行政院國家科學委員會補助專題研究計畫成果報告

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計畫主持人：馮正民教授
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行政院國家科學委員會專題研究計畫成果報告

跨國製造業廠商供應鏈改變對實體物流之影響

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一、中文摘要

隨著產業全球化的發展以及顧客消費習慣的改變，許多製造業廠商在降低成本以及行銷的考慮下，紛紛調整其原有的供應鏈作業與流程，以期獲得企業經營的最大利潤並快速滿足顧客的需求。本研究之目的即希望藉由對廠商供應鏈變化的瞭解，進而探討供應鏈改變對實體物流的影響。

本研究選擇台灣地區的資訊電子廠商進行問卷調查及面訪，深入瞭解廠商供應鏈的變化情形、國際分工的原因、及其調整製造與物流作業的作法。根據問卷調查及實際訪談所得資料的分析，本研究發現（1）我國資訊電子廠商專業化垂直分工及國際分工的情形相當明顯，（2）廠商隨著產品生命週期的不同階段，而有不同的供應鏈調整作法，（3）就引申的貨物運輸需求而言，在廠商改變供應鏈的過程中，對於運輸服務速度的要求提高，換言之，對於航空貨運需求有增加的趨勢，而對海運需求則趨於減少，（4）一個地區的運輸服務的確會影響廠商利用「時間」上的「延後」策略進行供應鏈的調整。

關鍵詞：供應鏈、物流、產品週期、資訊電子產品

Due to the globalization of industry, the explosion in customer services, and product life-cycle compression, most manufacturers have been adjusting the processes and activities of their supply chains in order to remain competitive and optimize profit. The objective of this study is to explore the issues surrounding the changes in manufacturing supply chains and the consequential impact on freight transportation demand. A questionnaire to survey Taiwanese IT firms was designed and conducted, to recognize in detail the changes in supply chains of manufacturers, tends in the international division of labor and the strategic adjustment of manufacturing and logistics. Surveys and interviews lead to the conclusions that 1) vertical integration and international division of labor are very conspicuous among Taiwanese IT firms, 2) there are different strategies of supply chain adjustment at various stages of the product life cycle, 3) with the transformation of the supply chain, manufacturers require faster transportation services, that is, the demand for air transportation may increase and the demand for sea transportation may decrease, 4) those firms who apply the postponement strategy to adjust their supply chain might be restricted to the availability of transportation services in the factory location area.

Keywords: *supply chain management, global logistics, product life cycle, information technology.*

二、緣由與目的

近年來，由於全球經濟環境變化快速，廠商面對的競爭愈來愈激烈，許多廠商都希望藉由適切地調整供應鏈的流程與作業（processes and activities**），以強化廠商的競爭力。另一方面，在全球化與自由化的環境下，廠商基於各地要素稟賦（**factor endowment**）的不同而前往海外不同地區設廠生產的情形日漸普遍。在上述主客觀環境的改變下，不但個體廠商運輸需求的起迄點（**O-D**）以及對運具的選擇將改變，整體而言，也可能進一步影響國際間貨物運輸的流向。**

本研究回顧相關文獻發現雖然以往在

供應鏈管理、運輸、空間經濟等領域均已分別有研究探討廠商產銷活動，惟對於供應鏈與貨物運輸相互影響的討論，則較為少見。然而，由於運輸需求是一種引申需求，在廠商全球分工的過程中，供應鏈的調整究竟將對運輸需求造成何種影響？影響的程度如何？都是令人關切的。因此，本研究希望藉由對台灣製造業（資訊電子）廠商全球分工及供應鏈變化的調查，探討影響廠商供應鏈調整的因素，並希望進一步了解供應鏈調整對運輸需求特性的影響，研究的發現可作為後續「量化」分析之基礎。

三、研究內容與成果

（一）、研究內容

本研究首先重新釐清「供應鏈」的定義，其次，說明一般廠商進行供應鏈作業調整的目的與作法，並由以往的研究歸納產品特性與供應鏈調整模式間可能存在的關係。主要的研究內容包括：

(1) 我國製造業廠商供應鏈是否進行「空間」上的調整？進行空間調整時，是否會受到產品特性（生命週期）的影響而有所差異？
(2) 製造業廠商的供應鏈是否進行「時間」上的調整？是否會受到產品特性的影響而有所差異？
(3) 供應鏈的調整是否會改變廠商運輸需求的起迄點，以及運具的選擇？
(4) 在不同區位對於運輸服務的提供，是否會影響廠商供應鏈的調整？
(5) 運輸成本對廠商供應鏈調整決策的影響。

本研究基於以下三項準則選擇資訊電子業作為調查的對象，分別為：(1)該項產業的產值相對於我國整體製造業的產值，佔有重要的地位；(2)該項產業的廠商供應鏈具有較佳的調整彈性，足以反映在經濟全球化環境下廠商供應鏈的變化情形，以及其對貨運需求之影響；(3)與其它產業相較，該項產業之產品具有短生命週期的特性，易於反映產品在生命週期不同階段的特性，並希望藉由對資訊電子廠商供應鏈調整模式與作法的瞭解，推估其對貨運需求可能產生的影響。同時，再以資訊電子產品國際分工製造的發展歷程，作為後續分析整體產業全球化趨勢下，對運輸需求及運輸產業衝擊的基礎。

本研究以台灣地區資訊電子產業已獲准於資本市場公開發行股票籌集資金的廠商，合計 152 家，作為調查的對象。調查期間自 1998 年 7 月起至 1999 年 9 月底完成。

（二）、研究成果

由本研究的調查資料分析發現，我國資訊電子廠商的生產活動的確存在明確的國際分工現象，即廠商對其供應鏈中的生產活動的確有進行「空間」上的分散調整。同時，有相當比例的廠商前往海外設廠生產的原因在於尋求較便宜、較具比較利益的生產投入要素。

其次，廠商供應鏈的調整作法的確會因產品在生命週期的不同階段而有所差異。基本上，廠商供應鏈隨著產品生命週期不同階段而有「空間」上的調整，由「集中」於國內製造逐漸調整「分散」至不同地點製造。在「時間」上的調整，則因產品所處生命週期階段的不同而可歸納出四種類型。

(1) 處於「推廣期」階段的產品，在製造與物流作業上，傾向於採「提前」或維持不變的策略；
(2) 處於「成長期」階段的產品，在製造上多採「提前」或維持不變之策略，在物流上亦採「提前」或維持不變之策略；
(3) 處於「成熟飽和期」階段的產品，在製造上多採「提前」策略，少部分廠商採維持不變之策略，在物流上則多採「延後」策略；
(4) 處於「衰退期」階段的產品，在製造上多採「延後」策略，在物流上亦多採「延後」策略。

此外，廠商供應鏈活動在空間上的調整的確會影響運輸需求的起迄點，同時，若廠商採取時間上的延後策略，則必須利用速度較快的運輸服務，始足以滿足交貨的需求。

關於不同區位運輸服務的提供是否會

影響廠商供應鏈的調整方面，首先，在廠商考慮是否對供應鏈活動進行「空間」調整的階段並不受到該區位是否具有充分的運輸服務所影響，惟一旦決定進行「空間」調整時，設廠地點的運輸服務供給條件的確是廠商考慮的因素之一；另一方面，當廠商採取「時間」上的「延後」策略時，廠商也會將運輸服務的供給納入考慮。

最後，本研究也發現對於資訊電子廠商而言，運輸成本並不是其調整供應鏈時的重要考量因素。

（三）討論

整體而言，本研究發現在電子廠商供應鏈的調整作法上，的確隱涵了空間上「集中」／「分散」以及時間上「延後」／「提前」之概念，祇是目前尚未形成模式化，如何經由更大規模的調查深入瞭解不同產業的供應鏈特性，在廠商供應鏈的調整與運輸需求之間，建立量化分析模型，將是後續研究的課題。

此外，許多台灣電子廠商採用的「代工製造」模式，由於利用此種模式製造的產品多半已進入「飽和期」以後的生命週期階段，在此階段廠商除了必須降低製造成本外，加強運輸效率以提昇對顧客的服務水準，將是必然的作法。任何產品，當進入「飽和期」或「衰退期」階段，隨著製造地點的外移對運輸服務速度的要求將會提高，再加以廠商「延後」策略的應用，接單後急迫的交貨時間，均更需結合快速運輸服務始足以滿足整個供應鏈的運作。就台灣資訊電子廠商供應鏈調整對運輸需求的影響而言，我國廠商供應鏈在「空間」上的「分散」將減少我國的總體貨物運輸需求；在「時間」上的「延後」則將使高速運輸服務需求大為增加。

在後續研究的建議方面，除了構建量化模型說明廠商供應鏈調整對運輸需求之影響外，若能針對其它產業進行類似的調查分析，亦將有助於尋求一個一般化的原則，供業者及政府部門參考。

四、研究成果發表

本研究成果部份已發表或投稿於國內外相關學術期刊，茲臚列如下。

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Logistics Opportunities in Asia and Development in Taiwan

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The economy in Asia is growing rapidly. As a consequence, transportation and communication technologies and the changing needs of customers and shippers have resulted in Asian and Taiwan's logistics being in transition. This paper discusses why logistics changes, and explores the opportunities for Asian logistics development. The issues of logistics perspectives of private sectors in Taiwan are then raised. Finally, logistics development in Taiwan is described.

1. Why does logistics change?

Logistics has rapidly changed as a result of the growing globalization of business, changing technologies, organizational patterns, deregulation policies and governmental infrastructure. For example, the multinational company, which is engaged in multinational production, is the typical organization in the free enterprise world of today. Also multiple-site manufacturing and assembly is the usual practice.

There are a variety of reasons for the needs of production dispersal. One main reason is the existence of comparative advantage, which leads to trade between two regions. Trade is generally beneficial if transport costs are relatively small compared with production cost. If the net gains from trade are considered to be positive, specialization in production will occur. Global trade, based on factor endowment and government regulations, covers the transfer of resources, including capital, labour, technology, management and know-how, as well as raw materials, semi-manufactures, components and end-products, from one nation to the other. The supply-chains and the movements of all those materials and products are the subject matter of logistics.

2. Opportunities for Asian logistics

Some indicators (CEPD 1998; IATA 1997) used to show the growing Asian markets are as follows.

- Gross Domestic Product (GDP) for Asia-Pacific will be higher than that for either North America or Europe by 2010. Among these three regions the market share of Asia-Pacific will be 37.1% by 2010.
- Relaxation of government regulations on trade and transportation has resulted in free flow of cargos, passengers, information and capital.
- According to the IATA, the Asia air cargo market accounted for well over one-half the world market (59%) in 1992, and is expected to continue to grow.
- According to Boeing World Air Cargo forecast (Boeing 1998), the air cargo growth rate in 1992-2010 is 9.3% for Intra-Asia, 7.9% for USA-Asia and 7.4% for Europe-Asia, all of which are above the world average of 6.8%. Intra-Asian growth has been the most rapid, due to the rapid market development in Japan, Hong Kong, Taiwan, and China during 1980-90.
- Asia air express cargo is also growing very fast, with volume at least double that of other

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major markets. For example, the express cargo growth rate in 1991-93 was 25% in Asia, 12% in Europe and 8% in North America. The customers in Asia rely heavily on the services of express carriers, especially on those of the integrated carriers.

- Between 1995 and 2010, Asia-Pacific international scheduled passenger traffic will grow at a projected average annual rate of growth of 7.4%. At the same time, international scheduled traffic for the rest of the world is forecast to grow by 4.4% per annum on average.
- By 2010, Asia-Pacific traffic will amount to 393 million passengers. This is an almost three-fold increase in the 15-year forecast period.
- The global share of Asia-Pacific international scheduled passenger traffic increased from 26.2% in 1985 to 35.2% in 1995. It will increase to nearly 50% by 2010.
- Europe was and will remain the most important world region for long-haul international passenger traffic to and from Asia-Pacific. By 2010, there will be 57.8 million passenger between Europe and Asia-Pacific. The main region-pairs, within North-east Asia, between North-east-South-east Asia and within South-east, will remain within the Asia-Pacific Area.
- Asia is particularly attractive in container shipping because return on sales was 5.7% in 1992 for transpacific routes, the only profitable long-haul routes, while it was -22.3% for transatlantic routes and -6.8% for North Europe-Far East routes.

According to the above indicators, opportunities for Asian logistics development are as follows: (1) strong economic growth in Asia Pacific area, (2) increasing disposable income, (3) intensification of inter- and intra-Asia-Pacific trade, (4) continuing deregulation and liberalization policies and (5) significant development of transportation infrastructures.

3. Perspectives of private sector in Taiwan

The total area of Taiwan is 36,300 square kilometers (14,000 square miles), which is slightly smaller than The Netherlands and Switzerland. Since the island is largely mountainous, Taiwan is the second-most densely populated country in the world, with a population of over 21 million, or 582 persons per square kilometer. The change in industrial structure in Taiwan has been accompanied by sustained economic growth. Table 1 reflects the growth of both GDP and GNP over the last few years.

Taiwan's economy is highly dependent on foreign trade. Accordingly, most major industries are export-oriented or are suppliers for export industries. The appreciation of the New Taiwan dollar and increasing wage costs mean that labor-intensive industries are facing fierce competition from neighboring lower-cost countries. Consequently, Taiwan is focusing increasingly on higher-value quality products and on high-technology industries for domestic production and is moving labour-intensive industries to South-east Asia and Mainland China.

International trade is the mainstay of Taiwan's economy. Table 2 summarizes major import and export commodities and trading partners. Taiwan has since the end of the 1980s embarked on a policy of reducing or removing controls on imports and reducing import tariffs.

Below is a summary of the report of the Council for Economic Planning and Development (CEPD) of Taiwan, where Taiwan's existing strengths and weaknesses in developing into a regional center in the Asia-Pacific area are assessed through interviews (CEPD 1994). The selected managers of local and foreign private sectors are grouped into two categories: transportation logistics companies and production logistics companies. The former category represents companies whose core business is freight transportation, and with which the multinational has established a long-term relationship. Federal Express (FedEx) and United Parcel Service Inc. (UPS) are two examples of these companies. The latter category

represents companies whose core business is supply chain-related manufacturing and assembly, and the logistics function in these companies may be operated by an in-house department. Examples are the computer companies of ACER and Compaq.

Table 1 GNP, GDP, NI, and the economic growth rate of Taiwan from 1991-1997

	1997	1996	1995	1994	1993	1992	1991
GNP (Million USD)	285,300	274,600	263,000	243,900	226,200	216,300	185,600
Per capita GNP (USD)	13,233	12,838	12,396	11,579	10,852	10,470	8,982
GDP (Million USD)	283,636	272,307	260,175	240,986	222,604	212,150	179,370
Economic Growth Rate (%)	6.81	5.67	6.03	6.54	6.32	6.76	7.55
Per Capita National Income (USD)	12,019	11,635	11,276	10,566	9,872	9,536	8,189

Source: Directorate-General of Budget, Accounting and Statistics, Taiwan (1998).

Table 2 The major trading commodities and partners

Major Import Commodities	Oil, Machinery, Electrical products, Chemicals, Steel, Steel work, Beverages, Tobacco, Motor vehicles, Delivery equipment, Metal products, Electrical machines
Major Export Commodities	Electronic products, Garments, Yarns, Shoes, Toys, Sporting goods, Base metal, Metal products, Machinery, Motor vehicles, Delivery equipment, Plastics.
Major Trading Partners	USA, Japan, Hong Kong, Germany, Singapore, UK

Source: CEPD (1994).

The comments on the perspectives of private sectors in Taiwan are as follows.

(1) Transportation logistics companies

- An air hub is needed in Taiwan to cope with the strong growth of the Asian market.
- A regional hub in Asia is needed to serve the rapidly growing Intra-Asia volumes.
- There is a growing opportunity in express air cargo for Taiwan to meet the needs of just-in-time (JIT) delivery.
- Since the logistics business is very sensitive to time, the less time the transportation takes the better.
- Airports serving the express cargo business and providing efficient operations are needed. Those airports that have strict regulations will be significantly less attractive.
- Customs services in airports operating on a 24-h basis are needed. Customs paperwork should be replaced with EDI (Electronic data interchange), which can immensely accelerate customs clearance.
- A good network of flights would help provide flexibility in scheduling and goods delivery. It is better to have direct access to Mainland China, which has a fast-growing market.

- Current regulations and restrictions constrain shipping operations in distribution activities and in utilizing berth and warehouse capacity.
- Foreign ocean carriers demand to extend their marine transport to the inland trucking market on condition of reciprocity.

To improve company competitiveness, the Taiwan and foreign managers of express carriers call for their own facilities to get control over their cargo handling, efficient customs procedures and 24-h operations for fast throughput time, and frequent flights to many regional destinations, including China.

(2) Production logistics companies

- Products can be developed quickly enough without a good industry infrastructure and supplier network.
- A more open trade relationship is needed, especially with mainland China.
- Partnerships with foreign multinational companies are needed.
- Attracting more foreign direct investment will help Taiwan to further improve productivity.
- Low cost of land and labour for manufacturing our products are required.
- Language barriers exist, as English is not sufficiently used in many situations.
- An advanced information and telecommunications infrastructure is required.
- Entering the global trade economy and in particular joining the World Trade Organization (WTO), is essential.

The Taiwan and foreign managers of production firms require a good industry infrastructure and supplier network to manufacture competitive products, fewer restrictions on trade with mainland China, extensive partnerships with foreign companies, low costs for land and labour for manufacturing, an advanced information and telecommunications infrastructure, and membership in the global trade economy.

4. The development of logistics in taiwan

Taiwan is an export-oriented country. Along with the increase of international trade and economic development, the volume of logistics has increased rapidly. According to the 1996 survey of the Institute of Transportation, Ministry of Transportation and Communications, the total amount of the logistics flow, including sea transport, ground transport and air transport, is nearly 13% of the total GDP with 973 billion NT dollars (nearly US$35.40 billion) annually (Institute of Transportation, MOTC 1998).

4.1 The problems

Facing the quickly changing environments, some problems of Taiwan's local logistics firms arise as follows:

(1) Infrastructure. Traffic congestion is an obstacle to the growth of logistics. The loading and unloading of cargos during normal working hours is considered to be the main cause of congestion in urban areas. A lack of parking space and traffic congestion in urban area has become a common phenomenon and leads to rapidly

increasing transport costs. Consequently, as far as cost is concerned, the domestic transport system may not support the JIT delivery requirements.

(2) Economic and Financial. Mounting demand and international competition have influenced the structure and location of industry as well as the local and international division of labour. Some advanced large companies in Taiwan could adopt new organizational structures and use advanced logistics services to maximize profit. However, most middle-sized and small logistics firms in Taiwan cannot react quickly to the changing market and new technologies. As a result, their competitiveness will not be based on efficiency but rather on drastically reduced prices.

The high land prices and land-use limitations are hindering the development of the logistics industry. The high cost of labor and labor shortage had resulted in increasing logistics costs.

(3) Legal and Administrative. The current land-use regulations do not give enough incentives to the establishment of a distribution center. The current regulations in the areas of Aviation and Harbour are outdated. The result is that airport and harbour pricing are less attractive and customs procedures are not efficient.

To enhance efficiency and competitiveness, the logistics firms have focused on the following areas:

- making smart investments on infrastructure equipment;
- supporting the usage of new technologies such as EDI to rationalize their distribution channels;
- encouraging multi-modal and cooperation between international logistics firms;
- developing joint distribution centers in the vicinity of metropolitan areas;
- improving the existing distribution channels to achieve an advanced logistics system; and
- enhancing the safety of distribution process.

4.2 Governmental actions

In addition to supporting a well-developed distribution and manufacturing center in Asia-Pacific region, Asia-Pacific Regional Operation Center (APROC) plan has been in place for 3 years. However, government agencies have spared no effort in carrying out market liberalization and internationalization. The current logistics-related actions taken by governments are described as follows.

(1) Transportation infrastructure construction. The infrastructure projects of air, sea and ground transport have been continuously undertaken and government agencies are engaged in the introduction and operation of new transport technologies to improve the service level of the transportation systems.

(2) Developing Taiwan as the Operation Center of Asia-Pacific Region. The purpose of developing Taiwan as an Asia-Pacific operation center is to attract enterprises to use Taiwan as their production, logistics and marketing bases for delivering high value-added goods to this region. The APROC plan will develop six specialized centers. In these, “software” programs are being re-engineered for the purpose of revamping the legal and macro-economic environment on Taiwan. Of these six centers, three will be aimed at developing the air transport, sea transport and telecommunications, which will lead to providing high quality infrastructure services to logistics firms.

(3) Civil Aviation Law amended. Revisions involving 117 articles of the Civil Aviation Law were adopted by the Legislative Yuan of Republic of China on 30 December 1997, with two revisions directly affecting foreign airline companies. First, the new provisions stipulate that for air cargo-forwarding companies, ground stations and cargo distribution companies, foreign capital shares and the number of foreign board members may represent 50% of the total shares or board seats, compared with only one third in the previous regulations. Second, airline companies can adjust their international flight fares on their own and later file a report with the authorities. This dispenses with the prior-approval system on pricing schedule for international flights.

(4) Customs surcharge reduced. The Ministry of Finance (MOF, 1998), under a customs regulation revision finalized in February 1998, drastically reduced the customs surcharge on export inspections to save time and to reduce costs of exporters.

(5) EHU (Express Handling Units) clearance limitations relaxed. Efficiency of customs clearance should be improved. Reducing the present customs clearance down to a par with Singapore's 2-4h or Hong Kong's 2-6h customs clearance is planned under which the average clearance time for air cargo will be reduced to 4h from 3 days.

New clearance regulations which became effective in August 1997 scraped the old rules that stipulated that EHU cargoes could not exceed NTD20,000 for non-export-and-import-controlled goods. The new regulations only prescribe that EHU cargoes shall not exceed 70 kg compared to 40 kg in the old regulations. The value requirement has also been scrapped. Goods that are subject to import and export control can also go through the EHU.

After the establishment of EHU at the CKS airport in December 1995, incoming cargoes into the units increased by nine times and outgoing ones jumped by 30 fold, representing 1.3% of the cargo handling in the airport. Adding those handled in the on-board-courier handling units (OBC), cargoes handled at OBC and EHU accounted for 3.3% of the total air cargo volume of CKS airport.

(6) Twenty-four-hours customs clearance at CKS International Airport. The CKS international airport announced that 24-h cargo claims would be expanded to general commodities, which had been inspected and checked in the past. Those eligible for 24-h claim include cargoes which do not require paper verification and inspection, cargoes which have passed paper verification and inspection, cargoes which have passed paper verification and inspection, and those imported to export processing zones and science-based industrial parks. The 24-h cargo claim operation is open 7 days a week.

(7) Pre-clearance system for air cargo. The implementation of preclearance system will significantly improve the efficiency of import clearance. Under the new system, airline companies can send through a computer network the manifest, declaration paper, and other documents to customs before the arrival of cargo. Customs may inform the customs agents whether those cargos must proceed for inspection. If not, cargo can be cleared within 24 h of arrival.

(8) Harbour charges lowered and foreign investment limitation reduced. The government finalized the revision of relevant rules in September 1997 and reduced the harbour construction fee from the previous 0.5% of cargo value to 0.4%. Also, the government raised the foreign investment ceiling in container yards.

In September 1997, the MOTC adjusted many tariff charges at international ports. The tugboat charge was reduced to 30% from 50%. Warehousing and container yard rental fees will be given a 20% discount. Warehousing charges will be voided for bulk carrier goods which stay in warehouses no more than five days. The loading cost of refrigeration boats will be reduced by 10%, while the rental of cranes and

other machinery will be reduced by 20%.

(9) Warehousing centers in Kaohsiung, Taichung launched. The Taiwan Export Processing Zone Administration formally established a branch office in Taichung Harbour and two branch offices in Kaohsiung Harbour in December 1997 to promote the transforming of processing zones into warehousing centers.

The warehousing center will attract high-tech manufacturing enterprises, warehousing and distribution companies, and other related service firms.

(10) Airport city development plan. The airport city development plan was approved in October 1997, and the local government started land acquisition. This marked the beginning of constructing a large-scale airport city, covering a total of 63 hectares of land around the CKS international airport, and accommodating a projected cargo volume of 1.2 million tons per year, up 10.4% from the present 732,000 tons.

The government plans the construction of the bonded warehouse, value-added operations and distribution centers. The primary construction plan will be finished by 1999. Private participation will be encouraged.

(11) Federal Express, UPS and DHL expand operations. The UPS Logistics Center in Taiwan began operation in November 1997 to provide value-added distribution, inventory management and warehousing services to customers all over the Asia-Pacific region. This could drastically reduce the time and cost of inland transport and warehousing.

The Federal Express CKS transport center covering 1,700 square meters began operations on 11 November 1997. The transport center provides 24-h customs clearance services. Its speedy sorting system can process 3,000 pieces of cargo per h. The new center will be able to provide more streamlined services.

DHL has upgraded its competitiveness by enhancing its point-to-point international courier services with distribution functions. It is constructing its distribution and inventory center near the CKS Airport.

The integrated logistics firms, e.g. UPS, FedEx and DHL, combine distribution, transport and advanced electronic-data-interchange (EDI) know-how to serve industries in inventory management, warehousing, sorting or assembling, and overnight handling to provide fast delivery service for manufacturing and high-tech industries.

(12) Air cargo terminal privatized. Privatizing the cargo terminal in CKS airport is the government policy. It is expected that privatization and integrating the upstream and downstream delivery services will make proper adjustments in hardware installation and will streamline procedures to upgrade clearance efficiency.

(13) New highway law takes effect. The revised Highway Law took effect on 1 November 1997, opening the market for the leasing of small passenger cars, automobile cargo transport, and automobile container transport to foreign investors.

(14) Land use release. Some farm and open land will be released for use such as car parks and distribution operation centers by logistics firms.

5. Conclusion

With the growth of globalized business, advanced technologies development, international specialization of labor, continuing deregulation and liberalization policies and governmental infrastructure improvement, the logistics market opportunities in Asia are attractive. But the logistics services required by customers have also become increasingly more complex and demanding. Faster and more sophisticated logistics for companies are needed to meet the changing needs of customers and shippers.

The results of interviewing managers of logistics companies showed that the managers

within transportation logistics companies recommended that government authorities continuously improve infrastructure facilities and develop regional hub operations to serve the rapidly growing freight demand. The express carriers' managers call for efficient cargo handling and 24-h operations in airports to improve company competitiveness.

On the other hand, the managers in production logistics companies focused on the macroscope recommendations of Taiwan's logistics development, such as gradually eliminating political barriers with mainland China, establishing partner-relationships with multinational companies, and entering the international World Trade Organization (WTO).

Following the perspectives of local and foreign logistics companies and reviewing the existing difficulties of logistics development in Taiwan, government agencies in Taiwan have taken several logistics-related actions to deal with aspects of the infrastructure, finance, legal regulations and administration to reduce the obstacles such as tariffs, import restrictions, etc. that the private sector encounters in conducting international business. Confronted with a fierce and constantly changing competitive environment, even with numerous opportunities, the government still has to improve the hardware and software performance to enhance the competitiveness of the logistics industry.

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THE EFFECTS OF GLOBAL LOGISTICS STRATEGIES ON INTERNATIONAL FREIGHT TRANSPORTATION DEMAND

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Abstract: For years, researchers and practitioners have investigated growing business globalization trends and international freight transportation forecasting. However, there are few discussions of the interrelationships between globalized business and its effects on international freight flow. This study reviews the experiences of multinational companies and surveys 152 Taiwanese IT firms to provide a detail picture of existing global logistics operations. It was found that the logistics strategies of the manufacturing supply chain will affect a firm's modal choice, and that the multiple-site of the multinational production logistics strategies will affect the trip generation and distribution. This paper also seeks to highlight gaps in the literature and issues for future research.

Key Words: *global logistics strategy, multinational companies, international freight transportation, information technology industry*

1. INTRODUCTION

Logistics has been rapidly transforming as a result of the growing globalization of business and changing technology. The globalization of the manufacturing industry refers to the internationalization of the manufacturing supply chain. Changes in geographical location or customers' expectations continually transform the nature of markets, applying pressures that in turn, cause the redirection of product flow within a firm generate. Advanced technologies allow for methods of adjusting the flow of raw materials, semi-finished goods, products, and spare parts. In this process, the demand of freight transportation services that support the delivery of goods also changes. Traditional freight transportation studies assumed that manufacturing activities were concentrated at a single manufacturing location, therefore these studies are inadequate at describing the operations of today's multi-national manufacturing supply chain.

Information-technology (IT) manufacturing firms in Taiwan have realized the changing dynamics of the global market, adjusting their logistics strategies to meet the needs of multiple-site and multinational production and assembly. The adjustment of logistics strategies in Taiwanese IT firms has contributed to the change of international freight transportation demand to and from Taiwan. This study aims to explore the effects of logistics strategies on international freight transportation demand, examining the change of trip generation, trip distribution and modal choice.

This study first explore and categorize the logistics strategies, taken by Taiwanese IT firms. One Taiwan firm that is worth discussing is the Acer Corporation. This company has set up multiple manufacturing sites in Southeast Asian countries and Mainland China to exploit the comparative advantages of lower land and labor costs. The supply-chain and the movement of all these materials and products lead to the change of transportation demand among Taiwan, offshore factories and marketplaces. Secondly, this study analyze how logistics strategies affect the international freight transportation demand pattern and by what degree. For this analysis, a questionnaire was designed to survey executive managers of 152 IT firms in Taiwan to better understand the approaches that these companies take to implement logistics strategies and the impact of these logistics strategies on transportation demand.

This article is organized as follows. Section 2 briefly examines the literature on logistics strategies and freight transportation demand given an overview of previous research. Section 3 describes logistics strategies as related to Taiwanese IT firms. Section 4 presents the impacts of various logistics strategies on international freight flow. Conclusions and prospects for future research follow.

2. LITERATURE REVIEW

There has been extensive research on logistics and freight transportation. This research has primarily focused on traditional logistics issues, which develop solutions only for implementation at a central location. The Council of Logistics and Management (1993) defines logistics as "the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from a point of origin to a point of consumption for the purpose of conforming to customer requirements." The components of a logistics system may include some or all of the following: suppliers, production facilities, transshipment points, and demand points. Distribution of freight from origin to destination is the core of logistics (Langevin, 1996). Moreover, as industry globalizes, logistics will involve more material flows through a supply chain that extends beyond national borders. The global company seeks to achieve a competitive advantage by identifying world markets for its products and developing a manufacturing and logistics strategy to support its marketing strategy. A successful company in the global marketplace will disperse production and assembly facilities across multiple regions to meet the needs of overseas markets using global logistics channels to supply these facilities (Christopher, 1998).

The cost-efficient arrangement of transportation and storage is a major issue when planning a logistics strategy. Before the first half of the 1990s, the function of logistics was to minimize total distribution costs and maximize profits, while achieving desired levels of service performance (Lambert, 1993; CLM, 1986; Gustin et al., 1995; Langevin, 1996). Today the aim focuses on maximizing manufacturing flexibility both inside and outside the firm towards customization at the minimum cost (Bowersox and Daugherty, 1995a; Novack et al., 1992). This means that logistics is now directed towards supply chain issues. Moreover, the aim of a firm's logistics strategy is to exploit the firm's unique product assembly and delivery features, to maximize profit and service, thus leading to competitive performance (Bowersox and Daugherty, 1995b).

Behind the expanding trend of globalization in logistics, there are several factors reshaping logistics operations and strategies. These factors are (Cooper, 1993): the globalization of markets, cheaper communications, removal of barriers to trade and foreign investment, achieving economies of scale in business, innovation in logistics, and decreasing transportation unit costs. These factors tend to increase world trade and the worldwide specialization of production. This means that freight transportation between continents and between countries will not necessarily increase with the growth of the world economy, but instead grow and diversify with the specific demands of the various regional markets (Lehmusvaara, 1998).

Therefore logistics operations will determine the direction of freight transportation flow.

These operations can not only be measured by the yardstick of a nation's gross national product (GNP), but must also be evaluated by the increasing influence that the transportation and distribution of goods have on the performance of almost all other economic sectors (Croinic et al., 1997).

On the other hand, Qrtuzar (1990), Langevin (1996), Crainic et al. (1997), Feng et al. (2000) and Garrido et al. (2000) all provide reviews on the solution approaches in freight transportation. They indicate that current freight transportation research tends to emphasize the role and importance that freight transportation plays in the overall manufacturing/ distribution processes. However, some of these previous analyses of freight transportation have suffered from a variety of shortcomings. First, most of these studies assume that product manufacturing is done at the factories in a concentrated area. Under the trend of globalized production, firms manufacture their products at diversified multiple-sites. The previous freight transportation studies are incapable of reflecting current manufacturing realities and the demands that firms currently placing on freight transportation services to meet their needs. Second, earlier studies were based on only a limited amount of data, and may not have captured all the effects of the international division of labor. Lastly, part of these previous studies underestimated the transportation demand incurred by the internationalization of production activity, since they do not take into account the dynamics of the interaction between a firm's freight demand, and adjustments in the manufacturing supply chain.

While previous studies have highlighted characteristics of logistics strategy and freight transportation, to the best of our knowledge, none of the previous academic work has researched the influences of global logistics on international freight transportation demand.

3. LOGISTICS OPERATIONS OF TAIWANESE IT FIRMS

Logistics has rapidly changed as a result of the growing globalization of economies. The IT firms in Taiwan have realized changing needs, adjusted their logistics operations and engaged in multiple-site and multinational production and assembly. This study applied Taiwanese IT firms' experiences to categorize the manufacturing firms' logistics operations.

3.1 Types of Logistics Operation Strategy

To establish an efficient international division of labor, Multinational Companies (MNCs) have created a network that addresses various needs when implementing value-added logistics. The experiences of IT industries supply the best cases to illustrate the evolution of logistics. The IT industry in this study refers to the manufacturing activities of firms involved in the following area: information hardware manufacturers (computer systems, peripheral equipment, important precision parts and components), consumer electronic manufacturers (audio products, video products, and other consumptive products) and semiconductor manufacturers (semiconductor manufacturing, semiconductor's raw materials). The IT production supply chain begins with a variety of component producers, each of which specializes in a particular component, usually distributed on the open market or supplied on an Original Equipment Manufacturer (OEM) basis to assemblers. The various components provide different levels of value to the completed system.

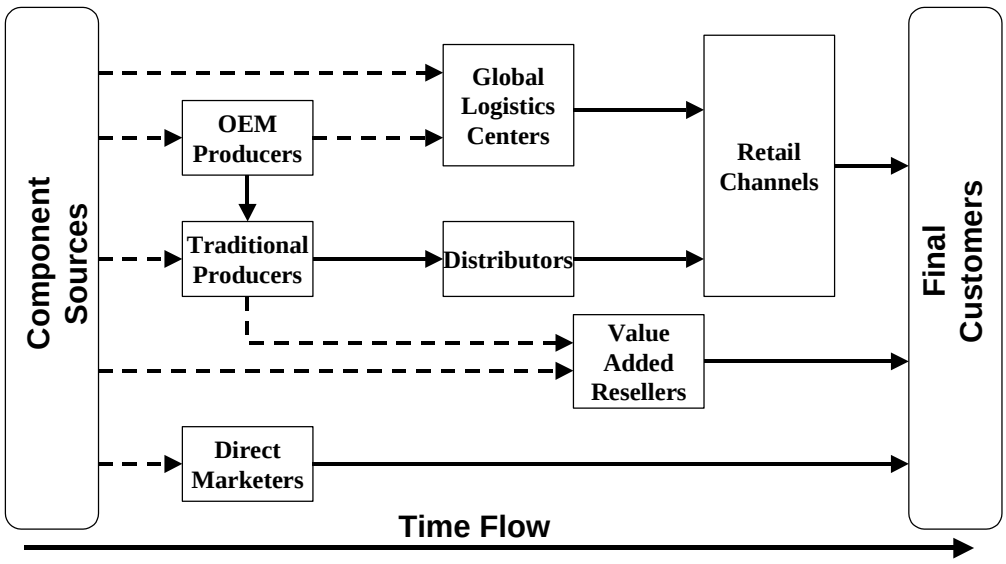
Curry et al. (1999) summarized the four types of logistics channels of the PC industry and their possible interactions from component sources to final customers. See Figure 1. Firms often utilized more than one method depending on the products or the markets, and there is much variation from firm to firm.

The first type of logistics strategy is found in the conventional supply chain, parts and components are delivered to warehouses and stored until required for assembly. The finished products are then shipped through conventional distribution channels (i.e. to distributors), and on to value-added resellers (VARs) or to retail stores.

The second type of logistics operation is global logistics. In dealing with global logistics strategies are designed to meet globalized sourcing and distribution. Global logistics strategies are based on the recognition that system assembly is a low value-added, but time-sensitive, segment of the supply chain. Global logistics systems have been developed to manage the higher-value-added portions of the supply chain involving distribution, marketing, original design manufacturing (ODM), OEM manufacturing, and distribution as a complete service. The majority of the practitioners of global logistics are based in Taiwan. The distance between final markets and manufacturers has created a need for a system that would protect components from depreciation risks. The global logistics system pioneered by Taiwanese firms is a response to opportunities that arose in the mid-1980s to supply U.S. assembly firms with inexpensive components and even finished PCs on an OEM basis.

In an attempt to reduce inventory exposure, a number of the largest PC assemblers are shifting some final assembly operations to distributors, thereby completing the finished product closer to the final customer. Their aim is to decrease inventory and increase responsiveness. The firms handling this work are part of a broad and amorphous category called value-added resellers (VARs). VARs complete the final stage in the third type of logistics operations, which is a delivery-oriented approach. VARs include distributors of relatively large parts, components, and systems and they may perform specialized system integration, partial system assembly services, or even whole system contract assembly for large PC marketers. Channel assembly through VARs resembles the global logistics system, but the critical difference is that the VARs often perform a wider range of downstream functions. Channel assembly has two features that make it superior to the traditional model. First, it shortens inventory-holding periods. Second, once the contract is concluded and the PC specifications are agreed upon, the contractor need not be concerned about value erosion because the final agent in the VAR chain deals directly with the customer's needs.

Direct marketing is the fourth type of logistics operation. The most serious competitive challenge to the established PC companies comes from direct marketers such as Dell Computer. These companies receive customer's orders before they actually build a computer. This means they do not need to hold any inventory, thereby eliminating most inventory and concomitant risk (Curry et al., 1999). As Figure 1 indicates, the direct marketing model reduces the number of activities from the factory to delivery of the finished products to the customer to an absolute minimum.



Note: Broken lines indicate component flows, solid lines are finished systems.

Figure 1. IT products logistics channels

3.2 Acer and Taiwanese IT firms' experiences

Acer Computer, founded in 1976, is the largest PC manufacturer in Taiwan. The company developed an order-based supply chain referred to as "Fast Food" operation and the "Client-Server" operating structure. Acer's Fast Food model endeavors to establish an efficient international network of division of labor through its selective use of international freight transportation modal for the operation. Acer's logistics strategy takes account of the rapid pace of change in customer needs using a logistics strategy that protects key parts with high added value from erosion. To eliminate this risk, parts are transported either by air or sea, depending on the degree of added value. Products with low added values, such as housing, power supply units, and floppy disk drives are normally carried by sea in order to reduce transportation costs. On the other hand, key parts with higher added value, such as CPUs, MPUs, hard disk drives, and memory chips are selected according to demand shifts and transported by air immediately prior to assembly if demand indicates the necessity. The selective choice of air or sea transportation services is common in the IT industry. The aim is to maintain the quality of parts used in finished products, ensure customer satisfaction, and at the same time, eliminate the risk of declines in the price of product inventory.

Because logistics strategies are dependent on a firm's supply chain operation, we divided Acer's logistics development into four stages in relation to changes in the supply chain. See Figure 2 and Figure 3. Before the late 1980s, during the first stage of Acer's logistics development, the company concentrated all its production activities at a single geographical location and served its world markets through traditional logistics and marketing networks. At this stage, the main freight transportation demand was from Taiwan to the market countries. Moreover, the value density -- the value of a product in relation to its weight and volume -- was low; as well as time was not considered to be a critical business variable, leading to a large part of the finished products being transported by sea.

Since the 1990s, the second stage of Acer's logistics development, Acer adjusted its supply chain as factories were relocated to Mainland China and Southeast Asian countries to utilize cheaper and cost comparative factors. Materials, semi-finished products, components and finished products were transported to the geographically dispersed manufacturing factories. In this stage, the output of a primary manufacturing factory in one country may simply be the input for a sub-assembly factory of Acer located in another country. The semi-finished products may be transported back to Taiwan for final assembly, then re-export to foreign markets. At this stage, the increment of transportation demand of semi-finished products ΔQ_1, as illustrated in Figure 3, was generated along with the process of supply chain operation.

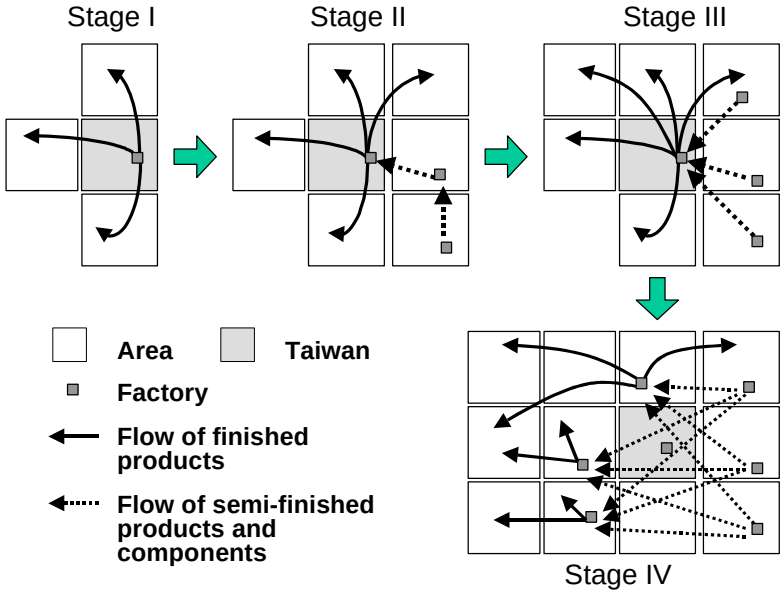


Figure 2. Acer's logistics development

In the third stage, each of Acer's offshore manufacturing factories performed an independent operation in the supply chain and ships output to a final assembly factory in Taiwan. After final assembly, the finished products were exported to the markets. Because the offshore factory was operated independently, the increment of transportation demand (ΔQ_2) was fully reflected in the freight flow from Mainland China and Southeast Asian countries to Taiwan.

But in recent years, the ability to respond to customers' requirements in ever-shortening time-frames has become critical, has lead Acer to further adjust their supply chain operation. All of the outputs from each offshore factory are shipped directly to the final assembly factories in locations near the marketplace. This is the fourth stage of Acer's logistics development, the physical flow of components and semi-finished products are not transported to Taiwan, freight flow between the offshore factory to the marketplace has increased and the freight flow to and from Taiwan has decreased ($-\Delta Q_3$). In the decision of modal choice, because the response time of IT industry operation has become shorter, air transportation services demand is increasing and sea transportation demand is decreasing.

Because all of the movements of materials, semi-finished products, components and finished-products determine the freight transportation demand, the various stages of logistics development mentioned above will create different freight transportation demands in terms of trip generation and distribution. Table 1 compares the volume – measured in US dollar cost – of the Acer Group's freight transportation between Taiwan factory, offshore factories (Mainland China and Southeast Asian countries) and market places over the years of logistics development from Stage I to Stage IV. The study found that the total freight movement of Acer Group increase in US dollars from 870.4 million USD at Stage I in the years of 1988 through 1990 to a total of 2,536.2 million USD at Stage IV (1997-1999). From Stage I to Stage III, the total freight volume of Acer Group to and from Taiwan increase from 838.3 million USD (815.8 million + 22.5 million), 1,318.5 million USD (1,122.7 million + 195.8 million) to 2,204.2 million USD (1,314.7 million + 889.5 million). In contrast, during Stage IV, freight volume to and from Taiwan decreased to 1,055.9 million USD (838.3 million + 217.6 million) since the products manufactured from offshore factories are shipped directly to the marketplace. Moreover, Table 1 and Figure 4 show that Acer Group's outgoing freight share of Taiwan decreased from 93.7% at Stage I to 33.1% at Stage IV. The incoming freight share of Taiwan increased from 2.6% at Stage I to 38.0% at Stage III but decreased to 10.7% at Stage IV. Considering the changes in Acer's international division of labor and supply chain arrangement in recent years, the flow of freight from Acer's offshore factories to their market places expanded and accelerated from Stage III (4.6%) to Stage IV (51.8%). In Acer's experience, the freight transportation demand to and from Taiwan will indeed fluctuate according to the firm's international division of labor as well as the various supply chain operation models.

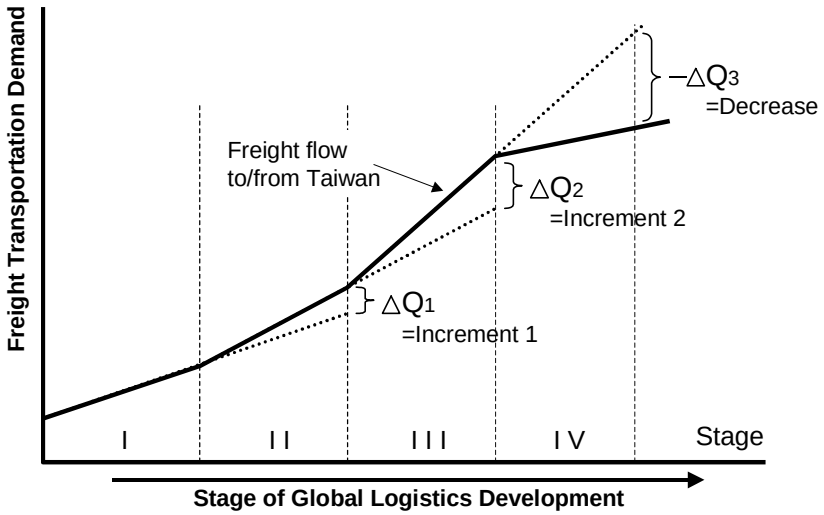


Figure 3. Acer's logistics development and freight transportation demand to and from Taiwan

Table 1. The changes in freight movement of the Acer Group: Stage I (1988-1990) -- Stage IV (1997-1999)

Unit: million US$

To / from	Taiwan		Offshore Factory		Market Place		Sub-total	
Stage I (1988-1990)								
Taiwan	0.0	0.0%	5.1	0.6%	810.7	93.1%	815.8	93.7%
Offshore Factory	22.5	2.6%	0.0	0.0%	32.1	3.7%	54.6	6.3%
Sub-total	22.5	2.6%	5.1	0.6%	842.8	96.8%	870.4	100.0%
Stage II (1991-1993)								
Taiwan	0.0	0.0%	21.7	1.3%	1,101.0	67.2%	1,122.7	68.5%
Offshore Factory	195.8	11.9%	250.1	15.3%	70.6	4.3%	516.5	31.5%
Sub-total	195.8	11.9%	271.8	16.6%	1,171.6	71.5%	1,639.2	100.0%
Stage III (1994-1996)								
Taiwan	0.0	0.0%	40.5	1.7%	1,274.2	54.5%	1,314.7	56.2%
Offshore Factory	889.5	38.0%	27.1	1.2%	108.2	4.6%	1,024.8	43.8%
Sub-total	889.5	38.0%	67.6	2.9%	1,382.4	59.1%	2,339.5	100.0%
Stage IV (1997-1999)								
Taiwan	0.0	0.0%	91.4	3.6%	746.9	29.4%	838.3	33.1%
Offshore Factory	271.6	10.7%	113.7	4.5%	1,312.6	51.8%	1,697.9	66.9%
Sub-total	271.6	10.7%	205.1	8.1%	2,059.5	81.2%	2,536.2	100.0%

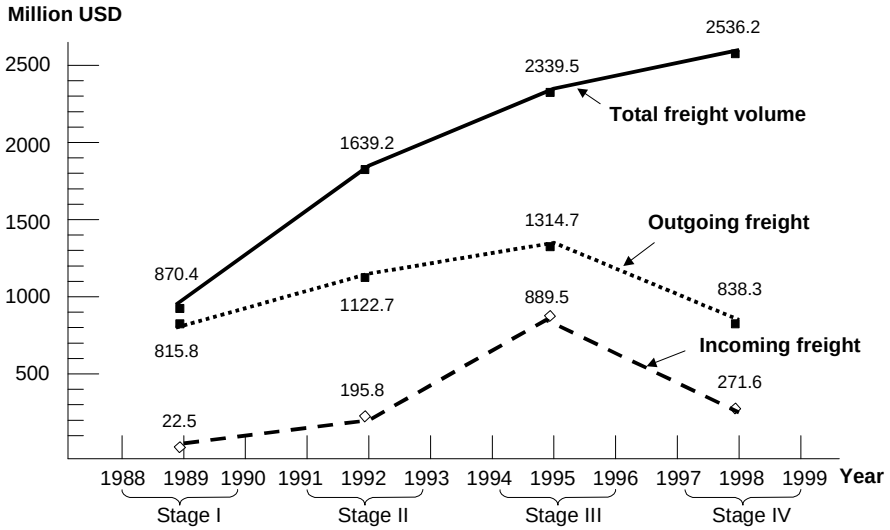


Figure 4. Acer Group's outgoing/incoming freight movement to Taiwan

4. THE EFFECTS ON INTERNATIONAL FREIGHT FLOW

Since many of the pervious studies are quite limited by a lack of available data, this study designed and conducted a questionnaire to survey the Taiwan IT manufacturing industry in order to learn the firms' logistics strategies. This section explains the rationale that was used in selecting respondent Taiwanese IT manufacturing industry, empirical research methodology, and the characteristics of the sample.

4.1 Research methodology

In order to explore issues of global logistics in Taiwan business, a survey instrument was sent to 152 IT firms listed on the Taiwan Stock Exchange (TSE). In-depth interviews, desk and

file research, cost and quantitative studies of logistics, and logistics strategies were also conducted. The objective of the interview process was to clarify the related details of firms' logistics operations and to validate findings from the survey analysis. The survey was conducted from July 1998 to June 2000. Before mailing the questionnaire, two companies were asked to pre-test the survey and to provide comments regarding the level of clarity and objectivity of the questions, the accuracy and applicability of the answer options, and the amount of time spent on the questionnaire. Suggestions were used to refine some of the questions and to add new answer options. The survey instrument was comprised of three sections. The first section contained questions asking respondents for basic information. The second section included questions regarding the manufacturing activities of the supply chain, including, the respondents' opinions concerning, the reasons driving the decision to establish offshore factories and the number of the factories of the respondents. The final section of the instrument questioned respondents as to the strategies of manufacturing and logistics, including identification of products' characteristics and cost of logistics.

4.2 Sample Analysis

A total of 45 usable surveys were returned each representing a unique firm for an effective overall response rate of 29.61 percent (i.e. 45/152). The low response rate may have been due to the very detailed nature of the survey. Despite the low response rate, it should be noted that the total number of surveys returned represented a very large database for Taiwanese IT industry supply chain research. Table 2 and Table 3 summarized the basic information regarding the respondents.

Table 2. Positions of surveyed respondents

Title of the Position	No. of Respondents	(%)	Responsibility for logistics operation			
			Yes	%	No	%
Top Management	1	2.22	0	0.00	1	2.22
Senior Management	4	8.89	3	6.67	1	2.22
Department Managers	25	55.56	20	44.44	5	11.11
Supervisors & Engineers	12	26.67	12	26.67	0	0.00
Others	3	6.66	0	0.00	3	6.67
Total	45	100.00	35	77.78	10	22.22

Table 3. Questionnaire survey response profile

Annual Sales (million USD)	No. of Respondents	(%)
Less than 500 million	31	68.89
$501 million – 1 billion	7	15.56
$1 – 1.5 billion	5	11.11
$1.5 – 2.0 billion	1	2.22
Greater than $2 billion	1	2.22
Total	45	100.00

As shown in Table 2, the positions held by the people who completed the questionnaire varied from top management to supervisors and engineers. The top management positions (2.22%) included chief executive officers, whereas the senior management positions (8.89%) included general and assistant general managers, technical directors, operations managers, and plant managers. The department managers (55.56%) were derived from control and logistics engineering; product engineering; and marketing and administration personnel, while the supervisors and engineers (26.67%) included those with the responsibility of handling manufacturing activities. Finally, the title of executive assistant and executive secretary are included in the last category (6.66%). Based on the profile of the respondents, it is assumed the sample provides a representative profile and can be used to analyze the general practices and views within the Taiwanese IT manufacturing industry. Subsequent to completing the

survey, five respondents were contacted for personal interviews to clarify perceived misunderstandings or misinterpretations of the questionnaire, and to get a more in-depth understanding of their opinions. Respondents were asked to provide demographic information related to their individual firms. Annual corporation sales per respondent ranged from $16 million to $3.06 billion USD, see Table 3, providing a wide coverage of the industry.

With regards to product lines, many firms may carry multiple products, some of these products accounting for only a small part of the total revenue. To simplify the analysis, only the products that take up to 5 percent of the total revenue will be analyzed. Among the respondents, there were 11 firms that carried a single product, 14 firms that carried two products, 13 firms that carried three products, and 7 firms that carried more than four products. Most Taiwanese IT firms carried three products on average. The vertical integration in the IT industry is obvious, and the degree of specialization is high.

4.3 Survey Results and Analysis

In order to examine the offshore relocation process of the Taiwanese IT industry, the respondents were asked to specify the location of their manufacturing factories. In this survey, the number of respondents and the related number of manufacturing locations were as follows: 9, 11, 11, 8, 6 respondents established their manufacturing factories at single, two, three, four, five and more different locations, respectively. The respondent's factories within Taiwan were considered as at a single location. In addition, the above offshore factory relocation will illustrate the Taiwanese IT firms' international division of labor. About 80 percent (36/45) of the responding companies have already relocated part of their manufacturing activities to overseas countries. In the survey, 92 offshore manufacturing factories had been established by 36 of the respondents. The distribution of those offshore factories is shown in Figure 5. There are 44 offshore factories in China, 13 in the US, 6 in Malaysia, 6 in Singapore, 5 in Thailand, 4 in the United Kingdom, 3 in Japan, 3 in the Philippines, 3 in Mexico, 1 in Hong Kong and 4 in other countries. Figure 6 illustrates the trend of the respondents' foreign investment in recent years. It indicates that the trend of foreign investment is increasing continuously.

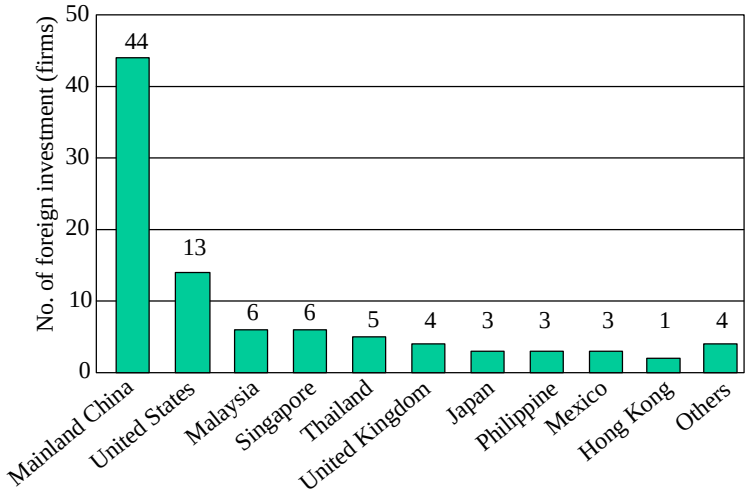


Figure 5. The distribution of surveyed IT firms' foreign investment

In addition, Table 4 highlights the reasons for the respondents' choice to relocate their factories offshore. Respectively, about 44.57 percent and 16.30 percent of the respondents agreed that lower labor and land costs were major incentives for relocation providing a long-term cost advantage. Moreover, about 3.26 percent of the respondents indicated that, lower tax and tariffs were the main reasons to relocate. Thus, in total about 64 percent of respondents indicated that labor and land costs as well as tax/tariff savings were the major cost considerations for the internationalization of the division of labor. Obviously, most of the

firms desired cheaper production input factors with cost advantages while they established their offshore factories. Furthermore, it should be noted that some respondents remarked that there were other reasons for their location selection. The reasons included “proximity to customer markets (23.91%),” “easier access to new technologies (6.52%),” “skilled labor availability (3.26%),” and “others (2.17%).”

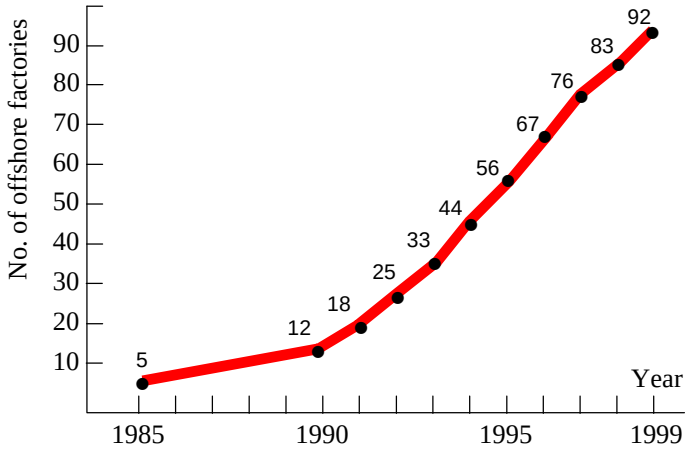


Figure 6. The trend of foreign investment

This research also tried to find the relationships between the reasons and the locations of a firm’s foreign investment. As shown in Table 5, in general, the reasons given by the respondents for establishing their factories in China and Southeast Asia were “cheaper labor costs,” and “lower tax/tariff”. On the other hand, the reasons respondents established their factories in the UK, Japan, Singapore, Mexico and the US were “proximity to customer markets,” “easier access to new technologies,” and “ skilled labor availability”. For further analyzed, this research categorizes the former countries as Group II and the latter countries as Group I.

Table 4. Reasons for offshore relocation

Reasons	No. of respondents	%
Cheaper labor cost	41	44.57
Proximity of customer markets	22	23.91
Lower land cost	15	16.30
Easier access to new technologies	6	6.52
Skilled labor availability	3	3.26
Lower tax/tariff	3	3.26
Other	2	2.17
Total	92	100.00

Note: Only the most major reason is considered for each offshore factory.

4.4 The Changes of Freight Transportation Demand to and from Taiwan

From the survey results of respondents’ international division of labor, we find that the strategies and relocating activities of Taiwanese IT firms are similar to the experience of Acer’s globalized development. Hence, this study uses respondents’ import/export data of electronics commodities to explore the relationship between firms’ globalization and the movements of freight demand. From 1990 to 1999, the import/export data of the category of electrical machinery (category of import/export goods used in the HS two-digit code) illustrated as Appendix 1.

The amount of imported and exported electronics commodities has increased since the development of the IT industry. All these products have increased their relative share of total freight transportation volume. From 1990 to 1999, the total amount of respondents’ imported

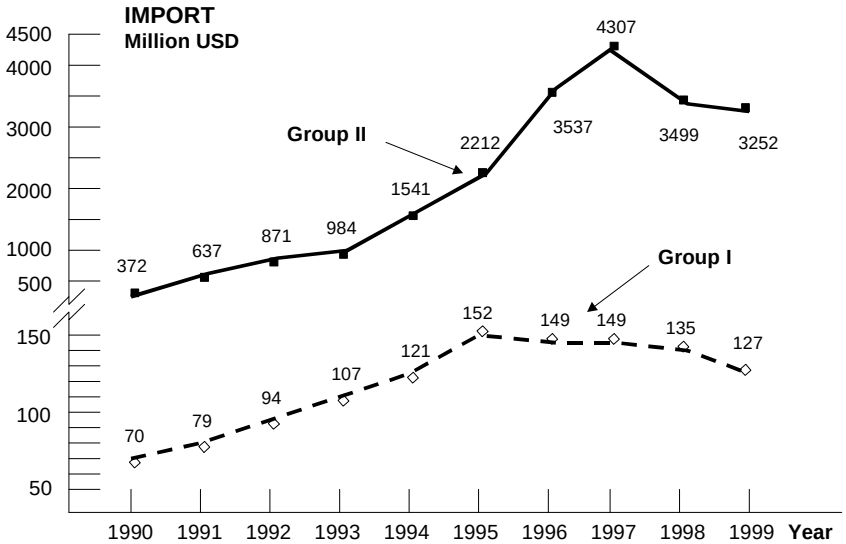
and exported electronics commodities increased from 422 million USD to 3,379 million USD and 5,603 million USD to 12,223 million USD, respectively. Moreover, from the statistical data analysis, the value of export to Group I countries were more than the value of import from those countries. In contrast, during the 1990-1999 period, the value of export to Group II countries were less than the value of import from those countries.

Table 5. The reasons of respondents offshore relocation

Unit: firm

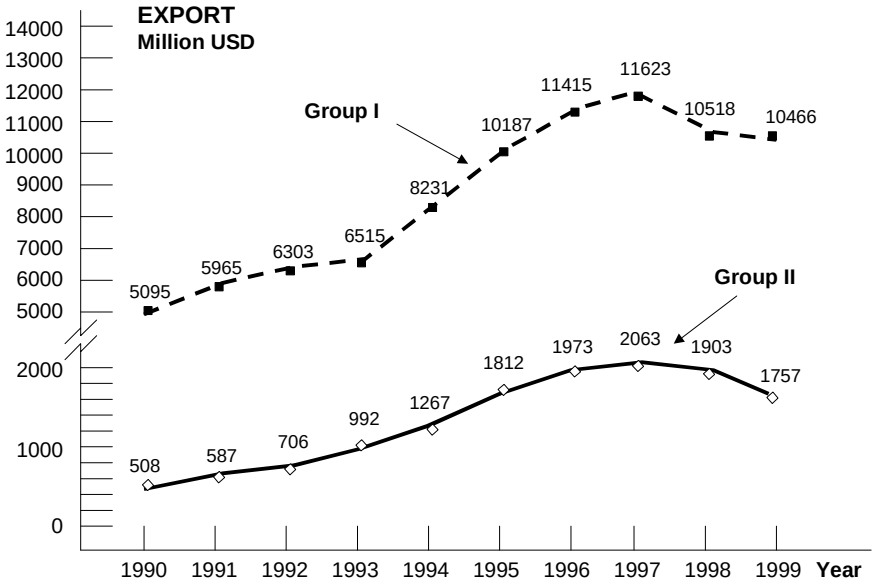
Reasons	Mainland China	Thailand	Philippines	Malaysia	Singapore	Mexico	UK	Japan	United States
Cheaper labor cost	29	4	3	5	--	--	--	--	--
Lower land cost	13	2	--	--	--	--	--	--	--
Lower tax/tariff	2	--	--	1	--	--	--	--	--
Easier to access new technologies	--	--	--	--	1	--	--	2	3
Skilled labor availability	--	--	--	--	1	--	1	--	1
Proximity of customer markets	--	--	--	--	4	3	3	1	7
Others	--	--	--	--	--	--	--	--	2
Total	44	6	3	6	6	3	4	3	13
	Group II				Group I				

Figure 7 and Figure 8 shows the trend of imports and exports by the categories of Group I and Group II. Based on the surveys, it was observed that import volume from the Group II countries' has been growing rapidly from 1990 to 1997 and decreased in 1998-1999. The total import volume from Group II is more than that from Group I, but the total export volume to Group I is much more than the volume exported to Group II. This result could reflect the features of respondents' offshore relocation and globalized manufacturing operation. In addition, the import volume from the Group II countries originated from offshore manufacturing by responding firms. This pattern exhibits characteristics similar to the global logistics development experiences of Acer Group described in Figure 4.



Note: Group I includes: US, Japan, UK, Mexico, Singapore;
Group II includes: Malaysia, Thailand, Philippines, Malaysia
Source: The Directorate General of Customs, Ministry of Finance, ROC. (1990-2000)

Figure 7. Import trend of respondents' products flow

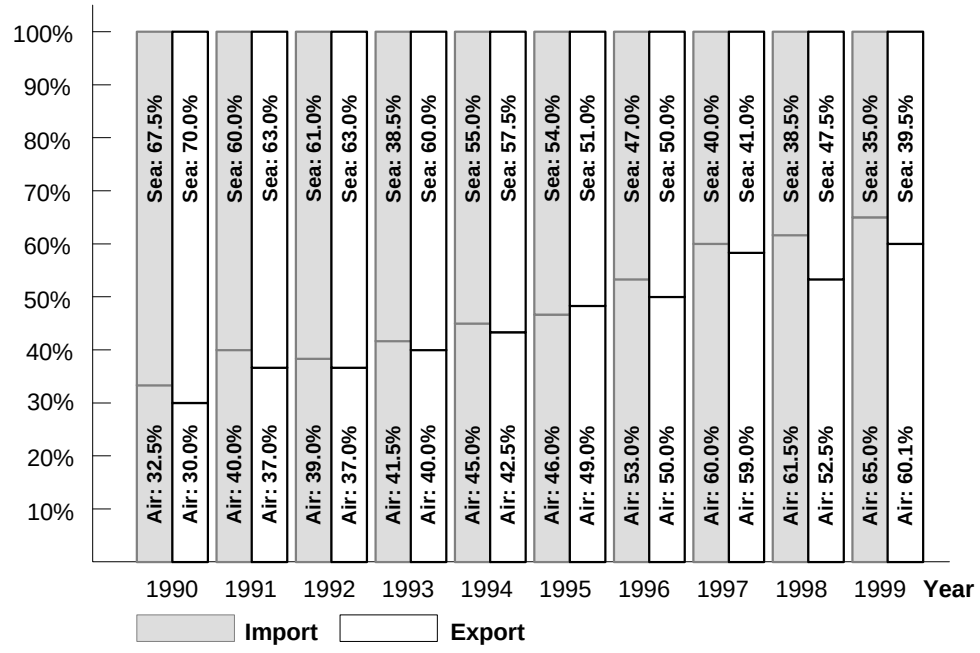


Note: Group I includes: US, Japan, UK, Mexico, Singapore;
Group II includes: Malaysia, Thailand, Philippines, Malaysia
Source: The Directorate General of Customs, Ministry of Finance, ROC. (1990-2000)

Figure 8. Export trend of respondents' products flow

Changes in the flow of goods reflect the freight transportation demand for diversification in the sophistication of handling goods. Figure 9 illustrates changes of freight transportation modal choice. In analyzing the firm's import freight transportation modal choice, the ratio by air is higher than the ratio by sea since 1996. During this same period, firms also exported their products by choosing more air transportation services than sea.

Considering the reasons for different modal choices in exports and imports, the commodity's value density (value/weight ratio) is seen as a key modal choice factor. The average import commodity's value per kilogram was higher than that of the ratio of exports. See Appendix 2. This result is also caused by IT firms' individual global logistics operations.



Source: The Directorate General of Customs, Ministry of Finance, ROC. (1990-2000)

Figure 9. Import/export freight transportation modal choice fluctuation trend

5. CONCLUSIONS AND RECOMMENDATIONS

Traditional freight transportation studies that assume manufacturing activities are concentrated at a single manufacturing location cannot well-describe the operations of today's multi-national manufacturing logistics. In order to explore the effects of various logistics strategies on international freight transportation demand, we utilized Acer's experience to describe a multinational company's global logistics operations and surveyed 152 Taiwanese IT firms to provide a detailed picture of existing global logistics operations. This study found that in Taiwanese IT firms logistics operation, the faster transportation demand increased and the slower transportation demand decreased.

It was also found that the logistics strategies of the manufacturing supply chain will affect a firm's modal choice, and the multiple-site of the multinational production logistics strategies will affect the trip generation and distribution.

This study has taken a step in the direction of defining the relationship between global logistics strategies and international freight transportation in IT industry. It is possible of course that other industries with different characteristics of the global supply chain may produce entirely different results. In addition, it is important to emphasize that methodological problems in the research design limited our interpretations.

The approach outlined in this study should be replicated in other manufacturing firms, as well as in other manufacturing industrial areas, such as the apparel and automobile industry in order to construct a typology of global logistics performance in a variety of industries. In future research, the measure of global manufacturing needs to be improved. Given the differences in application between industries it may be desirable to expand the list of activities further. Finally, other MNCs may be utilized in further studies.

ACKNOWLEDGEMENTS

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Appendix 1. Commodity Trade Flow with Major Foreign Investment Countries and Marketplace

Unit: million USD

Import from	Group I						Group II					
year	US	Japan	UK	Mexico	Singapore	Subtotal	Mainland	Thailand	Philippine	Malaysia	Subtotal	Total
1990	21	43	1	2	3	70	1	57	54	260	372	442
1991	22	49	1	3	4	79	1	87	67	482	637	716
1992	26	57	1	4	6	94	1	126	94	650	871	965
1993	30	64	1	4	8	107	61	181	126	616	984	1,091
1994	35	70	2	4	10	121	236	217	195	893	1,541	1,662
1995	41	89	3	6	13	152	470	411	264	1,067	2,212	2,364
1996	51	76	2	8	12	149	636	538	427	1,936	3,537	3,686
1997	46	75	3	12	13	149	889	578	800	2,040	4,307	4,456
1998	42	69	3	10	11	135	651	430	619	1,799	3,499	3,634
1999	43	63	2	9	10	127	595	411	589	1,657	3,252	3,379
Export to	**Group I**						**Group II**					
year	US	Japan	UK	Mexico	Singapore	Subtotal	Mainland	Thailand	Philippine	Malaysia	Subtotal	Total
1990	3,129	977	360	31	598	5,095	1	211	97	199	508	5,603
1991	3,644	1,107	391	42	781	5,965	1	209	99	278	587	6,552
1992	3,927	1,087	409	47	833	6,303	1	317	118	270	706	7,009
1993	4,052	1,090	415	68	890	6,515	6	390	150	446	992	7,507
1994	4,991	1,271	497	71	1,401	8,231	10	429	149	679	1,267	9,498
1995	5,887	1,885	539	102	1,774	10,187	87	667	187	871	1,812	11,999
1996	6,079	2,194	609	154	2,379	11,415	129	697	229	918	1,973	13,388
1997	6,529	1,996	681	157	2,260	11,623	209	631	374	849	2,063	13,686
1998	6,308	1,783	581	143	1,703	10,518	349	554	323	677	1,903	12,421
1999	6,150	1,703	572	147	1,894	10,466	301	508	299	649	1,757	12,223

Source: The Directorate General of Customs, Ministry of Finance, ROC. (1990-2000)

Appendix 2. Commodity Value Density with Major Foreign Investment Countries and Marketplace

Unit: USD/kg

Import from	Group I						Group II					
year	US	Japan	UK	Mexico	Singapore	Sub-Avg	Mainland	Thailand	Philippine	Malaysia	Sub-Avg	Average
1990	41.99	39.61	28.90	20.41	40.76	34.33	10.11	22.90	13.37	17.74	16.03	25.18
1991	43.60	38.40	27.99	22.98	41.52	34.90	9.87	23.24	14.64	20.12	16.97	25.93
1992	47.21	41.33	36.61	23.37	47.26	39.16	11.17	18.53	18.10	26.54	18.58	28.87
1993	48.34	46.08	41.97	28.86	48.31	42.71	12.08	17.53	21.98	25.88	19.37	31.04
1994	49.71	51.11	44.03	26.61	49.67	44.23	12.31	18.80	22.35	26.73	20.05	32.14
1995	59.84	50.09	40.82	30.27	53.77	46.96	12.45	25.20	30.67	33.64	25.49	36.22
1996	74.13	71.14	60.51	38.54	63.90	61.64	21.31	39.87	34.87	40.19	34.06	47.85
1997	80.83	70.36	61.33	51.14	74.12	67.56	25.40	40.59	45.21	43.37	38.64	53.10
1998	97.33	87.96	59.84	50.97	71.84	73.59	26.87	49.62	38.61	50.25	41.34	57.46
1999	96.51	90.04	71.64	49.62	80.27	77.62	29.08	52.27	48.03	56.29	46.42	62.02
Export to	**Group I**						**Group II**					
year	US	Japan	UK	Mexico	Singapore	Sub-Avg	Mainland	Thailand	Philippine	Malaysia	Sub-Avg	Average
1990	32.08	32.71	28.90	18.94	29.56	28.44	10.99	18.65	20.68	19.38	17.43	22.93
1991	33.69	34.69	32.61	23.56	34.52	31.81	11.32	20.33	21.72	23.54	19.23	25.52
1992	38.24	36.75	29.19	24.08	36.47	32.95	11.70	24.52	23.64	26.33	21.55	27.25
1993	37.58	39.18	34.07	27.65	39.50	35.60	12.55	25.61	23.09	28.50	22.44	29.02
1994	41.39	42.61	37.16	28.66	42.23	38.41	13.14	25.08	24.52	31.57	23.58	30.99
1995	55.57	43.50	39.62	31.22	44.10	42.80	16.44	28.37	26.61	36.49	26.98	34.89
1996	69.30	51.27	48.57	33.40	48.50	50.21	17.98	28.99	30.18	46.33	30.87	40.54
1997	75.64	63.39	60.73	39.50	49.76	57.80	22.37	35.64	31.09	48.50	34.40	46.10
1998	87.96	69.99	63.28	45.22	62.09	65.71	24.50	36.08	33.64	50.28	36.13	50.92
1999	97.83	75.81	60.24	45.98	61.77	68.33	25.09	37.52	35.20	59.80	39.40	53.86

Source: The Directorate General of Customs, Ministry of Finance, ROC. (1990-2000)

A survey analysis of supply chain adjustment for Taiwanese information technology firms

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Abstract

Due to the globalization of industry, the explosion in customer services, and product life-cycle compression, most manufacturers have been adjusting the processes and activities of their supply chains in order to remain competitive and optimize profit. The objective of this study is to explore the issues surrounding the changes in manufacturing supply chains and the consequential impact on freight transportation demand. A questionnaire to survey Taiwanese information technology (IT) firms was designed and conducted, to recognize in detail the changes in supply chains of manufacturers, tends in the international division of labor and the strategic adjustment of manufacturing and logistics. Surveys and interviews lead to the conclusions that 1) vertical integration and international division of labor are very conspicuous among Taiwanese IT firms, 2) there are different strategies of supply chain adjustment at various stages of the product life cycle, 3) with the transformation of the supply chain, manufacturers require faster transportation services, that is, the demand for air transportation may increase and the demand for sea transportation may decrease, 4) those firms who apply the postponement strategy to adjust their supply chain might be restricted to the availability of transportation services in the factory location area.
Keywords: supply chain management; global logistics; product life cycle; information technology

1. Introduction

Over the past decade, the trends in the rapidly changing world economy have been forcing firms to reshape the processes and activities of their supply chains to enhance competitiveness (Christopher, 1998). Manufacturers are increasingly establishing new factories overseas to survive in a fiercely competitive global environment. Hence, individual firms are not only changing the origin/destination (O-D) of transportation demand and modal choice, but they are also influencing overall international freight flows (Feng, et al., 2000). Under this worldwide specialization of production, transportation between continents and between countries increases at a faster rate than world economic growth.

As for the supply chain, previous studies focused on movement of goods from raw material procurement to product distribution during the manufacturing process. This includes producing sequences, placing orders, inventory management, transport, warehousing and

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customer services. Some studies include the entire commercial process from upstream suppliers and downstream customers in the domain of the supply chain, integrating into the discussion of supply chains, product, service and information, production and logistics. Wyland et al. (2000) suggested a conceptual structure for supply chain management to integrate manufacturing, retailing and logistics. Cooper (1997), Zinn and Bowersox (1998) and van Hoek et al. (2000) proposed the concept of postponement for supply chain. Furthermore, Pagh and Cooper (1998) identified four generic supply chain P/S-strategies, by combining manufacturing and logistics postponement and speculation. In addition, Ganeshan et al. (1999) provided a taxonomy of supply chain management research, which reviewed the studies on the conceptual perspective, evolution, categories and researched methodologies of supply chain management. Generally speaking, a great deal of research on supply chain management has been covered since 1953. However, most of the studies focused on the analysis of business processes within individual firms. Few studies describe the changes of freight flows and the modal choice of firms in relation to changes on the supply chain.

Regarding the influence that product development has on the supply chain, most research has categorized product life-cycle into a series of stages: introduction, growth, maturity and decline (Birou et al., 1998; Wyland et al., 2000; Dicken, 1992). Product life-cycle was adopted to expound on the evolution of international production. Birou et al. (1998) also conducted a three-part empirical study of production, purchasing, and logistics management professionals that investigated the linkage between functional level strategies and the product lifecycle. Birou identified that the product's lifecycle ability to define competitive priorities as well as important product characteristics makes it an ideal tool to use as a linking mechanism. Moreover, Pagh (1998) took product lifecycle as one of factors that could explain different adjustment strategies on the supply chain.

In previous freight transportation studies, discussions focused on demand forecasting over adjustments of the supply chain. One of the most important reasons for this involves the difficulty of accessing the details of supply chain operations. Qrtuzar (1990) has reviewed some articles on freight transportation demand indicating that current freight transportation research tends to emphasize the role of freight transport in the overall manufacturing/ distribution process. Traditionally, most of the freight transportation studies assumed that product manufacturing was completed in a concentrated region. However, under the trends of international division of labor, firms manufacture their products at diversified locations. Previous freight transportation studies are incapable of reflecting current manufacturing characteristics and the features of a firm's transportation demand.

Some researchers have utilized location theory and world system theory to explain industrial spatial distribution. Healey et al. (1990) indicated that world system theories explained the evolution of a world economy in terms of the international character of the capitalist system. The global distribution of a firm's operations can be explained by categorizing geographical locations by their level of economic development. The world economy is divided into a core, periphery, and semi-periphery and countries can move from core to periphery, periphery to semi-periphery, and so on. The core area is characterized by high wages, advanced technology and diversified production mix. Quite the opposite is true of the periphery (low wages, little technology, and a narrow economic base), whereas countries in the semi-periphery have a combination of both sets of characteristics exploiting peripheral countries while being exploited by core countries. Multinational enterprises have been moving standard and labor-intensive manufacturing activities from core to periphery regions, where more convenient geo-locations and transport, lower costs in labor, land and other production input factors provide a competitive advantage. Core regions are utilized mainly for R&D, finance, retailing and administration activities.

This study recognizes that most of the previous studies, similar to the above research

literature, focus on supply chain management, transport and spatial economy, yet discussion of their interaction is scarce. However, transport demand is a derived demand, adjustments on the supply chain affect transportation to different extents. Therefore this study would like to investigate supply chain adjustment factors through the survey of the international division of labor and supply chain reconstruction of information technology (IT) industry in Taiwan. The intention is to understand how supply chain adjustment may affect transportation demand. The findings may serve as the basis for future quantitative analysis.

The first section of this article gives a brief overview of previous research. The second section identifies the problems and domains of this study. It depicts the characteristics, adjustment strategy of manufacturers' supply chain and the propositions this study tries to verify. The third section explains the design of questionnaires, survey approaches, industry selection and sample analysis. The fourth section discusses the relevant results of the survey. The final section will offer conclusions and recommendations for future research.

2. Problem analysis and study domain

In this section, the 'supply chain' is defined first. The objectives and strategies of a firm's supply chain adjustments is also be stated. By reviewing previous studies, the potential relationships between product development characteristics and the supply chain changes may be described. At the end of the section, the propositions for investigation are developed.

2.1. Supply chain of manufacturing industry

In recent years, much research has focused on the performance, design, and analysis of the supply chain as a whole and the effects of the rising costs of manufacturing, the shrinking resources of manufacturing bases, shorten product lifecycles, and the globalization of market economies (Beamon, 1998). The supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services (Christopher, 1998). 'Supply chain management' introduces managerial components (such as planning and controls, organizational structure, information process) to the processes of supply chain operation, handling the mutual interrelationships between upstream and downstream processes with suppliers and customers to provide lower costs and better services. Figure 1 illustrates the conceptual framework of the manufacturing industry supply chain. In the figure, each node is an event of supply chain activities, and the links among nodes represent the supply chain processes. Together, the nodes and links comprise the entire supply chain network. For example, the main supply chain activities of the manufacturing industry include: raw materials procurement and storage, parts manufacturing, storage of the work-in-progress, assembling for semi-finished and finished products (labeling and packaging), warehousing for finished products, retailing/distributing to customers. The semi-finished products have to be gathered at one location and assembled to become final products. This operation may take place in one factory, or in the distribution centre/regional warehouse, midstream or downstream along the supply chain. The point of final assembly depends on the manufacturer's individual supply chain organization.

Moreover, logistics is defined as the process of managing the procurement, movement and storage of materials, parts, and semi-/finished products through the organizing and distributing channels. The Council of Logistics Management (1993) defines logistics as 'the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements'. Distribution of freight from one or more origins to one or more destinations is the core of logistics. This paper segmented logistics into the activities of supply chain. Logistics can be segmented into several parts: 1) inbound

logistics, i.e., the processes related to the raw material procurement; 2) manufacturing logistics, i.e., the processes covering the raw material/parts processing and the assembly for finished products; 3) outbound logistics, i.e., the processes that deliver the finished products to the customers as soon as the orders received. No matter what it is, inbound, manufacturing and outbound logistics demonstrate the demands toward transportation services. The paths they take are the transportation networks. The focus of this study is the downstream flow of the supply chain, from factory to end customer.

[Insert Figure 1 about here.]

2.2. Supply chain adjustments

2.2.1. Purposes of supply chain adjustments

The supply chain adjustments mentioned in this article include adding, removing, relocating activities (nodes) in the supply chain. These activities' rearrangement will alter the processes of the supply chain.

In general, two purposes are important in adjusting the supply chain of a manufacturing firm. One, decreasing the cost, requires that manufacturers look for inexpensive input factors to obtain comparative cost advantages, or that manufacturers obtain benefits of scale economies by concentrating the supply chain activities. Two, the enhancement of the level of customer service requires that manufactures offer customers more options by providing differentiated and customized products as well as faster display by delivering products to markets as early as possible.

2.2.2. The basic principles of supply chain adjustments

To meet needs, firms usually rearrange their supply chain activities by means of 'centralization' or 'diversification' in space and 'speculation' or 'postponement' in time. 'Centralization' concentrates the activities of the supply chain at one site to obtain the economy of scale in manufacturing and the economy of cluster caused by the geographic proximity of upstream and downstream production. This approach reduces manufacturing logistics by concentrating manufacturing activities. Firms usually apply the 'centralization' approach in laying out manufacturing activities, for example, one factory may take care of the operation from raw materials procurement to finished products, or several production lines design within a close area for mass production.

As to 'diversification', firms move some activities upstream to obtain cheaper input factors for reducing the production cost. Some may move downstream to respond to customer's needs quickly. As manufacturing activities become more scattered, manufacturing logistics increases. In recent years, the international division of labor in global business has become an important 'diversification' in space for supply chain adjustment.

The logic behind 'postponement' is that risk and uncertainty costs are tied to the differentiation (form, place and time) of goods that occurs during manufacturing and logistics operations. To the extent that parts of the manufacturing and logistics operations can be postponed till final commitments have been obtained, the risk and uncertainty of those operations can be reduced or fully eliminated. The notion of manufacturing postponement is to retain the product in a neutral and non-committed status as long as possible in the manufacturing process. This means to postpone differentiation of form and identity to the latest possible point. The notion of logistics postponement is to maintain a full-line of anticipatory inventory at one or a few locations. This means to postpone changes in inventory location downstream in the supply chain to the latest possible point.

The converse concept to postponement is 'speculation', which holds that changes in form, and the movement of goods to forward inventories, should be made at the earliest possible time to reduce the costs of the supply chain. Speculation makes it possible to gain economies

of scale in manufacturing and logistics operations, and limit the number of stock outs. At the same time, the firm's speculations must meet the predicted market demands and customer services. Under this concept, manufacturing and logistics operations are initiated earlier according to the prediction, thus risks and uncertainties increase relatively.

Many previous studies discussed the impacts of supply chain activities' speculation or postponement adjustments on the manufacturers' production performance. Cooper (1998) identified four different supply chain postponement strategies for some global brands. Zinn and Bowersox (1998) proposed five different types of postponement strategies. Four different strategies of form postponement (labeling, packaging, assembly and manufacturing) together with time postponement, constitute the five postponement strategies. Pagh (1998) suggested four supply chain adjustment strategies, 'the full speculation strategy', 'the manufacturing postponement strategy', 'the logistics postponement strategy', and 'the full postponement strategy', after he decided to combine activities in manufacturing and logistics based on related studies.

Basically, supply chain adjustments rearrange the combinations of activities and processes in the supply chain. The adjustment in 'space' varies activity location and the adjustment in 'time' varies the operation scheduling of the supply chain. The processes change along with the adjustments in the supply chain activities.

2.2.3. The relationships between product development and supply chain adjustments

Since its initial conceptualization in the early 1950s, the product life-cycle theory has gained significant recognition as a tool for effective marketing strategy formulation and implementation. The product life cycle, as defined by Dicken (1992), is the growth of sales of a product from initial innovation through a series of stages: introduction, growth, maturation, and decline, as illustrated in Figure 2. When a new product has just been introduced on to the market, the total volume of sales tends to be low because consumers are unaware and not confident about the product's quality and reliability. At this stage, few competitors exist in the market therefore as long as consumers become aware of the product via its own quality and promotion, the product should enter the 'growth stage'. There is an increase in demand for the product. Other competitors may then enter the market as the demand/sales increase. Next, manufacturing techniques should stabilize under the growing competition among firms, and the manufacturing supply should reach its peak, as market growth hits a ceiling. However, when the product attains maturity demand begins to level out. New products often appear at this stage replacing the current one, and shifting market demand, thus the sales of the old product decrease and enter the 'decline stage.' A product's life cycle is a continuous development. The divisions on the above life cycles at different stages are conceptual. However the differences in the demands, competition environments, technology developments at various stages are quite distinct.

At different stages of the product life cycle, a firm may have correspondingly different strategic plans for each activity in the supply chain due to the various manufacturing technologies and market needs. The length of each product life cycle is different, the life cycle period is distinct from product to product. However, there is growing evidence that product life cycles are tending to become shorter, industrial customers and distributors require just-in-time deliveries, and end customers are ever more willing to accept a substitute product if their first choice is not instantly available.

Birou et al.(1998) indicated that product life cycle can reflect important characteristics of a product. Thus life cycle can be taken as an adequate tool in determining strategies for logistics, operation and purchasing. Higashi et al. (1994) also presented that the form of corporate alliance used may also depend on what stage of the product life cycle is involved.

[Insert Figure 2 about here.]

2.3. Propositions of this research

When reviewing literature concerning the supply chain, freight transportation, spatial economy and product life cycle theory, many discussions of manufacturing supply chain planning and principles of supply chain adjustments prevail. However, few investigations discuss the following issues: whether globalization will affect the firm's supply chain adjustments; if the supply chain adjustment strategy should vary with the stage of the product's life cycle; how supply chain adjustments affect the decision making of firms in modal choice and in freight transportation origin/destination; while the firms adjusting the supply chain, what is the role of the availability of transportation service.

Based on the previous discussion and literature review, the propositions to be investigated are as follows:

Proposition 1: Globalization of industry and changing international division of labor will induce Taiwanese firms' manufacturing activities to shift to overseas countries.

Many studies recognize that firms will relocate their manufacturing sites due to cheaper raw materials procurement --- or to respond to customers' needs quickly. Especially, with the liberalization of international trade and the reduction of trade barriers, firms establish factories in overseas countries to manufacture products to meet local demand. Under this changing environment, whether the Taiwanese manufacturing industry will undergo international collaboration, and if adjustments will follow in the supply chain is the first issue of discussion in this study.

Proposition 2A: The stage of product life cycle will indeed affect the firm's supply chain adjustment strategy in 'Space'.

Proposition 2B: The stage of product life cycle will indeed affect the firm's supply chain adjustment strategy in 'Time'.

Since the nature of the production process tends to vary according to stages in the life cycle, each stage will tend to have different production features: of technology, of market demand and of competition. Proposition 2A and 2B would like to depict the fact that for system optimization, the supply chain adjustment strategies in space and time will vary accordingly.

Proposition 3: The supply chain adjustments will affect the manufacturers' modal choice and change freight transportation origin/destination.

The manufacturing industry supply chain is incomplete without transportation services delivering raw materials, work-in-progress and finished products. All the adjustments in the supply chain will directly affect the manufacturer's distribution operations, modal choice, and then freight O-D patterns of a firm's transportation demand.

Proposition 4: The supply chain adjustments depend on the availability of transportation services.

This proposition intends to depict that transportation service will not only affect the shipping time to the end customers, but also be the important factor manufacturers consider in adjusting their supply chains.

Proposition 5: The transportation cost will affect the firm's supply chain adjustment.

This proposition intends to depict that transportation cost will be the important factor manufacturers consider in adjusting their supply chains.

3. Questionnaire design and sample analysis

Since many of the pervious studies are quite limited by data unavailability, this study designed and conducted a questionnaire survey on Taiwan manufacturing industry in order to collect information concerning firms' supply chain adjustment strategies and obtain the relevant freight transportation data. This section explains the rationale that was used in selecting respondents from the Taiwanese manufacturing industry, the empirical research

methodology, and the characteristics of the sample.

3.1. Industry selection

Industry selection was based on three criteria. First, the industry had a representative output share in the Taiwan economy. Second, the supply chains that were utilized by firms in a particular industry had to be highly flexible to highlight the significance of supply chain changes under global conditions and the impact on freight transportation. Third, the product life cycle of the industry had to be short to reveal the features of different life cycle stages.

According to these criteria, relevant economic data, and the Taiwan Standard Classification of Commodities, the IT industry was selected as the target industry for the survey. Investment in Taiwan IT industry has been growing rapidly and the production value has been increasing continuously. In 1998, IT industry accounted for 30.3% of the total production value of the Taiwanese manufacturing industrial sector. It grew an additional 12.4 percent from 1989 to 1998. The manufacturing industry structure of Taiwan is shown in Table 1. The IT industry in this study includes: information hardware (computer hardware, key components), semiconductor (semiconductor manufacturing, semiconductor service-IC testing, semiconductor's raw materials).

In general, because IT products have shorter life cycles and the adjustment of the supply chain is more flexible, IT firms respond to the comparative advantages of input factors and the market demand quickly. Furthermore, under this quick responding business model, it is easier to investigate the interactive relationship between freight transportation services and the supply chain changes from IT firms' operations.

[Insert Table 1 about here.]

3.2. Research methodology

In order to explore issues of supply chain operations in Taiwan business, a survey instrument was sent to 152 IT firms listed on the Taiwan Stock Exchange (TSE). In-depth interviews, desk and file research, cost and quantitative studies of logistics and manufacturing strategies were also conducted. The objective of the interview process was to clarify the related details of firms' supply chain adjustments and to validate findings from the survey analysis. The survey was conducted from July 1998 to September 1999. Before mailing the questionnaire, two companies were asked to pre-test the survey and to provide commends regarding the level of clarity and objectivity of the questions, the accuracy and applicability of the answer options, and the amount of time spent on the questionnaire. Suggestions were used to refine some of the questions and to add new answer options. The survey instrument was comprised of three sections. The first section contained questions asking respondents for basic information. The second section included questions regarding the manufacturing activities of the supply chain, including, the respondents' opinions concerning, the reasons driving the decision to establish offshore factories and the number of the factories of the respondents. The final section of the instrument questioned respondents as to the strategies of manufacturing and logistics, including identification of products' characteristics and cost of logistics.

3.3. Sample analysis

A total of 45 usable surveys were returned each representing a unique firm for an effective overall response rate of 29.61 percent (i.e., 45/152). The low response rate may have been due to the very detail nature of the survey. Despite the low response rate, it should be noted that the total number of surveys returned represented a very large database for Taiwanese IT industry supply chain research.

Table 2 and 3 show the profile of respondents from selected industries. As shown in Table

2, the positions held by the people who completed the questionnaire varied from top management to supervisors and engineers. The top management positions (2.22%) included chief executive officers, whereas the senior management positions (8.89%) included general and assistant general managers, technical directors, operations managers, and plant managers. The department managers (55.56%) were derived from control and logistics engineering; product engineering; and marketing and administration personnel, while the supervisors and engineers (26.67%) included those with the responsibility of handling manufacturing activities. Finally, the last category includes the titles of executive assistant and executive secretary (6.66%). Based on the profile of the respondents, it is assumed the sample provides a representative profile and can be used to analyse the general practices and views within the Taiwanese IT manufacturing industry. Subsequent to completing the survey, five respondents were contacted for personal interviews to clarify perceived misunderstandings or misinterpretations of the questionnaire, and to get a more in-depth understanding of their opinions. Respondents were asked to provide demographic information related to their individual firms. Annual corporation sales per respondent ranged from $16 million to $3.06 billion USD, see Table 3, providing a wide coverage of the industry.

With regards to product lines, many firms carried multiple products, some of these products accounting for only a small part of the total revenue. To simplify the analysis, only the products that take up to 5 percent of the revenue were analysed. Among the respondents, there were 11 firms that carried a single product, 14 firms that carried two products, 13 firms that carried three products, and 7 firms that carried more than four products. Most Taiwanese IT firms carried three products on average. The vertical integration in the IT industry is obvious, and the degree of specialization is high. Table 2 and 3 summarizes the basic information regarding the respondents.

[Insert Table 2 about here.]

[Insert Table 3 about here.]

4. Survey results and analysis

This section discusses the respondents' survey results concerning supply chain adjustments in order to investigate the above propositions. In addition, it tries to identify the model of supply chain adjustment.

Proposition 1: Globalization of industry and changing international division of labor will induce Taiwanese firms' manufacturing activities to shift to overseas countries.

In order to examine the offshore relocation of supply chain activities, the respondents were asked to specify the location of their manufacturing factories. In this survey, the number of respondents and the related number of manufacturing locations were as follows: 9, 11, 11, 8, 6 respondents established their manufacturing factories at single, two, three, four, five and more different locations, respectively. The respondent's factories within Taiwan were considered as at a single location. The above offshore factory relocation illustrates Taiwanese IT firms' international division of labor. About 80 percent (36/45) of the responding companies have already relocated part of their manufacturing activities to overseas countries. The results indicate that the supply chains of respondents have already been adjusted in 'space' diversification. In the survey, 92 offshore manufacturing factories had been established by 36 of the respondents. The distribution of those offshore factories is shown in Figure 3. There are 44 offshore factories in China, 13 in the US, 6 in Malaysia, 6 in Singapore, 5 in Thailand, 4 in the United Kingdom, 3 in Japan, 3 in the Philippines, 3 in Mexico, 1 in Hong Kong and 4 in other countries. Figure 4 illustrates the trend of foreign investment among respondents in recent years, it is a continuously trend. In the IT products'

manufacturing processes, most of the semi-products (parts) can be independently manufactured, therefore, the supply chain adjustments are relatively flexible and the activities of the supply chain can be relocated with few restrictions. Taiwanese IT firms have been establishing their offshore factories to manufacture parts or products utilizing the international division of labor. The results of the survey support Proposition 1.

[Insert Figure 3 about here.]

[Insert Figure 4 about here.]

In addition, Table 4 highlights the reasons for the respondents' choice to relocate their factories offshore. Respectively, about 44.57 percent and 16.30 percent of the respondents agreed that lower labor and land costs were major incentives for relocation providing long-term cost advantages. Moreover, about 3.26 percent of the respondents indicated that, lower tax and tariffs were the main reasons to relocate. Thus, in total about 64 percent of respondents indicated that labor and land costs as well as tax/tariffs savings were major cost considerations for the internationalization of the division of labor. Obviously, most firms desire cheaper production input factors, however some respondents indicated that other reasons instigated their location selection. The reasons included 'proximity to customer markets (23.91%),' 'easier to access new technologies (6.52%),' 'skilled labor availability (3.26%),' and 'others (2.17%).'

[Insert Table 4 about here.]

This research also tries to find the relationships between the reasons and the locations of firms' foreign investment. As shown in Table 5, in general, the reasons given by the respondents for establishing their factories in China and Southeast Asia were 'cheaper labor costs,' and 'lower tax/tariffs'. On the other hand, the reasons respondents established their factories in the UK, Japan, Singapore, and the US were 'proximity to customer markets,' 'easier to access new technologies,' and 'skilled labor availability'. In the former, most of the products of offshore factories were in the 'maturity' or 'decline' stage of their life cycle, and in the later, the products were in the 'introduction' or 'growth' stage.

[Insert Table 5 about here.]

In conclusion, a majority of Taiwanese IT manufacturers relocated their factories to China and Southeast Asian countries for cheaper and cost comparative advantages in production input factors, while manufacturers who established their factories in the UK, Japan, Singapore and the US cited the ability to interact quickly with customers and advanced technology as the motivating factors. Although they are both foreign investments, the purposes and the products' characteristics are different. Different types of geographical relocation are relevant to different stages of the product life cycle.

Proposition 2A: The stage of product life cycle will indeed affect the firm's supply chain adjustment strategy in 'Space'.

In order to investigate Proposition 2, this research tries to identify the interrelationship between the manufacturing products' characteristics and the firms' supply chain adjustment strategies. There were 65 major products carried by the surveyed forty-five respondents. In the survey, the definitions of the four stages of product life cycle, as shown in Figure 2, were introduced to the firms, and then the firms categorized their own product development. As confirmed by the respondents, out of the 65 products, there were 2 in the introduction stage,

19 in the growth stage, 35 in the maturity stage and 9 in the decline stage.

Examining manufacturing locations, it was discovered that the 1 products in the introduction stage were made within Taiwan (50.0%). Out of the 19 products in the growth stage, 15 products were made fully in Taiwan (78.9%) and 4 products were partially or not at all made in Taiwan (21.1%). Out of the 35 products in the maturity stage, 9 products were made fully in Taiwan (25.7%) and 26 products were partially or not at all made in Taiwan (74.3%). At last, out of the 9 products in the decline stage, 2 products were made fully in Taiwan (22.2%) and 7 products were partially or not at all made in Taiwan (77.8%), see Table 6. According to the survey results, as the life cycle proceeds, manufacturing activities shift from Taiwan to offshore factories. More generally, along with the product life stage, firms adjust their supply chain in 'space', that is, diversify to different locations instead of centralizing in Taiwan. The results of the survey support Proposition 2A.

[Insert Table 6 about here.]

Proposition 2B: The stage of product life cycle will indeed affect the firm's supply chain adjustment strategy in 'Time'.

In addition, this research also investigated whether firms adopted a 'speculation' or 'postponement' strategy in 'time' in manufacturing and logistic operations.

When analyzing the data the stage of the product life cycle was important in determining manufacturing and logistics strategies; the results took the following pattern:

1) For the speculation strategy in manufacturing, there was 2 product in the introduction stage, 12 in the growth stage, 25 in the maturity stage, and 2 in the decline stage.
2) For the postponement strategy in manufacturing, there was 0 product in the introduction stage, 1 in the growth stage, 2 in the maturity stage, and 6 in the decline stage.
3) For the speculation strategy in logistics, there was 2 product in the introduction stage, 7 in the growth stage, 4 in the maturity stage, and 0 in the decline stage.
4) For the postponement strategy in logistics, there was 0 product in the introduction stage, 3 in the growth stage, 26 in the maturity stage, and 7 in the decline stage. See Table 7.

[Insert Table 7 about here.]

Following the survey results, four types of 'time' adjustments are seen applied by Taiwanese IT firms. (1) The characteristics of products in the introduction stage are less significant due to a lack of samples. 'Speculation' strategy or no action is taken in manufacturing and logistics. (2) 'Speculation' strategy or no action is mostly applied on products in the growth stage for manufacturing and logistics. (3) For products in the maturity stage, most of the firms apply the 'speculation' strategy in manufacturing, while some take no action. In logistics, they tend to use the 'postponement' strategy. (4) For the products in the decline stage, the 'speculation' strategy is taken in both manufacturing and logistics.

Due to the limited number of surveyed respondents, the statistical significance test is not applied on the questionnaire results. In particular, there were too few samples of products in the 'introduction' and 'decline' stages. However, this survey offers considerable support that supply chain adjustments in 'time', are functions of the product life cycle. Proposition 2B is supported.

Proposition 3: The supply chain adjustments will affect the manufacturers' modal choice and change freight transportation origin/destination.

In the manufacturing supply chain, freight transportation demand occurs when materials, works-in-process, and finished products are moving among nodes. It includes 'inbound logistics,' 'manufacturing logistics,' or 'outbound logistics' as mentioned in previous sections. The supply chain adjustments of the firms in this survey may be divided into 'space' and 'time'. The influences that the supply chain adjustments have on freight transportation will be

discussed for both approaches.

As to the 'space' adjustments, the respondents' diversified their supply chain activities to different locations through the establishment of offshore factories. Due to the supply chain manufacturing activity dispersion and relocation, new freight transportation demand was generated. The origin/destination pairs of freight transportation varied as those supply chain activities shifted in 'space.' The products' weight and value also changed within the supply chain activities' movement.

As to the 'time' adjustments, manufacturers applied 'speculation' or 'postponement' strategies to manufacturing and logistic operations according to the stages of the product life cycle. If manufacturing activities were speculated, the stock and risks for firms increased but the impact on freight transportation demand decreased. If postponement was applied, firms choose faster transportation services to compensate for the loss in time caused by the postponement of operations in manufacturing. If speculation is applied to logistic operations, no significant impact on freight transportation demand and the speed of transportation services is observed. However, when logistic operations were postponed, manufacturers may have had to use faster transportation services to compress shipping time. In general, supply chain adjustments affected the shipping time and the modal choice. Manufacturers tend to select faster transportation services to compensate for the shortened response time. For such cases, transportation costs are usually not major considerations. On the other hand, 'speculation' strategy provides longer response time, firms may select less speedy and lower cost transportation services.

Table 8 shows date from respondents about the average lapse of time from receipt of a customer's order through to delivery (i.e. response time), average transportation time, and modal choice. The results of the cross-analysis for average response time and products' life stages, at 'introduction,' 'growth,' 'maturity,' and 'decline' was 8.2 to 8.5 days, 6.9 to 7.5 days, 4.9 to 5.1 days, and 5.3 to 5.4 days, respectively. The average transportation time was 7.2 to 7.5 days, 5.7 to 5.9 days, 3.5 to 3.6 days and 1.6 to 1.8 days, respectively. In modal choice, most of the respondents used airfreight transportation services; only a few products were transported by sea freight. For most of the products, the transportation cost accounts for a low portion of the sale price. Different manufacturing/logistic strategies were adopted in relation to the different stages of the product life cycle, and the status of products differed with the time that orders were received. The survey discovered that the products in the 'introduction', 'growth' and 'maturity' stages were completely finished when the orders were received, but the products in 'decline' stages were still works-in-progress.

[Insert Table 8 about here.]

From the results of the survey, the supply chain 'space' adjustment affected the freight transportation origin/destination. Newly induced transportation demand was generated by the fragmentation of the supply chain's manufacturing activity. As to the 'time' adjustments in supply chains, if 'speculation' was adopted, there was no significant impact on the transportation demand. If 'postponement' was adopted in manufacturing or logistics, to compress the response time, firms chose a faster transportation mode. Under this changing trend, the faster transportation services increased and the slower transportation services decreased.

Proposition 4: The supply chain adjustments depend on the availability of transport services.

As shown in the analysis, the respondents adjusted their supply chain in 'space' and/or 'time'. This research also investigated the impact on supply chain adjustments with transportation services availability in the two approaches mentioned above.

In the survey, respondents were posed with the following question, 'In selecting the region/country for offshore manufacturing factories, would you consider the availability of the local transportation services in that foreign country?' None of the 36 respondents with overseas factories considered the availability of local transportation services as an important decision-making factor. However, as the questionnaire moved to the question, 'In selecting the city for the establishment of a new factory, would you consider the availability of transportation services in that city?' There were 32 respondents out the 36 that took this consideration seriously. Transportation service availability did not affect the decision making process for international division of labor but it was an important factor for selecting factory sites.

If firms adopted a 'postponement' strategy in 'time' adjustment, the average transportation time ranged from 1.8 to 3.5 days. See Table 8. Therefore, we may conclude that if no fast transportation service is available in a region, it would be impossible to ship products on time and the 'postponement' strategy could not be applied to supply chain adjustments.

According to the above analysis, the availability of transportation services seemingly does not constitute a reason for firms to relocate their manufacturing factories to other countries. But once the relocation decision is made, the availability of transportation services becomes an important decision-making factor in selecting the factory cities. In 'time' adjustments for the supply chain, availability of fast transport services is a necessary condition for firms to adopt the 'postponement' strategy.

Therefore, the information from this survey offers partial support for Proposition 4. The results for space adjustments do not support Proposition 4. However, when manufacturers had decided to relocate their factories overseas, the transportation services availability of each alternative site will be the criteria of evaluation. Furthermore, when the factory applies the 'postponement' strategy, the Proposition is supported.

Proposition 5: The transportation cost will affect the firm's supply chain adjustment.

From Table 8, we found that the respondents' supply chain adjustments affected the shipping time and mode choice, but transportation cost was not a major consideration. Even the value of (transportation costs/product sales prices) in the 'maturity' and 'decline' stages were higher than the value in the 'introduction' and 'growth' stages, the respondents in the stages of 'maturity' and 'decline' chose the faster but more expensive airfreight transportation services. Therefore, this survey of information technology firms does not support Proposition 5.

In addition, it recognizes that the response time in the supply chain is inversely proportional to the level of customer services, as shown in the upper part of Figure 5. The lower part of the Figure presents the relationship of transportation speeds vs. response time with various distances ($Dist_1$、 $Dist_2$、 $Dist_3$) between the manufacturing factories and customer markets.

[Insert Figure 5 about here.]

When a new product is first introduced to the market, the demand is low. Manufacturing and logistics operations stay on schedule. The response time to customers or retailers is not rushed. See Point A in Figure 5, the response time t_1 will map the customer service level LOS_1. The transportation service provides speed v_1 delivers the products from manufacturer to the customer/retailer ($Dist_1$) during period (t_1).

Moreover, as the product life cycle proceeds, firms adjust their supply chain in 'time', from 'speculation' strategies to 'postponement' strategy. In the meantime, the customer service requirements increased from Point A to C in the Figure. In this case, the response time is shortened from t_1 to t_2. If the distance $Dist_1$ remains unchanged, then a faster transportation

speed v_2 is needed.

No matter whether 'centralization' or 'diversification' is adopted in supply chain 'space' adjustments, the transportation service has to increase its speed to v_3 due to the increased distance $Dist_2$ as long as the response time is unchanged. This is quite a common situation for firms seeking cost advantage input factors to relocate factories overseas. On the contrary, if the reason for factory relocation is to locate 'close to the customer market', then the distance between factory and customer/retailers is shorten from $Dist_1$ to $Dist_3$. For this case, to maintain the same response time t_2, slower transportation speed v_4 is satisfactory.

In general, the transportation demand will change both when the supply chain adjusted in 'time' and 'space.' Especially, to resolve the incurred pressure caused by the response time, faster transportation services are needed in order to deliver the products to the end customers and retailers on time.

The survey also finds that a lot of Taiwanese IT products are in the maturity stage of the life cycle. Many manufacturers conduct their business operations as 'original equipment manufacturer (OEM)'. In Figure 5, Taiwanese manufacturers mostly pin at Point C. The firms always shorten the response time to enhance the level of customer services. In other words, faster transportation services are applied to reach the above goals. 'Build to order (BTO)' is another most conventional business model for supply chain adjustments taken by the manufacturers. Therefore, Taiwanese IT firms have to improve their manufacturing technology as well as come up with fast and highly efficient logistics operations in order to meet the requirements of the global customers. This explains the phenomena of why Taiwanese firms, one after another, build up global logistics management systems.

5. Conclusions and recommendations

Little research has focused on the interrelationship of supply chain dynamics and freight transportation demand, this article compared supply chain adjustment practices at forty-five IT firms in Taiwan and investigated five Propositions.

As to Proposition 1, the survey indicates that Taiwanese IT firms are indeed involved in international collaboration. Firms actually diversify and adjust their manufacturing activities in their supply chains with respect to space factors. There are also quite a few manufacturers who have established offshore factories for cheaper, cost advantage production input factors.

Proposition 2A and 2B are supported. The firms apply different supply chain adjustments to the products according to their product life cycle. Basically the supply chain adjustments in 'space' do appear according to the stages of the product life cycle. The adjustments in space migrate from domestic 'centralization' to 'diversification' at various sites. As to the adjustments in time, there are four basic types, which correspond to the various stages of the product life cycle.

Proposition 3 for supply chain adjustments that affect freight transportation origin/destination and modal choice is supported. The supply chain adjustments in space will actually affect the transportation demand between origin and destination. In the meantime, if the postponement strategy is adopted, faster transportation services will be needed.

Proposition 4 contains two layers. Not until the firms decide to undergo the adjustments in 'space,' does this proposition find support. However, once the firms decide on foreign investment, the transportation service availability becomes one of the considering factors for factory relocation. Additionally, when firms apply 'postponement' strategies, this proposition is also supported.

Finally, this study found that the transportation cost was not a major consideration for the respondents' supply chain adjustments.

In general, this study discovered that the concepts of 'centralization'/'diversification' in space and 'postponement'/'speculation' in time do exist in the supply chain adjustments of

the IT manufacturing industry. How to establish the quantitative model for supply chain adjustment and freight transportation demand would be an interesting focus for future research.

The ‘OEM’ business model is popular among many Taiwanese IT manufacturers. Most of the products manufactured under this model have entered into the maturity life cycles. Firms not only have to lower the manufacturing costs, but also have to enhance the transportation efficiency to satisfy the fierce competition. Any product steps in the maturity or decline stages will more and more rely on faster transportation services when the manufacturing locations diversify. If the ‘postponement’ strategy is applied, the turnaround time gets shorter once the order is received. Fast transportation services will be necessary to meet the supply chain operations. In terms of the influences that the supply chain adjustments have on the transportation demand, the diversification in space will lower the total quantity in freight transportation in the host country. The postponement strategy will increase the demand for faster transportation services.

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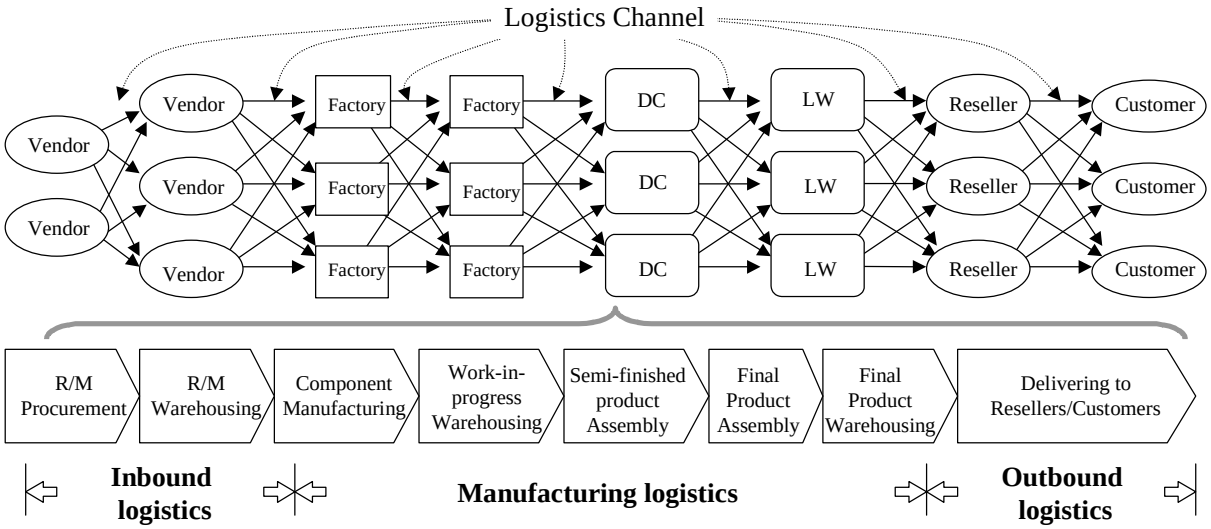

Notes: DC=Distribution Center, LW=Local Warehouse, R/M=Raw Materials

Figure 1 Supply Chain of Manufacturing Industry

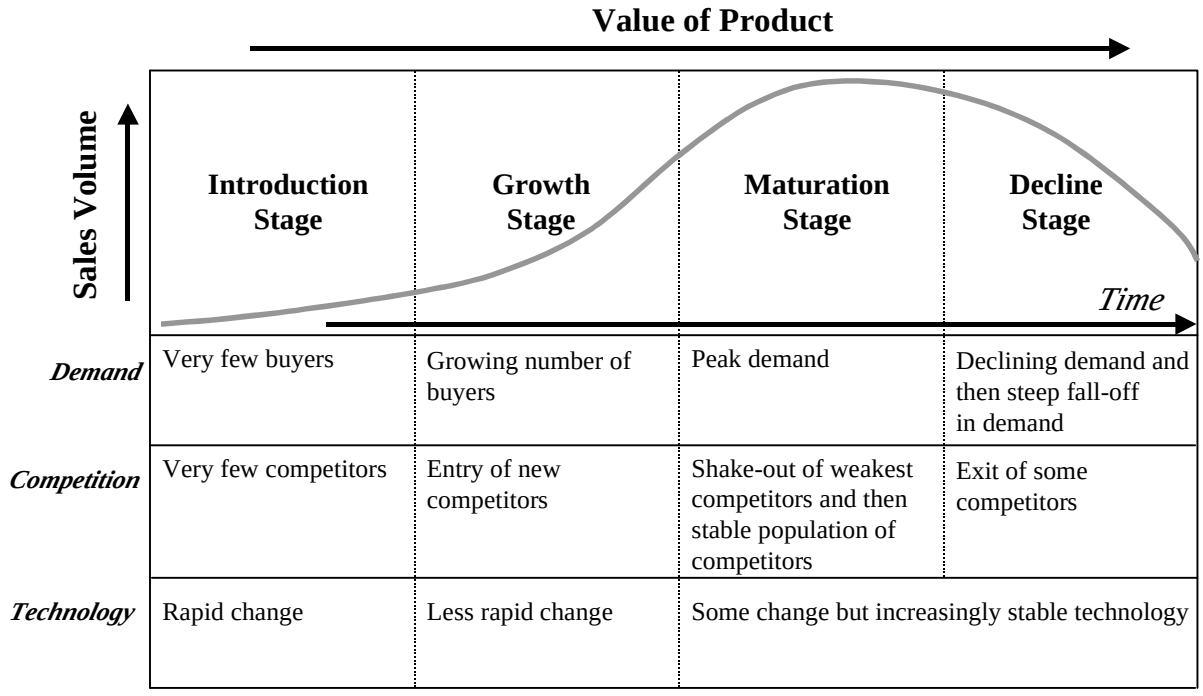

Figure 2 Profile of product life cycle.

Source: (Dicken, 1992).

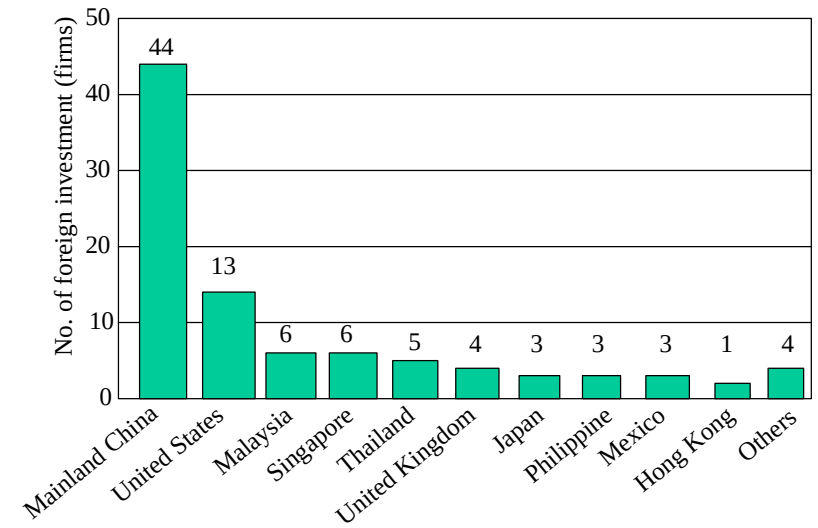

Figure 3 The distribution of surveyed IT firms' foreign investment.

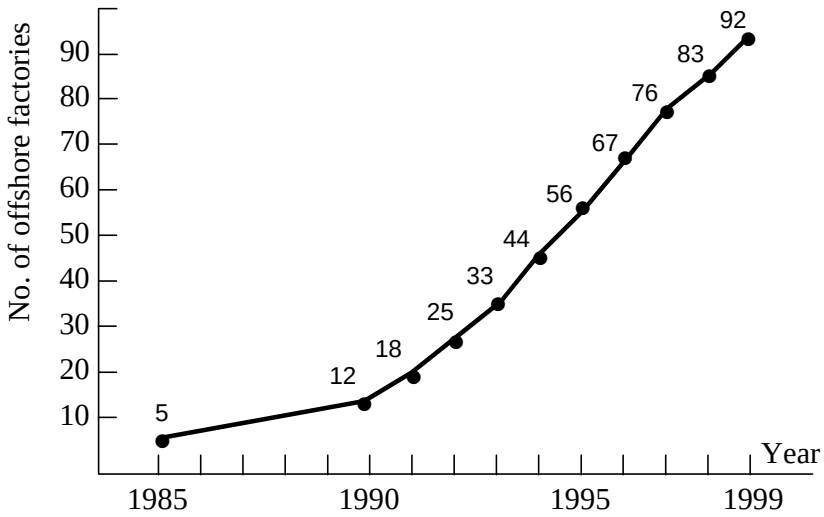

Figure 4 The trend of foreign investment.

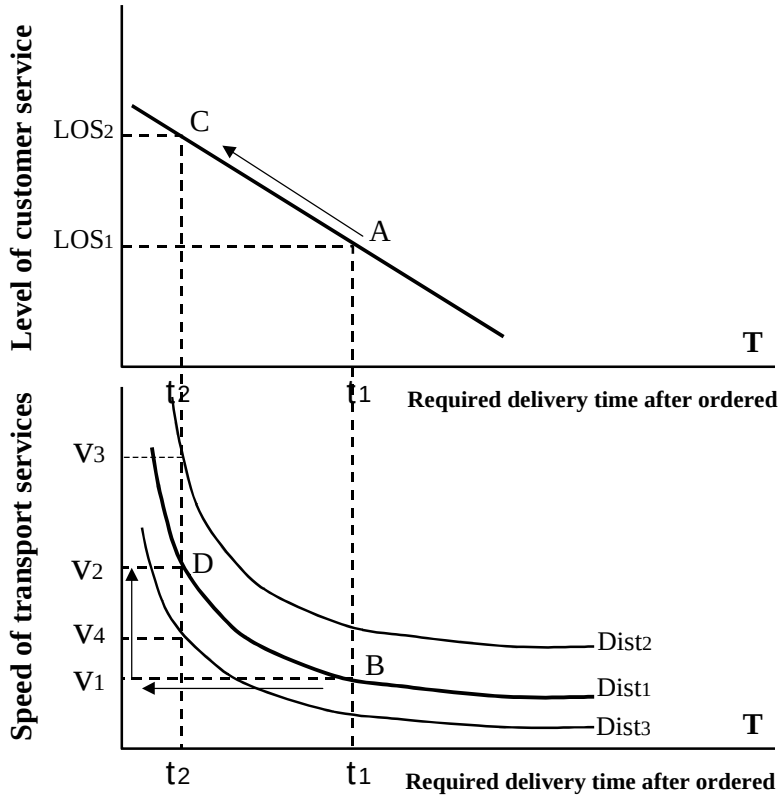

Figure 5 The relationships among response time, transportation speed and level of service.

Table 1 The manufacturing product structures (by production values)

Unit: %

Year	Information technology	Chemical	Metal	Consuming Industrial	Total
1989	17.9	29.4	24.4	28.3	100.0
1990	18.6	29.0	25.0	27.4	100.0
1991	19.0	28.4	25.7	26.8	100.0
1992	19.2	28.2	26.8	25.8	100.0
1993	20.3	28.2	27.0	24.5	100.0
1994	21.7	28.6	26.5	23.2	100.0
1995	24.1	28.4	26.1	21.4	100.0
1996	25.2	29.1	25.3	20.4	100.0
1997	27.6	28.1	25.7	18.7	100.0
1998	30.3	27.3	24.9	17.5	100.0

Source: Directorate-General of Budget, Accounting and Statistics, 2000.

Table 2 Positions of Surveyed Respondents

Title of the Position	No. of Respondents	%	Responsibility for logistics operation			
			Yes	%	No	%
Top Management	1	2.22	0	0.00	1	2.22
Senior Management	4	8.89	3	6.67	1	2.22
Department Managers	25	55.56	20	44.44	5	11.11
Supervisors & Engineers	12	26.67	12	26.67	0	0.00
Others	3	6.66	0	0.00	3	6.67
Total	45	100.00	35	77.78	10	22.22

Source: The survey in this study.

Table 3 Questionnaire Survey Response Profile

Annual Sales (million USD)	No. of Respondents	(%)
Less than 500 million	31	68.89
$501 million – 1 billion	7	15.56
$1 – 1.5 billion	5	11.11
$1.5 – 2.0 billion	1	2.22
Greater than $2 billion	1	2.22
Total	45	100.00

Source: The survey in this study.

Table 4 Reasons for Offshore Relocation

Reasons	No. of respondents	%
Cheaper labor cost	41	44.57
Proximity of customer markets	22	23.91
Lower land cost	15	16.30
Easier to access new technologies	6	6.52
Skilled labor availability	3	3.26
Lower tax/tariff	3	3.26
Other	2	2.17
Total	92	100.00

Note: Only the most major reason is considered for each offshore factory.
Source: The survey in this study.

Table 5 The interrelationship analysis on the location selections, investment reasons and product characteristics for offshore factories

Unit: firm

Reasons	Mainland China	Thailand	Philippines	Malaysia	Singapore	Mexico	UK	Japan	United States
Cheaper labor cost	29	4	3	5	---	---	---	---	---
Lower land cost	13	2	---	---	---	---	---	---	---
Lower tax/tariff	2	---	---	1	---	---	---	---	---
Easier to access new technologies	---	---	---	---	1	---	---	2	3
Skilled labor availability	---	---	---	---	1	---	1	---	1
Proximity of customer markets	---	---	---	---	4	3	3	1	7
Others	---	---	---	---	---	---	---	---	2
Total	44	6	3	6	6	3	4	3	13
Life cycle stage								Unit: No. of offshore factories	
Introduction	0	0	0	0	1	0	0	1	1
Growth	1	0	0	0	4	0	2	2	10
Maturity	21	3	1	2	1	2	2	0	2
Decline	22	3	2	4	0	1	0	0	0

Source: The survey in this study.

Table 6 Analysis on product life cycle stage and supply chain adjustments in 'space'.

Unit: No. of products

Stage of product life cycle	Introduction	Growth	Maturity	Decline	Total
No. of products	2	19	35	9	65
Made fully in Taiwan	1	15	9	2	27
(%)	50.0%	78.9%	25.7%	22.2%	---
Partial or not at all made in Taiwan	1	4	26	7	38
(%)	50.0%	21.1%	74.3%	77.8%	---

Source: The survey of this study

Table 7 Analysis on product development and supply chain adjustment strategies in 'time'

Unit: No. of products

Stage of product life cycle	Introduction	Growth	Maturity	Decline	Total
No. of products	2	19	35	9	65
Manufacturing Strategy					
Speculation	2	12	25	2	---
No action	0	6	8	1	---
Postponement	0	1	2	6	---
Logistics Strategy					
Speculation	2	7	4	0	---
No action	0	9	5	2	---
Postponement	0	3	26	7	---
Made fully in Taiwan	1	15	9	2	28
Manufacturing Strategy					
Speculation	1	9	7	1	---
No action	0	5	1	0	---
Postponement	0	1	1	1	---
Logistics Strategy					
Speculation	1	4	1	0	---
No action	0	8	1	0	---
Postponement	0	3	7	2	---
Partial or not at all made in Taiwan	1	4	26	7	37
Manufacturing Strategy					
Speculation	1	3	18	1	---
No action	0	1	7	1	---
Postponement	0	0	1	5	---
Logistics Strategy					
Speculation	1	3	3	0	---
No action	0	1	3	2	---
Postponement	0	0	19	5	---

Source: The survey of this study.

Table 8 Statistics on transportation service demand vs. product development

Stage of product life cycle	MS	LS	Location of Factory	No. of samples	Required Delivery time after ordered	Final assembly time after ordered	Average transport time	Mode Choice		No. of products in each group of transportation cost / sales price*				
								Air	Sea					
				(product)	(day)	(day)	(day)	%	%	I	II	III	IV	V
Introduction	S	S	Taiwan	1	8.5	1.0	7.5	100.0%	0.0%	1	0	0	0	0
			Offshore	1	8.2	1.0	7.2	0.0%	100.0%	1	0	0	0	0
Growth	S	S	Taiwan	15	6.9	1.2	5.7	80.0%	20.0%	8	5	2	0	0
			Offshore	4	7.5	1.6	5.9	75.0%	25.0%	3	0	1	0	0
Maturation	S	P	Taiwan	9	4.9	1.3	3.6	89.9%	11.1%	2	3	2	1	1
			Offshore	26	5.1	1.6	3.5	96.2%	3.8%	4	4	8	8	2
Decline	P	P	Taiwan	2	5.3	3.7	1.6	100.0%	0.0%	0	0	1	0	1
			Offshore	7	5.4	3.6	1.8	100.0%	0.0%	0	0	1	4	2

Notes: MS = Manufacturing strategy, LS = Logistics strategy, S = Speculation, P = Postponement.

* I: Unit transportation cost / product sale price≦0.01; II: 0.01＜Unit transportation cost / product sale price≦0.05; III: 0.05＜Unit transportation cost / product sale price≦0.10; IV: 0.10＜Unit transportation cost / product sale price≦0.15; V: 0.15＜Unit transportation cost / product sale price。

Source: The survey in this study.