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Singapore as a Node of Transnational Operations: A Study of The Disk Drive Industry

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Executive Summary

Firms are increasingly internationalizing their operations, often in ways which dramatically alter the fortunes of nations. The transnational operations of such a firm are very complex, not only because of the intricate organizational structure required, but also because of the varying extent to which its different parts can be separated out functionally and spatially. The hard disk drive industry, characterized as technology-driven and buyer-dictated, is well suited for transnational operations.

The disk drive industry is dominated by independent disk drive manufacturers. There is intense competition, with cyclical over-production of drives and price wars. To survive in such an environment, industry players need to secure technological edge, low-cost edge, time-to-market edge and timely-delivery edge. There have been numerous acquisitions and mergers in the short history of the disk drive industry.

Almost all disk drive manufacturers have an operation in Singapore and Singapore produces half of the world output of disk drives. Why did all major disk drive manufacturers choose to locate their operations in Singapore and not elsewhere? This paper examines the operations of the disk drive industry and analyzes why Singapore is attractive to disk drive manufacturers. By drawing on the literature from economic geography, we show how Singapore has successfully integrated itself into the value-chain of the transnational operations of disk drive manufacturers. Over the past twenty years or so, Singapore has developed an attractive infrastructure of telecommunications, human resources, manufacturing capabilities and a broad and deep network of suppliers and subcontractors. These factors, combined with its stable, pro-business social, political, and economic environments, have made Singapore a choice location for many different functions of a disk drive manufacturer, particularly as a location for regional headquarters, R&D activities, and production operations.

1. Introduction

Hard disk drive¹ (commonly known as hard disk) is a major component of a personal computer (PC) and all new PCs are shipped with a hard disk. Perhaps unknown to most PC users, almost half of the world's output of hard disks is from Singapore. Almost all disk drive manufacturers have an operation in Singapore. This is remarkable given that Singapore is a small island nation with an area of 625 square kilometers (240 square miles) and a population of 3 millions. How did Singapore achieve this? Why did all major disk drive manufacturers choose to locate their operations in Singapore and not elsewhere? Answers to these questions are important because they can suggest whether Singapore's competitive advantage is sustainable and whether other countries can emulate or better Singapore's strategies and hence attract the major disk drive manufacturers to re-locate operations in these countries.

¹ In this paper, *hard disk drive*, *disk drive*, *hard disk* and *hard drive* will be used interchangeably.

This paper seeks to provide answers to the above questions by examining the characteristics of the disk drive industry and transnational operations. The economic geography literature is drawn upon to provide insights into the locational needs of transnational operations. We then analyze why Singapore is attractive to disk drive manufacturers, particularly as a regional head-quarters, as a center for research and development, and as a location for production operations. This paper provides an explanation for the emergence of Singapore as the Winchester Island of the world and concludes with a discussion of some recent trends facing the industry.

2. Industry Overview

The disk drive industry has been characterized as technology-driven and buyer-dictated. To survive such harsh conditions, players need to secure competitive advantages such as technological edge (developing better drives), low-cost edge (manufacturing in volume), time-to-market edge (introducing new products in time), and timely-delivery edge (especially in fulfillment of OEM contracts²).

2.1 The Disk Drive

Table 1 summarizes the market and technology trends. Technology trends are driven by market trends (the type of disk drives demanded). These are, in turn, driven by three major market forces. First, the industry is saturated with independent disk drive manufacturers. This results in intense competition, causing over-production of drives and constant price wars, and driving down prices. Second, downsizing has shifted more data processing tasks down to the microcomputers level, and there is increasing demand for graphical user interface and multimedia applications. These computing needs require higher-capacity and faster drives. Third, portable and mobile computing pushed for smaller drives with higher reliability and shock absorption.

Table 1. Market and technology trends

Market (Demand) Trends		Technology Trends	
Capacity	↑	Area Density	↑
Form Factor	↓	Disk Diameter	↓
Performance	↑	Access Time	↓
Reliability	↑	Mean Time Before Failure (MTBF)	↑
Cost	↓	Capacity per Surface	↑

2.2 Characteristics of the Industry

Hard disk drive was introduced by IBM whose target market was the mainframes and minicomputers. IBM overlooked the growing microcomputers market in the late 1970s which was promptly filled by independent disk drive manufacturers. In 1979, the first such company, Seagate, was founded. Its phenomenal success attracted many new start-ups, until the industry was saturated by 1983. Price wars ensued and some started leaving. By the end of 1985, the number of players had stabilized to 36.

There have been countless acquisitions and mergers in the short history of the disk drive industry. Examples include Seagate's acquisition of Imprimis in 1989 and Maxtor's acquisition of Miniscribe in 1990. New entrant Western Digital acquired Tandon's drive operations in 1987, and has grown into a big player. There were also companies that could not survive the competition and died. PrairieTek was the first disk drive company to ship out 2.5" drives, but "died prematurely" within a year as it was late in introducing higher-capacity 2.5" drives to the market. Rodime suffered the same fate in the 3.5" market. This attests to the incredibly fast pace of change in this industry (EDB, 1991).

² In an OEM (Original Equipment Manufacturer) supply relationship, the supplier's product will be bought as an intermediate product (or component) to be integrated into the buyer's product.

In 1988, there was a major industry downturn, caused mainly by uncontrolled capacity expansion and fierce "price wars" by its players. The industry took another two downturns in 1991 and 1993 for the same reasons. Other factors included increasing product overlap among competitors and downward pressures on prices.

2.3 Current State of the Industry

In 1995, more than 90 million units of disk drives were shipped worldwide. Compared to the 34 million units in 1991, the industry has grown about 200%, or an average of 20% annually. It is estimated to reach 116 million units for 1996. IDC estimates that global shipments will grow at an average of 21% annually over the next five years. DiskTrend estimates that US companies control about 70% of the global disk drive market. However, they are facing increasing competition from the Japanese and lately, the Koreans and Taiwanese too. Until 1995, the chief players are all US firms: Seagate, Quantum, Conner, Western Digital, and Maxtor. Seagate is the overall leader in terms of firm size, production volume, as well as sales revenue and margins, but Quantum is the market leader in terms of sales volume.

Recently, significant shifts in the industry's power balance took place. In 1994, the largest disk drive maker (for internal consumption), IBM's System Storage Division (SSD), announced its entry into the disk drive market, immediately toppling Seagate's lead as the largest and highest-output independent drive supplier by 50% (Business Times, 16 September, 1994). In a short one year, it has managed to capture a 10% market share, placing it at the fifth position! However, in the third quarter of 1995, Seagate's acquisition of Conner helped regain its lead from IBM's SSD, as well as gain a significant lead over Quantum with its new 39% market share. During the same period, inconspicuous Korean conglomerate Hyundai acquired Maxtor and intend to invest aggressively to become the number one in the disk drive industry by 2005 (Business Times, 21 September, 1995). Loss-making Micropolis was taken over by new comer Singapore Technologies in early 1996.

3. Overview Of The Singapore Disk Drive Industry

Singapore's disk drive industry has emerged, over a 15-year period, as one of the most prominent segments of the electronics sector. In the process, it has developed a strong supporting industry and introduced new technologies.

3.1 Build-up of the Electronics Sector in Singapore

In the 1970s, intensive promotion brought in exceptional growth in foreign investments into the manufacturing sector — in high value-added industries like electronics, petro-chemicals, precision engineering, and ship and rig building. By 1979, they accounted for more than 67% of manufacturing employment and value-added, and helped to double export ratio to 65% of output (EDB, 1980). As a result, Singapore established itself as a competitive manufacturing base for world markets, especially for high value-added industries.

Singapore's aim for the 1980s was to increase productivity through higher skills, capital-intensive high-technology industries and "brain services" industries. Industries that could help attain the productivity and value-added targets were designated as "priority industries", the electronics industry was one. Priority industries were offered several investment incentives, including "tax holidays", export incentives and investment allowances (EDB, 1981). In addition, tax incentives were provided to stimulate R&D, automation and computerization (EDB, 1980).

To provide enough skilled manpower for these industries, Singapore's tertiary institutions began to increase student intake in the science and engineering fields in 1979. The Economic Development Board (EDB) established industrial training schemes for technicians. It also established the Skills Development Fund, especially tailored for the training and re-training of workers who would otherwise be redundant on economic restructuring (EDB, 1980).

3.2 Birth of the Disk Drive Industry in Singapore

Singapore's disk drive industry was started by Magnetic Memories International (MMI) in 1979. MMI produced hard disk drives for a year, then closed down. At the same time, Tandon was producing floppy drives in Singapore. Tandon helped created the supporting industries for the hard drive industry, leading Seagate to choose Singapore as a production site in 1981 (Callon, 1994). Seagate's impressive returns quickly attracted many others: Maxtor, Miniscribe, Microscience, Micropolis, Rodime, Conner, and Western Digital. Since 1987, the number of entrants has leveled off, and a consolidation process took place gradually. Some left, selling their Singapore operations to veterans

or new entrants; therefore, there was virtually no impact on the industry. Victors of this consolidation process included: veterans Seagate and Maxtor, and new entrants Western Digital and Taiwanese firm Myrica (which acquired Rodime) which were diversifying into this business. The period after 1990 was generally dull. A few start-ups wanting to carve a niche market on the new form-factors, took advantage of the short start-up time in Singapore: PrairieTek in 1991 to produce solely 2.5" drives, followed by Integral and MiniStor in 1992 to produce solely 1.8" drives.

3.3 Current State of the Industry

The disk drive industry in Singapore has grown phenomenally from a humble beginning in 1979 to what is now an industry exceeding \$10 billion a year. In 1994, Singapore's output of 29 million units was more than 48% of global output of 60 million units. This maintained Singapore's position as the world's leading producer of disk drives.

Singapore began to lose its cost-competitiveness to its neighbors in the early 1990s. Since 1990, many major disk drive manufacturers in Singapore, notably Conner, began to set up their new plants elsewhere, notably Penang, Malaysia. In the process, they also shifted many of their lower value-added manufacturing operations out of Singapore; but at the same time, they were shifting some higher value-added activities (especially R&D) to Singapore. In 1994, Matsushita (MKE) and IBM chose Singapore instead of other cheaper locations. In 1995, Seagate invested \$200 million to build a huge manufacturing complex to consolidate all its manufacturing facilities in Singapore.

3.4 Contribution to Singapore's Economy

Disk drive accounts for about 25% of the exports of the electronics sector in 1995. It represented about 21% of the total electronics industry value-added. For the last five years, the breakdown of its export market has been fairly consistent: 50% to United States, 25% to the European Community, and 20% to Japan and the newly industrialized economies.

The disk drive industry has helped Singapore to build up a strong supporting industry which includes sectors like precision machining, die-casting, electronic components and Surface Mount Technology Printed Circuit Board Assemblies (SMT PCBAs) — through both increased business opportunities and technology transfers. Skills pertinent to the disk drive industry (ranging from process engineering to magnetic technology) have created a pool of trained manpower, and upgraded the level of expertise in the supporting industries. These in turn form "core technologies" for other Precision Electro-Mechanical (PEM) sectors.

The Local Industry Upgrading Program (LIUP) has helped to forge closer business ties between multi-national corporations and the local suppliers. For example, Maxtor and Seagate have been actively helping their local suppliers to broaden their range, quality and efficiency of services, through transfer of manufacturing technology and management skills. Some local suppliers, such as CAM Mechatronics and Venture Manufacturing, have benefited so tremendously that they have grown big enough to be listed on the stock exchange and to regionalize their operations. The supporting industry has now become a significant contributor to the competitiveness of the disk drive industry, and will continue to be a major pull-factor for disk drive manufacturers to expand or locate new operations in Singapore, so as to achieve a fast ramp-up in volume production.

4. Operations Of Transnational Corporations

This section examines the operations of Transnational Corporations (TNC), which are defined as firms that engage in the *coordination* of international production from one center of strategic decision-making (*without necessarily owning all the production units*)" (Dicken, 1992, p. 48).

4.1 Geographical Dispersal of a Firm's Functions

Haig (1926) observed that: "every business is a *package of functions, which can be separated out and located at different places within limits*". Though technology advances have overcome the "limits", the extent to which a firm does so is determined by:

Strategic orientation of the firm. A firm's choice of international competitive strategy affects whether *each* of its operations is to be geographically concentrated or dispersed. Therefore, strategic orientation is one reason for a TNC to separate out geographically *some or all elements* within its value-chain.

Technological characteristics of firm's operations. Such separation depends upon the industry-dependent technological characteristics of a firm's operations, which limits the degree to which they can be separated out geographically. This limit has been largely overcome by technological advances in the production process, namely, increasing specialization of production process and fragmentation into smaller operations; increasing standardization of the individual operations themselves; and the use of flexible production technologies to lower cost without producing at large scale.

The particular spatial expression of this division of labor — precisely where the separate parts are located — is the result of the interaction between two sets of factors: organizational and technological factors on one hand, and relevant location-specific factors on the other. *Different parts of the TNC have different locational needs* and these needs can be satisfied in various types of locations. In the next three sections, we examine the spatial patterns of three of the most important functions of the TNC: regional headquarters, research and development facilities, and production operations. By contrast, the last section explains why the supporting functions of a TNC's value-chain do not exhibit any identifiable locational pattern.

4.2 Locational Needs of a TNC's Regional Headquarters

4.2.1 Characteristics of Regional Headquarters

Regional headquarters constitute an intermediate level of hierarchy in the organizational structure of a TNC. They are both coordinating mechanisms within the organization and also an important part of its intelligence-gathering system. The characteristic functions of regional headquarters are:

- To coordinate activities of the firm's affiliates (like production units and sales offices) in the region, by being a handler and transmitter of information between them and the corporate head office. It also needs to process some of this information in order to make decisions for the decentralized corporate responsibilities (like marketing) delegated to it.
- To act as a handler, processor and transmitter of information, to similarly high-level organizations outside, such as major business services (like financial and advertising) the firm depends on, and government departments of its major national markets in the region.

These characteristic functions of the regional headquarters define its locational requirements. First, a regional headquarters requires a strategic location on the global transport and communications network in order to keep in close contact with other geographically dispersed parts of the TNC. Second, it requires access to high-quality external services (like financial and legal) and a particular range of labor market skills (especially IT professionals). Third, since much regional headquarters activity involves interaction with the head offices of other similarly high-level organizations and face-to-face contacts with their top executives is preferable, there are strong "agglomerative" forces involved.

4.2.2 Singapore as a Regional Headquarters

Singapore is one of the best-connected cities in the global economy. It has maintained its lead — in the top three positions — as both the busiest port and the best airport in the world for the last ten years. Within the country, its land transport system have remained highly efficient despite the growth in traffic. Since the government initiated its new strategy of making Singapore a "*Total Business Center*" in 1986, there has been considerable emphasis on improving Singapore's connectedness — both within and to the rest of the world — in communications: notably in video-conferencing, the Internet, and using IT to connect the whole country into an "intelligent island".

Singapore's economy has a strong service sector, so there is no lack of the major business services. The government's emphasis on promoting IT has already created a substantial supply of such professionals. Moreover, the presence of regional headquarters of many other TNCs which have a substantial Asian market, help to strengthen the "agglomerative" forces. It is also extending its expertise in cargo-handling to provide total logistics management. Hence, Singapore is more than able to meet the locational needs of a regional headquarters.

Major disk drive companies have established regional functional headquarters in Singapore. In 1990, Seagate set up a regional distribution center in Singapore to improve response time to distributors and enhance its growing business in the Asia-Pacific region. Quantum — the only major drive maker without any manufacturing presence in Singapore — set up a regional technical service center and a regional marketing and sales headquarters in 1992. In 1993, it established a regional distribution center, followed by a full-fledged regional headquarters to serve its Asia-Pacific market, where a large proportion of its sales depends on OEM clients that operate in this region.

4.3 Locational Needs of a TNC's R&D Activities

The locational needs of a TNC's R&D activities are more complex than that of its regional headquarters (Dicken, 1992; Howells, 1990; Pearce, 1990). First, its market focus (a function of its international competitive strategy) determines its level of overseas R&D (Behrman and Fischer, 1980) and some of these locational needs. Next, the level of overseas R&D is closely related to a particular phase of the R&D process (Hood and Young, 1982) which has its own peculiar locational needs (Buckley and Casson, 1976). Table 2 combines these interlocking factors.

Table 2. The influence of market focus on the level and location of overseas R&D activities

	Overseas R&D carried out		Locational Criteria
	Maximum Level	Respective Functions	
Home Market firm	Support Laboratory (Phase III)	<ul style="list-style-type: none"> - "debugging" of products and adapting to local circumstances - technical service center 	<ul style="list-style-type: none"> - Quick two-way contact with the users of the innovation (viz. the production/marketing functions). ❖ regards its foreign sales as not requiring any R&D beyond that carried out for its domestic market.
Host Market firm	Locally Integrated R&D Laboratory (Phase II)	<ul style="list-style-type: none"> - product innovation & development for local market - transfer of technology 	<ul style="list-style-type: none"> - Proximity to overseas markets (that are sufficiently substantial to justify separate R&D work). - Access to a large supply of highly qualified engineers and technicians.
World Market firm	International Inter-dependent R&D Laboratory (Phase I)	<ul style="list-style-type: none"> - support firm's global production strategy - basic scientific / marketing research and close links to international research - may (not) interact with firm's overseas production 	<ul style="list-style-type: none"> - Access to sources of basic scientific/technical and marketing developments. - Availability of highly-skilled scientists and engineers - Appropriate infrastructure. ❖ Basically, requires a strong local university system. ⇒ limits these R&D work to <i>developed countries</i>.

(Source: based on materials from Dicken (1992, chapter 7), Behrman and Fischer (1980), Hood and Young (1982), and Buckley and Casson (1976))

4.3.1 Characteristics of R&D in Disk Drive Industry

A disk drive is primarily an intermediate product, bought by computer manufacturers to serve as a component in the computers they produce and sell. In fact, this OEM market makes up 80% of the disk drive market. The major computer makers are the predominant buyers in the OEM market, and they are, virtually without exception, TNCs pursuing *complex global strategy* to some degree. This implies that they will invariably pursue a global procurement strategy, and as a result, a disk drive manufacturer can be said to be world-market oriented. Moreover, disk drives need not be customized to the local preference of each national market.

Based on the classification in Table 2, a world-market firm is likely to operate an International Interdependent R&D Laboratory, to undertake R&D work for its world market as a whole. However, due to the limited resources and market size of a disk drive manufacturer, its International Interdependent R&D Laboratory may not be able to perform all the R&D functions spelt out in Table 2, especially basic research. Hence, it may actually seem more like a Locally Integrated R&D Laboratory doing product innovation and development, *but for a world market*, rather than for customization to local preferences.

4.3.2 Singapore as a Location for R&D

Singapore has been emphasizing science and technology in its education system, prior to the Economic Committee's (MTI, 1986) recommendation to promote high technology industries. Thereafter, the government took more aggressive steps to promote local R&D. The National Science and Technology Board (NSTB) was set up in 1991 to develop selected fields of science and technology to enhance Singapore's competitiveness. It set up and funded dedicated research institutes to carry out industrial research, in collaboration with local universities. Many programs have been put in place to bring in overseas experts to complement its universities' production to grow a local pool of scientists and engineers faster. Its universities' emphasis on research is beginning to gain wider recognition for their research efforts and capabilities. Coupled with the necessary finances to aggressively promote R&D, Singapore is rapidly building up its R&D capabilities.

A number of the research institutes set up by the NSTB have benefited the disk drive industry greatly. The Magnetic Technology Center³ was set up in 1991 to complement the product design and development efforts of disk drive and component manufacturers, and enhance Singapore as a location for this industry (EDB, 1991; ST, 5/8/91). Since then, many disk drive manufacturers have upgraded their level of R&D activity. The GINTIC Institute of Computer Integrated Manufacturing, the Institute of Manufacturing Technology and the Data Storage Institute are involved in joint R&D activities with disk drive manufacturers in areas related to improvement of product and process design, plant automation, and development of flexible manufacturing techniques. For example, Conner enlisted GINTIC's help in a joint R&D project to develop ways to overcome production bottleneck and extend the usefulness of a product line.

Since 1990, Conner has been operating a Locally Integrated R&D Laboratory in Singapore. Despite its "moving out" in 1991, it assured that, the plant "...will continue to be a center for product engineering." (Business Times, 7 November, 1991). By 1993, this was upgraded into an engineering center to develop manufacturing and testing processes needed *for worldwide operations*. Western Digital has been running a Support Laboratory to test its drives since 1987. In 1993, this was upgraded to "a design center...[to] design disk drive components and develop software for manufacturing and testing disk drives" (Straits Times, 24 August, 1993). In both cases, the Locally Integrated R&D Laboratory is responsible not just for product design but also for process design; and more importantly, *for a world market*.

4.4 Locational Needs of a TNC's Production Operations

The locational needs of regional headquarters and R&D activities are broadly similar for all TNCs, regardless of their industries. However, the locational requirements of production operations vary greatly from one industry to another, depending upon the TNC's choice of four possible transnational production strategies (Dicken, 1992), as shown in Figure 1. Table 3 summarizes the locational considerations associated with each production strategy.

4.4.1 Characteristics of Production in Disk Drive Industry

All major disk drive manufacturers, virtually without exception, pursue a production strategy of "Vertical Integration (or Rationalized Specialization) by Process". This is not a coincidence, but a consequence of industry conditions:

³ EDB had another aim in setting up the Magnetic Technology Center. Magnetic technology is the critical enabling technology in a wide spectrum of industries including: power generation, sensors, telecommunications and consumer electronics. The development of a magnetic technology capability provides an entry into these other industries.

1. Shortage of critical components can cause delayed delivery by a magnitude of months. With product life-cycles getting much shorter, time-to-market becomes critical to survival. Especially in the case of introducing new models during market transitions, such delays will delay product introduction and result in a substantial loss of market share.
2. Such shortage can also cause disk drive manufacturers to be unable to produce at their maximum capacity during boom periods, constraining revenue growth (EDB, 1991).
3. Intense competition in the industry puts tremendous pressure to cut production costs. In fact, price erosion — not a plunge in demand — has been the main culprit for the past three industry downturns. One of the ways to cope with this is to produce better components cheaper than the cheapest component supplier.

The transnational aspect does not apply equally to all disk drive manufacturers. They vary greatly in the size and geographical spread of their operations. Excluding IBM's Systems Storage Division, Seagate stands out above the rest in both its degree of transnationality and degree of vertical integration.

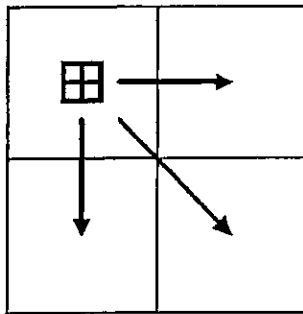
4.4.2 Singapore as a Location for Production

Many disk drive manufacturers which can afford to pursue a Transnational Vertical Integration (by Process) production strategy, have chosen to build their final-assembly⁴ operations in Singapore. Among them are Seagate, and recently IBM. Many others also carry out their final assembly of drives in Singapore, but most of their components are procured from elsewhere.

In 1991, Seagate restructured its worldwide operations and made Singapore the site for final assembly of disk drives, while its plants in this region produce many of the components needed — PCBs in Batam, Indonesia, magnetic head assemblies in Thailand, and head gimble assemblies in Malaysia. However, disk media is still produced in its home country, the USA. Although it is the most vertically integrated in the industry, its components output still cannot meet all its needs. In 1995, IBM scaled down its manufacturing operations in Japan, and set up new ones in Singapore as part of the company's new strategy to consolidate its worldwide disk drive assembly and testing operations. IBM is expected to shift its assembly and testing operations from other parts of the world to Singapore.

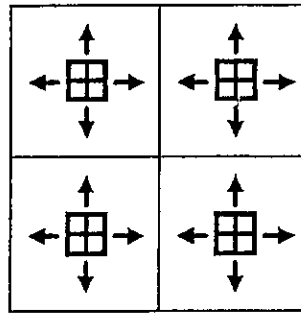
⁴ Final assembly always goes hand-in-hand with testing of the finished drives. They are usually done in the same location.

(a) Globally Concentrated Production



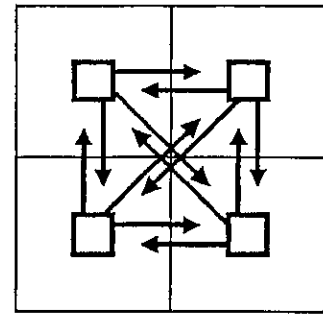
All production occurs at a single location. World markets is served through exports.

(b) Host-market Production



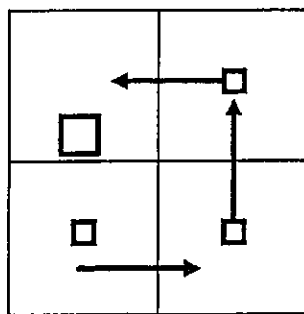
Each national market has its own local production unit, hence, no cross-market sales. Range of products based on local preferences; same for customization of products, which may require separate R&D facilities locally. Individual plant size limited by host market size.
 ♦ Most commonly adopted strategy.
 ♦ This is in effect import-substituting!

(c) Product-Specialization for Regional/Global market



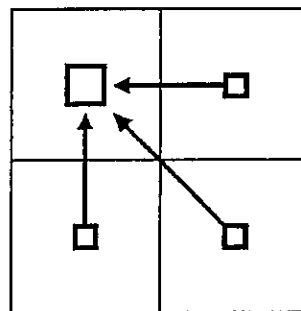
A huge "integrated" regional market, with very different factor endowments between member countries facilitates this strategy. Each production unit specializes in only one product; but produces at large-scale to serve huge regional market, reaping economies of scale.
 ♦ also called Rationalized Geographical Specialization (by Product)

(d) Transnational Vertical Integration (i) by Semi-Finished Product



Each production unit performs a separate stage of the production sequence; reap economies of scale. Output of one plant is shipped as input, to next plant in the sequence, across national boundaries.
 ♦ also called Rationalized Geographical Specialization (by Semi-Finish Product)

(d) Transnational Vertical Integration (ii) by Process



Each production unit performs a separate operation in the production process; reap economies of scale. The components produced are shipped to a final assembly plant in another country.
 ♦ also called Rationalized Geographical Specialization (by Process)

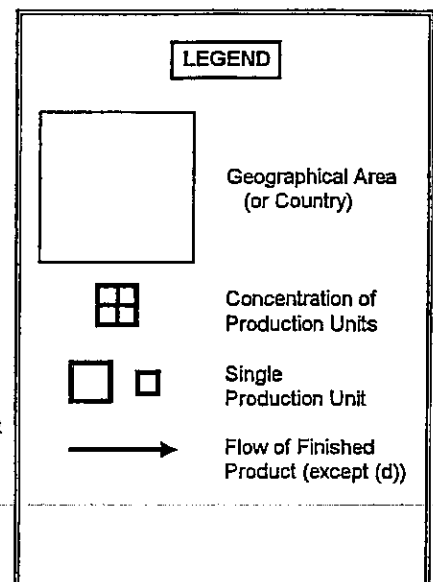


Figure 1. Classification of transnational production strategies (Source: based, in part, on Dicken (1992), chapter 7)

Table 3. Key locational considerations of different transnational production strategies

	Competitive Strategy	Key Locational Considerations
Globally Concentrated Production	- Basic Global strategy - Export-based strategy	1. treat the concentration of plants as one plant 2. locate at point of minimum production costs 3. factor in transport costs & forces of "agglomeration"
Host-market Production	- Multi-Domestic strategy	- size & sophistication of the host-market - structure of demand & consumer taste - cost-related advantages to locate directly in market
Regional / Global Product Specialization	- Complex Global strategy ❖ Regional strategy is part of Global strategy.	- economies of scale gained VS additional transport costs involved in gathering necessary inputs and in shipping final product to a huge regional market
Transnational Vertical Integration	- Complex Global strategy	- labor-intensity of the production process - degree of standardization of the production process - degree of fragmentation of the production process into independent operations VS additional "distance" costs - Home govt.'s policies towards off-shore processing (e.g.: import duties only on value added overseas) and Host govt.'s policies towards export production (e.g.: EPZ)

(Source: based on material in Dicken (1992), chapter 7)

4.5 Locational Needs of Supporting Functions

The previous sections show that three primary functions of the TNC (regional headquarters, R&D, and production operations) have different locational needs and Singapore is able to meet the needs of TNCs in these three areas. By contrast, the supporting functions in the TNC's value-chain — such as marketing and sales, distribution and services — do not exhibit any special locational pattern, but rather, they tend to be distributed far more widely in accordance with the firm's geographical markets. Their only locational need is simply to be close to the market they serve for a host of reasons. These include: (1) being able to be more sensitive to the local preferences and tastes of each market, (2) establishing closer ties with the local distribution channels, (3) providing the local customer with faster after-sales service, and even (4) cutting down on transportation costs. The main consideration in setting up supporting functions in a location is whether the market size is substantial enough to justify the costs of running them.

Although a disk drive manufacturer's orientation is towards the world market as a whole, nonetheless, when it comes to physically serving the market, geographical considerations still come into play. There may be no need to know the local preferences, but there is still a need for timely delivery and service to the customer, be they end-users or OEM clients. Moreover, a network of supporting functions is essential to any effort to capture the end-user replacement market, which amounted to an estimated 20% of global sales volume for 1994.

Many disk drive manufacturers have sales offices, distribution channels and technical service centers in their major national markets. They have a strong presence in Singapore because 20% of PCs are produced in Asia-Pacific. Quantum has sales offices in Hong Kong, Korea, Australia, New Zealand, Taiwan, and Thailand. Recently, it established a sales office in Beijing to grow its distribution business in China.

5. Discussion

The separation of functions of a TNC varies according to: the nature of its organizational strategy, the technological characteristics of its industry, and the locational requirements of its component parts. Different functional parts of a TNC has its own peculiar locational needs, which can be satisfied in various types of geographical locations.

As pointed out in Section 3.3, *Singapore has begun to lose its cost-competitiveness to its neighbors in recent years*. Since 1990, rising labor costs has caused many disk drive manufacturers to set up new plants elsewhere and shift production away. This may potentially cause a "hollowing out" of the manufacturing activities in Singapore's disk drive industry.

Conner was the first major disk drive manufacturer to show signs of shifting out. Its third Penang (Malaysia) plant, built in 1991, is its second largest operations center and the only facility it owns (rather than leases) after its headquarters in San Jose, USA. This new plant employs 6000 workers, higher than its peak employment of 5000 in Singapore. Moreover, Conner is the only one to make complete disk drives in Penang (EDB, 1991). All these attest to its intention to make Penang its main overseas production base eventually; this implies that it would have to phase out production in Singapore. In fact, Conner has been retrenching at every industry downturn, yet not recruiting during the booms.

As early as 1991, the Singapore government was already laying plans to counter the possible "hollowing out" of its disk drive industry. It warned that, "Disk drive manufacturers have started production facilities elsewhere in the region...To stay ahead, we must attract firms making key components of disk drives, and get more of the product design done locally." (Straits Times, 5 August, 1991). To counter the potential impact of "hollowing out", a number of steps may be taken. These include attracting more components manufacturers to build up agglomerative forces for the industry and attracting higher value-added manufacturing operations as well as R&D activities to justify the higher labor cost in Singapore. Singapore's success in retaining the disk drive industry depends on the extent to which it is successful in these initiatives.

6. Conclusion

Our analysis shows that the characteristics of the disk drive industry lends itself to transnationalization. Virtually all disk drive manufacturers operate with some degree of transnationality. In locating its transnational operations, a firm is not one single entity, but a collection of value-chain and corporate functions, each with its own peculiar locational needs, which can be satisfied in many different geographical locations. Singapore has been successful as a center for disk drive manufacturing because it has successfully integrated itself into the value-chain of the transnational operations of disk drive manufacturers. Over the past twenty years or so, Singapore has developed an attractive infrastructure of telecommunications, human resources, manufacturing capabilities and a broad and deep network of suppliers and subcontractors. These factors, combined with its stable, pro-business social, political, and economic environments, have made Singapore a choice location for many different functions of a disk drive manufacturer, particularly as a location for regional headquarters, R&D activities, and production operations. With rapid technological change and with hard disk drive becoming a cheap commodity product, the importance of the disk drive industry to Singapore's economy is expected to decline in the coming years. Whether Singapore can repeat its strategies and success with other information technologies, such as chip fabrication, remains to be seen.

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