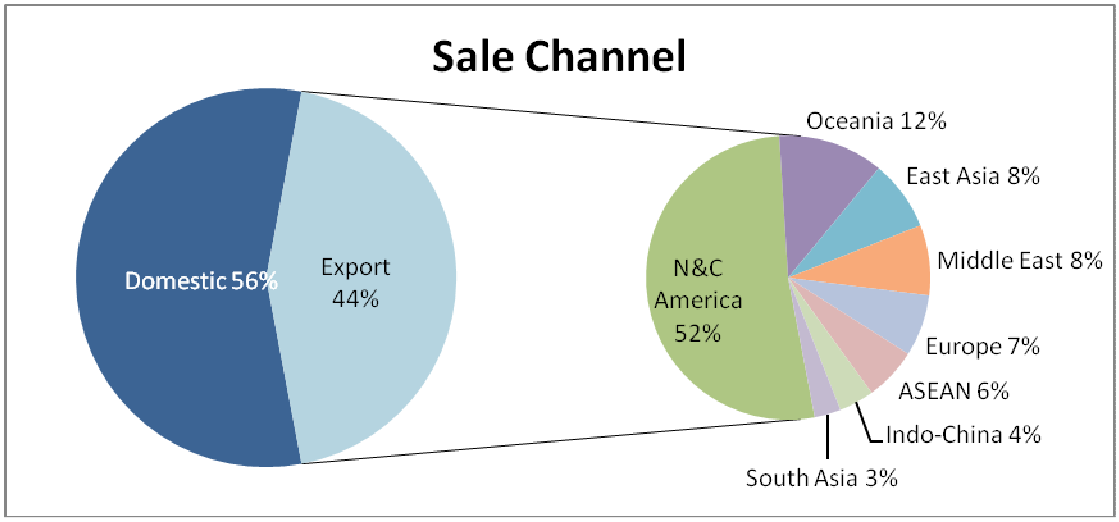

Figure 8 Sales Channel (Thai Ceramic Co., Ltd.)

The existing markets in Europe of the company are in 14 countries; Sweden, United Kingdom, Finland, France, Belgium, Norway, Germany, Netherlands, Czech Republic, Italy, Cyprus, Armenia and Spain.

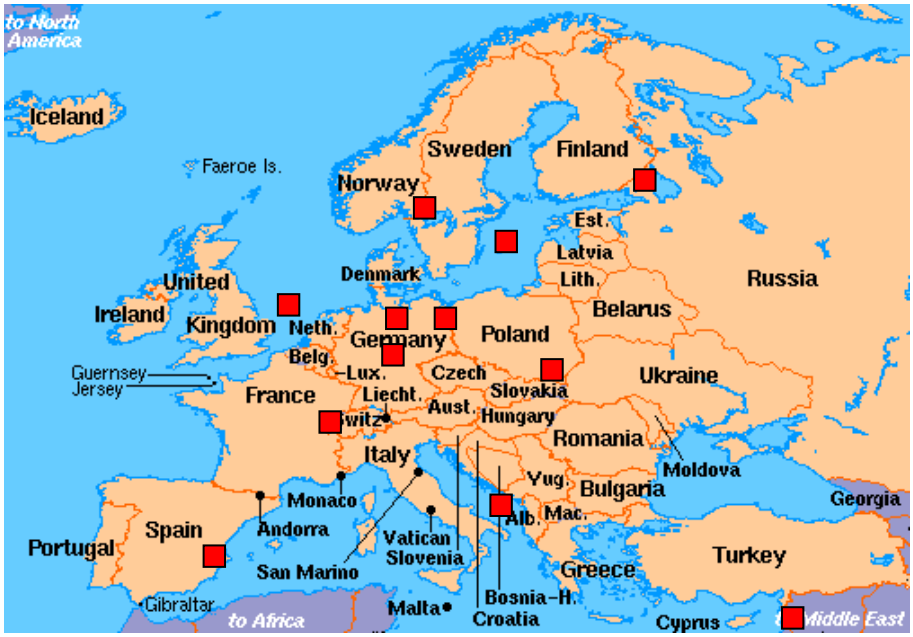

Figure 9 Export countries in year 2010 (Thai Ceramic Co., Ltd.)

The sale breakdown by country in square metres of year 2010 is shown Figure 10;

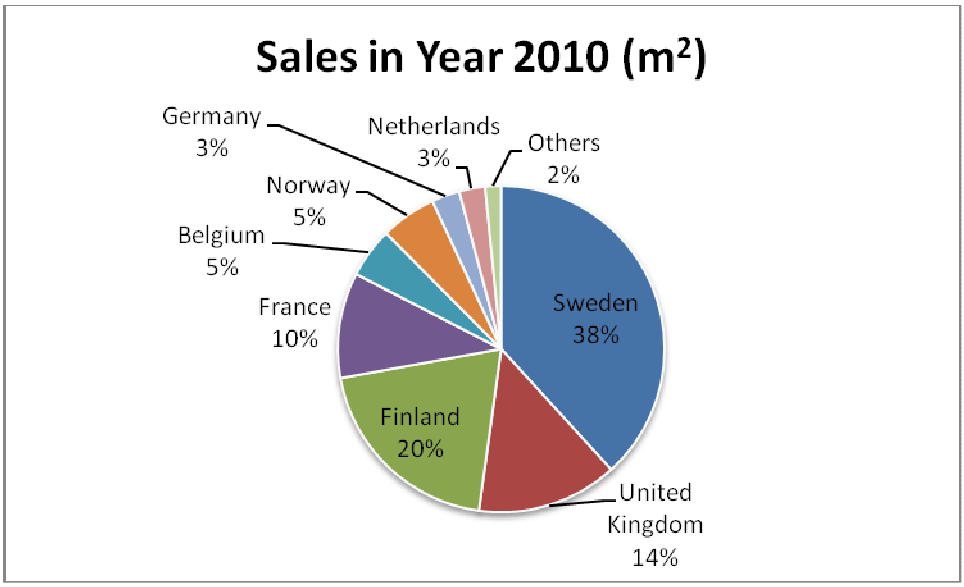

Figure 10 Sales breakdown by Country in square metres of year 2010 (Thai Ceramic Co., Ltd.)

By the types of product, almost 80% of sales in Europe of the year 2010 come from Wall Tiles and Mosaic Tiles. The sale breakdown by product type in square metres of year 2010 is shown Figure 11;

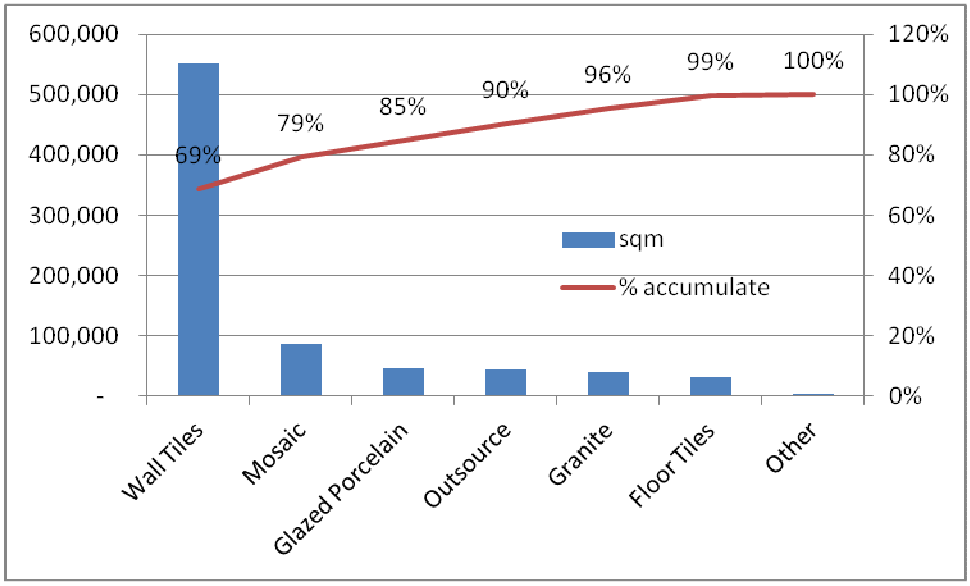

Figure 11 Sales breakdown by Product Type in square metres of year 2010 (Thai Ceramic Co., Ltd.)

Appendix D

According to data collected in a survey conducted by the magazine Ceramic World Review (published by Tile Edizioni), world tile output dropped to 8,515 million m2, 0.1 percent down from 8,520 million m2 in 2008. This compares unfavorably to average annual increases that were 6 to 7 percent in the period 2004-2007 and a 3.2 percent increase in 2008.

TOP MANUFACTURING COUNTRIES (Sq.m Mill.)

	COUNTRY	2005	2006	2007	2008	2009
1	CHINA	2,500	3,000	3,200	3,400	3,600
2	BRAZIL	568	594	637	713	715
3	INDIA	298	340	385	390	490
4	ITALY	570	569	559	513	368
5	IRAN	190	210	250	320	350
6	SPAIN	609	608	585	495	324
7	VIETNAM	176	199	254	270	295
8	INDONESIA	175	170	235	275	278
9	TURKEY	261	265	260	225	205
10	EGYPT	112	122	140	160	200
11	MEXICO	196	210	215	205	200
12	THAILAND	138	139	130	130	128
13	RUSSIA	100	115	135	147	117
14	POLAND	108	110	112	118	112

15	MALAYSIA	71	75	75	85	90
16	UAE	68	75	76	77	77
17	PORTUGAL	72	74	74	74	70
18	ARGENTINA	48	54	60	60	56
19	SAUDI ARABIA	20	22	34	40	55
20	MOROCCO	44	47	50	51	54
21	GERMANY	62	64	67	59	51
22	COLOMBIA	40	44	48	50	50
23	USA	61	58	51	45	50
24	UKRAINE	20	21	27	39	44
25	SOUTH KOREA	46	44	42	39	42
26	SOUTH AFRICA	33	37	38	38	32
27	TAIWAN	53	53	50	40	32
28	SYRIA	19	19	19	28	31
29	ALGERIA	28	28	28	28	30
30	VENEZUELA	26	28	30	32	30
TOTAL		6,713	7,395	7,866	8,145	8,176
WORLD TOTAL		7,077	7,760	8,252	8,495	8,515

Appendix E

TOP CONSUMPTION COUNTRIES (Sq.m Mill.)

	COUNTRY	2005	2006	2007	2008	2009
1	CHINA	2,050	2,450	2,700	2,830	3,030
2	BRAZIL	443	484	535	605	645
3	INDIA	303	350	397	403	494
4	INDONESIA	155	148	178	262	297
5	IRAN	153	182	236	265	295
6	VIETNAM	120	145	210	220	240
7	EGYPT	93	103	105	140	180
8	USA	303	308	249	197	169
9	SAUDI ARABIA	90	100	110	136	166
10	MEXICO	161	164	173	176	163
11	SPAIN	303	319	314	240	156
12	ITALY	192	199	199	176	146
13	RUSSIA	131	151	176	191	139
14	TURKEY	169	179	161	129	138
15	THAILAND	120	121	120	120	117
16	FRANCE	130	120	129	128	113
17	GERMANY	132	128	124	112	106
18	SOUTH KOREA	94	99	110	99	99

19	POLAND	101	102	100	103	93
20	UAE	70	80	81	96	77
21	MALAYSIA	52	45	53	50	69
22	MOROCCO	49	52	56	60	66
23	ARGENTINA	44	48	55	59	55
24	COLOMBIA	44	48	53	54	53
25	GREAT BRITAIN	72	75	75	66	50
26	PORTUGAL	51	47	48	50	48
27	UKRAINE	29	33	47	59	48
28	SOUTH AFRICA	44	48	50	50	43
29	ALGERIA	33	34	35	37	40
30	PHILIPPINES	30	33	37	38	40
TOTAL		6,713	5,762	6,456	6,914	7,150
WORLD TOTAL		7,077	6,750	7,420	8,060	8,350

Appendix F

TOP EXPORT COUNTRIES (Sq.m Mill.)

	COUNTRY	2005	2006	2007	2008	2009
1	CHINA	342	450	500	570	584
2	ITALY	390	396	379	355	281
3	SPAIN	341	336	333	306	235
4	TURKEY	97	93	104	92	67
5	BRAZIL	114	115	102	81	61
6	MEXICO	46	55	56	62	51
7	IRAN	14	19	17	27	40
8	THAILAND	25	27	25	25	36
9	POLAND	19	21	30	34	35
10	PORTUGAL	34	36	37	37	32
11	UAE	25	32	38	34	31
12	VIETNAM	12	15	25	25	28
13	EGYPT	16	17	22	23	23
14	MALAYSIA	18	22	18	23	23
15	GERMANY	21	24	26	28	23
TOTAL		1,514	1,657	1,712	1,722	1,550
WORLD TOTAL		1,715	1,865	1,910	1,919	1,735

Appendix G

TOP IMPORT COUNTRIES (Sq.m Mill.)

	COUNTRY	2005	2006	2007	2008	2009
1	USA	245	254	202	157	124
2	SAUDI ARABIA	80	89	77	99	116
3	FRANCE	110	110	110	112	101
4	GERMANY	90	87	83	80	78
5	SOUTH KOREA	51	54	66	59	55
6	UAE	35	51	43	55	45
7	GREAT BRITAIN	64	66	67	58	43
8	IRAQ	2	3	10	23	40
9	ISRAEL	29	26	30	30	30
10	RUSSIA	35	42	47	54	30
11	GREECE	42	43	51	44	30
12	NIGERIA	19	27	22	30	29
13	THAILAND	22	20	22	25	28
14	AUSTRALIA	32	31	34	33	28
15	CANADA	32	33	35	30	27
16	BELGIUM + LUX.	22	23	28	26	25
17	ROMANIA	27	28	33	35	22
18	PHILIPPINES	9	15	15	16	21

19	KUWAIT	19	18	16	23	19
20	ITALY	22	28	31	25	19
TOTAL		985	1,043	1,020	1,012	910
WORLD TOTAL		1,715	1,855	1,910	1,919	1,735

BIOGRAPHY

Pookpan Ratanapairojkul was born on 3rd October 1984, Bangkok, Thailand. He was graduated from Chulalongkorn University, faculty of Engineering, majoring in Industrial Engineering in 2006. He started working with the Siam Cement Kaeng Khoi, Saraburi, a cement factory of Siam Cement Group (SCG) as a production engineer. After working for four years, he got a scholar from Siam Cement PLC to study Master degree in Engineering Management at Regional Centre for Manufacturing System Engineering (RCMSE), a dual master's degree programme of Chulalongkorn University in Thailand which cooperates with University of Warwick in United Kingdom.