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Strategies for global competition: transnational chemical firms and Singapore's chemical cluster

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Abstract. The strong performance of Singapore's chemical industry in recent years has increased public awareness about the importance of this obscure sector in the Singapore economy. In the public rhetoric, much of this robust growth is attributed to the industrial policies implemented by the Singapore government. However, the ultimate decision to built a multibillion dollar chemical-processing plant in resource-scarce Singapore still depends very much on the global strategies of transnational chemical firms (CTNCs). The authors propose a firm-level perspective to aid in understanding the development of Singapore's chemical industry. They argue that the global strategies of CTNCs have a vital role to play in promoting growth within the Singapore chemical industry cluster. Conceived under the 1991 Strategic Economic Plan, the idea of clustering represents a radically different approach to the development of the petroleum-refining, petrochemicals, specialty chemicals, and pharmaceutical industries where previously each was deemed a separate activity. Based on field research into over forty subsidiaries and local suppliers of CTNCs in Singapore, the authors highlight the importance of two major contextual influences on the global strategies of CTNCs: rising global competition and the huge market potential offered by developing countries. Given these circumstances, CTNCs have relied on their established capabilities to formulate spatial strategies for increasing global competitiveness. In Singapore, subsidiaries of CTNCs have tapped into cluster-based advantages to enhance their capabilities, thereby contributing to the further growth of Singapore's chemical industry cluster.

Introduction

The chemical industry is a key industry as its products are used in nearly all other industries, either in intermediate forms or as finished products. The international chemical industry accounts for about 10% of world manufacturing output and exports (Sang and Dong, 1995, page 7). A major share of this production comes from a few developed countries. In 1995, three countries—the USA, Japan, and the former West Germany—contributed 52.6% of the world's total value-added in industrial chemicals production (see table 1, over). Between 1985 and 1995, this share distribution of world production had not changed appreciably. Significant changes, however, have taken place in the league of developing countries. One of these changes is the emergence of East Asian and the Association of South East Asian Nations (ASEAN) countries as major producers of chemicals. In particular, Taiwan has now overtaken Brazil to become the top developing country, and the Philippines has joined three other ASEAN members (Indonesia, Malaysia, and Singapore) as one of the leading developing countries in chemical production. More importantly, these Asian producers have all increased their shares of total value-added among developing countries. On the other hand, in 1993 the world chemical market saw the USA producing 27% of world sales, with Japan and Germany producing 17.4% and 8.5%, respectively (Sang and Dong, 1995). These top three producer countries are also the top three market countries, and account for half of the world chemical market. In comparison, the chemical sales market of developing countries is relatively small in size. For example, in 1993, the market shares of Asian newly industrialised economies (NIEs) and ASEAN countries

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Table 1. Shares of total value-added in industrial chemicals by the world's leading countries (source: United Nations, 1998).

Country[a]	1985		1995	
	share (%)	rank	share (%)	rank
USA	23.5	1	23.7	1
Japan	**15.4**	**2**	**16.2**	**2**
West Germany (former)	15.3	3	12.7	3
United Kingdom	5.7	4	5.5	4
France	5.3	5	4.8	5
Italy	5.0	6	3.7	6
The Netherlands	3.1	8	3.0	7
Taiwan	**1.5**	**13**	**2.8**	**8**
India	**1.2**	**14**	**2.4**	**9**
Brazil	3.2	7	2.3	10
Mexico	2.4	9	2.3	11
Republic of Korea	–	–	**2.2**	**12**
Belgium	2.1	11	2.1	13
Spain	2.1	10	1.9	14
Canada	1.5	12	1.8	15
Saudi Arabia	0.8	15	–	–

[a]Asian countries are shown in bold.

were only about 9% and 3.6% of world sales, respectively. Since the end of the 1980s, the chemical markets of developing countries have experienced growth. After a period of substantial restructuring, the market share of developing countries has increased from 16% in 1988 to about 17.4% in 1994 (Sang and Dong, 1995, page 9).

In the context of this growing importance of Asia as a world centre of production and consumption of chemicals, it is relevant to investigate the underlying causes behind the remarkable expansion of the industry in Asia. In particular, the rapid expansion of the chemical and related industries in certain Asian countries should be seen as an intended consequence of the global strategies of transnational chemical firms and sustained national industrialisation initiatives. Despite the continual dominance of Western Europe and North America as the major centres of the world's chemical production and consumption, we argue that transnational chemical firms from these two regions have increasingly taken a more strategic view of Asia as a major platform from which to engage in truly global competition. As agents of economic transformation, transnational corporations (TNCs) have the capabilities to influence global investment and consumption trends (Dicken, 1998; Dunning, 1993a; OECD, 1997). Our first objective in this paper is to examine how the global strategies of transnational chemical corporations (CTNCs) enhance their competitive advantages in an era of global competition. Recently, Asian countries have become engaged in fierce competition to attract foreign capital to develop their chemical industries. The rules of competition have changed so significantly that CTNCs are now attracted to a different set of locational advantages. The spatial implications of this change have led to growing attention being paid to the formation of chemical clusters, both at national and at regional scales.

A second and related objective in this paper is to explain the geographic clustering of chemical and other related firms in an Asian NIE—Singapore.[(1)] During the last

[(1)]Most existing studies of the role of transnational corporations in Singapore's economic development have been focused on the electronics industry (see Brown, 1998; Mathews, 1999; Mirza, 1986; Perry and Tan, 1998; Wong, 1991).

three decades, Singapore has distinguished itself as a regional centre for trade in petroleum, petrochemicals, and chemicals. Although Singapore's geographical advantages have provided the basis for the country to secure a role as a regional producer, supportive state policies have been just as important in creating a business environment conducive to the transnational operations of international oil, petrochemical, and chemical companies. Given today's highly competitive environment, however, the provision of incentives by local, regional, and national authorities will not automatically attract foreign investments. The fact that many of the world's leading chemical companies have chosen Singapore as their strategic hub in the Asia–Pacific region points to the competitive position attained by the city-state in embedding these foreign investments. As such, Singapore's chemical industry is considered to provide an excellent case study for examining the strategic role of CTNCs in the development of Singapore's chemical clusters and the competitive advantages offered by these evolving chemical clusters to embed CTNCs. The Singapore case also has important applications for urban and regional development (see Cooke and Morgan, 1998; Scott, 1998; Storper, 1997).

This paper is organised into five sections. In the first section we provide an overview of the characteristics and evolution of Singapore's chemical industry. This is followed by a critical review of existing studies of the global strategies of CTNCs, and a conceptual framework for the analysis of the role of CTNCs in the development of chemical industry clusters. In the third section we briefly explain the research methodology of this paper. In section four, we provide an account of the evolution of the global strategies of CTNCs, using primary data collected from field research on their subsidiaries in Singapore. In the penultimate section we analyse the role of CTNCs in the development of Singapore's chemical industry cluster (SCIC). In the concluding section we summarise our main findings and highlight some challenges for urban and regional development.

The chemical industry cluster and Singapore's industrialisation

The development of Singapore's chemical industry cluster (SCIC) is closely related to the industrialisation phases that Singapore has undergone since the government launched its industrialisation programme in the early 1960s. Singapore's role as a petroleum-refining centre began in 1961, when Royal Dutch Shell opened the country's first refinery on the island of Pulau Bukom (Ng, 1997). Singapore's geographical location and the worldwide trend among international oil companies to locate refineries near rapidly growing markets were the major reasons determining investments in petroleum refining during this period (Lim and Lloyd, 1986). During the next two decades, the country's refining industry grew significantly to become an important foundation of its economy. More importantly, the refineries served as a launching pad for the new petrochemicals industry (see table 2, over).

After its separation from the Federation of Malaysia in 1965, Singapore adopted an export-oriented industrialisation programme to stimulate industrial growth (Low, 1998; Perry et al, 1997; Rodan, 1989). During the next two decades, Singapore experienced remarkable growth in its manufacturing sector fuelled by increasing foreign investments especially in the fields of petroleum refining and petroleum products. Success in the petroleum-refining sector inspired the Economic Development Board (EDB) to conduct feasibility studies on the potential of developing a petrochemical industry in Singapore (Lee, 1973). Efforts were also made to look for experienced international petrochemical companies to participate in the project. Sumitomo Chemical of Japan eventually assumed the role of leader and coordinator (Ng, 1997). It was not until 1977 that Sumitomo Chemical and EDB managed to secure endorsement from the Singapore

Table 2. The evolution of Singapore's chemical industry cluster (source: compiled from Ng, 1997).

Phases of industrialisation	Landmark events in the history of the Singapore chemical industry cluster
Initial phase (1961 to 1965)	1961 Royal Dutch Shell begins operating Singapore's first refinery on Pulau Bukom 1962 Japan's Maruzen builds and operates a refinery at Pasir Panjang 1963 Mobil begins operating a refinery in Jurong 1964 BP buys the Maruzen refinery
Export-oriented industrialisation (1965 to 1979)	1970 Esso's refinery comes onstream 1973 Singapore Petroleum Company (SPC) beings operating a refinery on Pulau Merlimau 1977 Incorporation of the main upstream company, Petrochemical Corporation of Singapore (PCS)
Second industrial revolution (1979 to 1984)	1980 Incorporation of the first downstream companies: Phillips Petroleum Singapore Chemical (PPSC), The Polyolefin Company Singapore (TPC), Denka Singapore (DSPL) 1982 Incorporation of Ethylene Glycols Singapore 1984 Start-up of Singapore's first petrochemical complex—PCS, PPSC, TPC, and DSPL plants 1991 Proposal of the cluster-development strategy in the Strategic Economic Plan 1994 Announcement of plans to build PCS II 1995 Reclamation work begins under the Jurong Island Project 1998 Opening of the S$3.4 billion PCS II complex

and Japanese governments: in July that year, 23 Japanese companies incorporated the Japan–Singapore Petrochemicals Company Limited. In August, the Japan–Singapore Petrochemicals Company and the Singapore government established a 50–50 joint venture, the Petrochemical Corporation of Singapore. The Singapore government offered Pulau Ayer Merbau, an island just off the south coast of mainland Singapore, as a site for the construction of the petrochemical complex. The need for a petrochemical base gained urgency with the launch of Singapore's Second Industrial Revolution in 1979. After nearly two decades of strong growth based on a liberal policy of attracting all kinds of foreign investments, the 'revolution' was aimed at raising the value-added content of the country's economic activity (Ho, 1994; Rodan, 1989; Yeung and Olds, 1998). Given its limited resource base, Singapore now focused on attracting investments and industries that would sustain its long-term economic growth and objectives. As Singapore strove to move up the value-added chain, the development of a petrochemical industry was a timely move to ensure employment in the refining industry. The unemployment issue became yet more important in the early 1980s when Singapore's refining industry was threatened by capacity-expansion plans in the Middle East and Indonesia (Ng, 1997).

After more than a decade of planning and preparation, Singapore's—and Southeast Asia's—first petrochemical complex (PCS I) finally came on-stream on Pulau Ayer Merbau in February 1984. This was a milestone in the historical development of Singapore's chemical industry. The establishment of PCS I provided a key link to the integrated process among the subsectors of the chemical industry. In the period following the 1985/86 recession, the Singapore government appointed a ministerial committee to identify the causes of the downturn and to search for 'new directions' for future growth (MTI, 1986). The early 1990s marked the dawn of a new political era in

Singapore, when Lee Kuan Yew stepped down as prime minister and was succeeded by Goh Chok Tong. The new leadership introduced a portfolio of economic strategies encapsulated in the Strategic Economic Plan (SEP). Under the SEP, an 'industrial strategy' was proposed to develop Singapore's own world-class industries (MTI, 1991). To realise this objective, the SEP, in conjunction with the Manufacturing 2000 (M2000) programme, recommended a cluster approach to industry development. Under this approach, linkages between and within individual industries are analysed to map out the potential opportunities and synergies that can be tapped to enhance overall competitiveness (EDB, 1996a, page 9). Towards this end, a S$1 billion Cluster Development Fund has been set up to enable the EDB to share the risks and costs of strategic investments in Singapore and the region.

Under the M2000 umbrella, the Chemical 2000 (C2000) study was completed with specific recommendations to enhance the chemical cluster. This marked a new phase in the development of the SCIC. Through a cluster-development approach, C2000 aims to reinforce Singapore's position as a strategic manufacturing centre of chemicals in the Asia – Pacific region (EDB, 1995). More importantly, the implementation of the C2000 programme reaffirms the role of the government in developing the SCIC. Committed to nurturing Singapore as a regional chemical hub, the government has invested S$7.2 billion to build a chemical island complex that will rival the world's best. This infrastructural project involves combining seven southern offshore islands of Singapore into a single land mass, known as the Jurong Island Chemical Complex (EDB, 1995). In March 1994, the buoyant mood in the industry spurred the partners of PCS I to announce a S$3.4 billion investment to build PCS II (EDB, 1995). A few months later, Hoechst Celanese expressed its intention to built a S$150 million vinyl-acetate-monomer plant in Singapore, drawing feedstock from the second complex. As related and interdependent activities, these diverse petrochemical investments have contributed to the cluster-development strategy by adding strength to a highly integrated industry structure. Such a strategy, however, would not have been brought to fruition without the significant role and support of foreign chemical firms. This issue of foreign investments and cluster development is the key theoretical and empirical focus of the following sections.

Strategies in global competition: competing perspectives

Existing studies of transnational chemical firms

Authors of most studies of transnational chemical firms have attempted to trace the changes in corporate strategy and organisational structure during the 20th century (Arora and Gambardella, 1998; Chandler, 1990; Chandler et al, 1998; Chapman, 1991; Mussati and Soru, 1991). They argue that the evolution of corporate strategy is influenced by the nationality of the chemical firms and by changes within the global chemical industry. For instance, the postwar boom of 1945 – 70 saw an enormous upsurge of investment in production capacity throughout the chemical industry. During this period, most North American companies pursued a strategy of growth. Dow, for example, expanded its production capacity by vertical integration, building new plants, and investing in overseas markets (Chandler et al, 1998). On the other hand, the British firm, ICI, did not respond positively to the postwar boom. In fact, ICI's performance was hampered by its dependence on the British domestic market which grew only slowly during the postwar years (Pettigrew, 1985).

In these studies of CTNCs different analytical frameworks have been employed. For example, the internationalisation strategy of chemical firms is conceptualised in different ways. Using the logic of product and industry life cycles, Chapman (1991) postulates that chemical firms are both pushed overseas as domestic markets mature

and rates of growth slacken, and pulled overseas by the attractions of repeating the cycle in an undeveloped market. Indeed, the maturity of the traditional markets is perceived to be the driving force behind the internationalisation of production by chemical firms (Sang and Dong, 1995). Establishing an international presence is another way of analysing the internationalisation strategy of chemical firms. In this case, foreign direct investment (FDI) is seen as a defensive reaction to the emergence of domestic competition in markets previously served by exports (Chapman, 1991; Royse, 1996; Sang and Dong, 1995). Similarly, competition may come from other CTNCs, leading to the phenomenon of follow-the-leader behaviour and oligopolistic reaction from their competitors (Chapman, 1991; see also Knickerbocker, 1973). The recent scramble into Asia has, to a large extent, been initiated by the defensive strategic mentality of CTNCs. As Eckstut (1996, page 25) noted, "everyone else is there, so I must be there too".

Yet, other authors offer different perspectives on the internationalisation strategy of CTNCs. To them, investing overseas involves factors other than establishing a presence in an undeveloped foreign market. Knowledge about different markets is rather important in this case (Willmott et al, 1996). For instance, the strong family networks that exist from mainland China to Taiwan, Thailand, Indonesia, and Singapore, do not always play by the rules with which CTNCs from the West are familiar. In most cases, customers are not as developed as in advanced economies; yet they want the latest products and technology (Eckstut, 1996). Hence, CTNCs often adopt a focus strategy by delivering a single type of value to their customers. This 'value proposition' may be the best cost, the best product, or the best solution. As such, internationalisation by chemical firms can be seen as an action plan rather than a strategy. The strategy now is to serve only those foreign markets and customers who pay attention to—and so are willing to pay for—the specific value proposition.

However, different perspectives are held for this second strategy too. This strategy is seen as a fundamental change in CTNCs' strategic approach to growth. Historically, the strategies of most chemical companies were to "build additional products; build when existing capacity runs out and more is needed; build it in different places to access different geographic markets" (Eckstut, 1996, page 21). There was no addressing of value-added growth, new product developments, technology leverage, or any of the activities and processes typically associated with growth. The strategy of focus required chemical firms to perform only core functions in which they had a competitive edge in order to ensure long-term competitiveness and growth (Chandler et al, 1998; see also Mascarenhas et al, 1998; Prahalad and Hamel, 1990). By focusing on core competencies, chemical firms were able to differentiate themselves from their competitors. Instead of taking Asia as another market driven by the supply–demand commodity cycle, CTNCs could achieve long-term competitiveness and growth by focusing on their customer needs and organisational capabilities. In this 'value-chain' concept the strategy of focus is viewed as a way in which chemical firms restructure themselves (Dicken, 1998; see also Porter, 1980; 1985; Willmott et al, 1996). Suppliers of CTNCs can undertake every component, from applied research to process design, manufacturing, brand management, and sales-channel management. What remain in-house are those skills, capabilities, and technologies that offer CTNCs a distinct competitive advantage in the global marketplace.

One obvious lacuna in these business and management studies of CTNCs is the geographical analysis of their global activities. Among a few geographical studies of the chemical industry, Chapman (1991) has specifically emphasised the spatial evolution of the international petrochemicals industry and has adopted an eclectic approach by drawing upon ideas from a variety of disciplines. In recent studies of the German chemical industry Bathelt (1995; 1997) has also analysed the learning processes and

organisation of communication of chemical firms with their suppliers and customers, and shown how the spatial structures of these processes are reorganised in the context of changing economic and social trends.

However, little empirical research has been conducted to investigate the global strategies of CTNCs. Indeed, most industrial economists and social scientists have largely neglected the chemical industry. Academics have generally concentrated their research efforts on industries "that have experienced dramatic declines in employment and output, or on advanced technology industries that affect both the organisation of industrial processes and the life of consumers" (Martinelli, 1991, page 10). A major weakness of the literature, therefore, is the lack of a firm-level perspective on the strategies employed by CTNCs. Most authors have chosen to examine the global strategies of CTNCs from an industry perspective (for example, Chapman, 1991). Another weakness of the empirical literature is that few studies have offered an exploration of the geographical implications of these global strategies for urban and regional development. Although the locational patterns of CTNCs are mentioned in some of the studies, there is a bias toward a focus on the macrolevel explanations of the phenomenon, with little analysis on the resultant local impact (for example Bathelt, 1995; 1997; Chandler et al, 1998; Martinelli, 1991). Certainly, few studies have been conducted on the role of CTNCs in the development of chemical clusters in specific host countries and/or regions. In the next subsection, we attempt to develop an analytical framework to integrate the global strategies of CTNCs and the formation of chemical clusters in specific host regions.

An analytical framework for understanding strategies in global competition

The ability of a firm to formulate and implement strategies depends on its resources (Barney, 1991; Peteraf, 1993; Rangone, 1999; Wernerfelt, 1984). These strategic assets provide the foundation for a firm to achieve competitive advantages. Similarly, a TNC can improve its global competitiveness by building its firm-specific resources and capabilities across borders (Bartlett and Ghoshal, 1989). This *resource-based* perspective defines global strategy as a deliberate choice by a TNC to acquire and organise its resources and capabilities to achieve an objective or set of objectives (Dunning, 1993b). In Dunning's (1988; 1993b) eclectic framework of international production, the organisation of firm-specific or ownership-specific advantages, or O advantages, is one of the necessary three types of competitive advantage possessed by TNCs. The other two types of competitive advantages are location-specific advantages, or L advantages, and internalisation advantages or I advantages. The resulting character and pattern of international production will depend on the configuration of the O advantages of TNCs, the L advantages of countries/regions, and the organisational modes in which TNCs seek to acquire and organise these O and L advantages. A TNC can influence its O advantages by acquiring or creating new firm-specific resources and capabilities. For example, improved research and development (R&D) capabilities can enhance the O advantages of a TNC. Given the O and L advantages of specific TNCs, the ways in which they are organised will depend on the perceived advantages of hierarchical control. These are also referred to as internalisation advantages (I advantages) (Dunning, 1993b). The global strategies of TNCs, therefore, reflect their OLI configurations (see figure 1, over).

Our analytical framework in figure 1 can be considered an integrated approach for the conceptualisation of the global strategies of TNCs. We formulate a *strategy-based* concept of cluster development in an urban and regional context. Clusters are defined as "geographic concentrations of interconnected firms, specialised suppliers, service providers, firms in related industries, and associated institutions in particular fields that

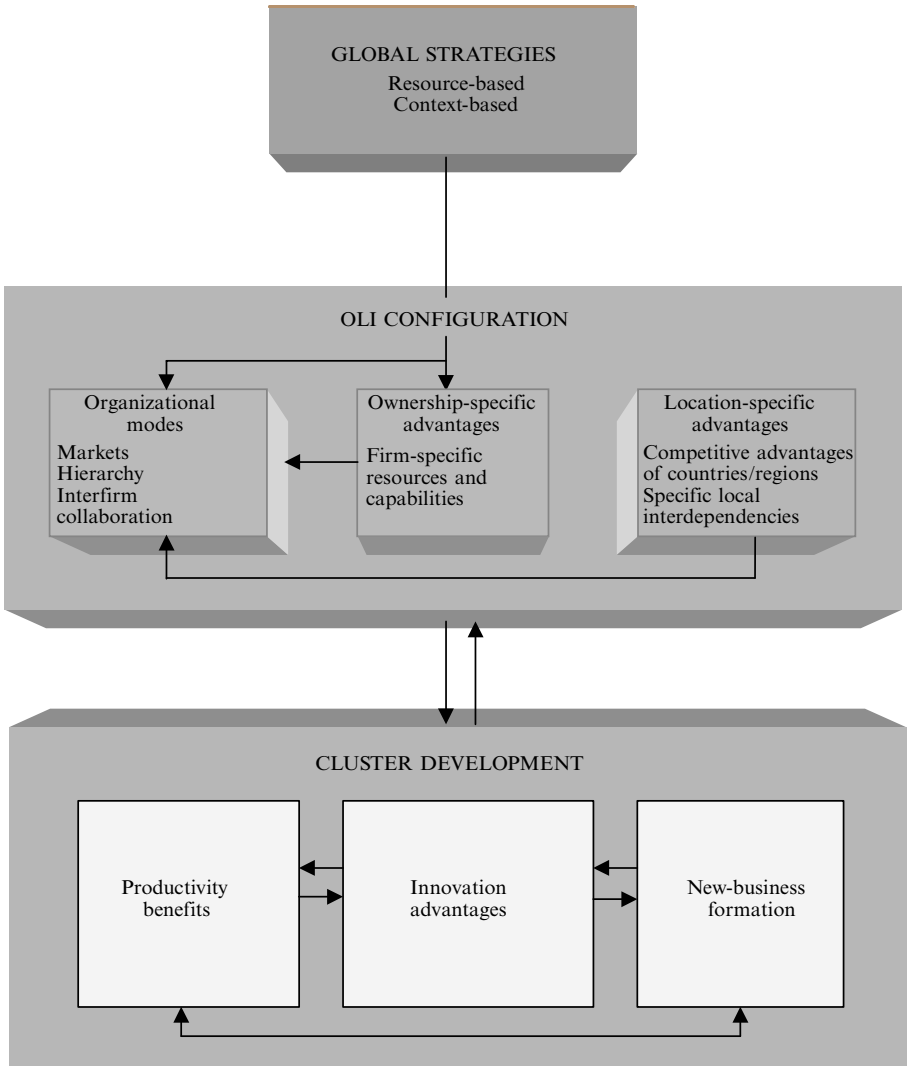

Figure 1. An analytical framework for understanding strategies in global competition. Note: OLI configuration—configuration of ownership-specific (O), location-specific (L), and internalisation (I) advantages.

compete but also *cooperate*" (Porter, 1998a, page 197; our emphasis). The emergence of clusters is not a recent phenomenon and has been recognised and explored in a wide range of literature (Amin and Thrift, 1994; Ellison and Glaeser, 1999; Hirschman, 1958; Lloyd and Dicken, 1977; Markusen, 1995; Schmitz and Nadvi, 1999; Storper, 1997). The concept is also well explored in the geographic literature on spatial agglomerations (Malmberg and Maskell, 1997; Maskell and Malmberg, 1999). In this geographic literature it is argued that cluster development is significantly embedded in networks of relational assets and geographical proximity, particularly at the local and regional scales, such that "territorialization is often tied to a specific interdependencies in economic life" (Storper, 1997, page 20). Such social processes as norms and conventions, collective learning, and localised capabilities help to define these specific interdependencies and subsequent territorial tendencies. When tapped by firms in specific localities, these interdependencies provide a significant source of location-based advantages,

both through competition and through cooperation (see figure 1). Porter (1990; 1998a) has also offered a similar version of cluster formation that provides important insights into the nature of competition and the role of location in developing competitive advantage. According to Porter (1998a), competition is dynamic in that it is based on innovation and the search for strategic differences. In this view of competition, location affects the competitive advantages of firms through "its influence on *productivity* and especially on *productivity growth*" (Porter, 1998a, page 209; original italics). The productivity with which a firm competes in a location is strongly influenced by the quality of its business environment. This is in turn determined by the level of interconnectedness and linkages in a particular location (see the geographic literature). As clusters consist of geographically proximate groups of interconnected firms and associated institutions in a particular field, such a business environment or 'industrial atmosphere' will affect the competitive advantages of these firms.

Transnational corporations can shape the development of industrial clusters through the ways in which they configure their ownership, location, and internalisation advantages. More specifically, clusters are a source of *factor inputs* that can reinforce the OLI configurations of TNCs.[2] By tapping into these factor inputs, TNCs are able to influence the development of industrial clusters. Our rationale for adopting this framework is that the theory has taken location as an important factor in influencing the competitiveness both of firms and of regions. However, a dialectical relationship exists between firms and clusters [and, similarly, between capital and space (see Yeung, 1998a)]: on the one hand, clusters hold significant implications for firm strategy; on the other hand, firms have a major role to play in cluster development and upgrading. In accordance with their global strategies, TNC can attain their desired OLI configuration by tapping into the resource-rich environment or milieu of clusters. There are three broad ways in which a cluster environment can help firms to fulfill their strategic objectives: (1) by increasing their productivity; (2) by increasing their capacity to innovate; and (3) by stimulating new business formation that supports innovation

Table 3. Mechanisms of cluster growth (source: Porter, 1998a; 1998b).

Cluster-based advantages	Effects on competition
Productivity benefits	Access to labour and suppliers Access to specialised information Complementarities Access to institutions and public goods Better motivation and performance measurement
Innovation advantages	Presence of sophisticated buyers Flexibility Lower experiment costs Presence of competitive and peer pressure
Formation of new businesses	Ease of detecting gaps in products and/or services Lower entry barriers Availability of needed assets, skills, inputs, and labour Established relationships

[2] Space limits preclude a comprehensive evaluation of theoretical perspectives by Michael Porter and John Dunning. For a critique of the excessive focus on competition and the lack of attention to internationalisation in Porter's model, see Cooke (1999), Dunning (1992; 1993c), Hodgetts (1999) and Hoskisson et al (1999). See also Cantwell (1991) and Gray (1996) for a critique of Dunning's eclectic framework and his recent auto-critique (Dunning, 1995). Specifically, the dynamics of location-based advantage are not well explained in the eclectic framework of international production.

(see figure 1). Table 3 summarises how each of these cluster-based advantages provides support to firms. Clusters are seen as critical masses—in one place—of unusual competitive success in particular fields. Porter (1998a, page 222) argues that this "geographic concentration of clusters occurs because proximity serves to amplify many of the productivity and innovation benefits of clustering". These benefits, as explained in table 3, are the various O, L, and I advantages which firms can source from clusters to configure their global resources or assets. By tapping into the resource-rich environment of clusters, firms can, in turn, pursue their evolutionary trajectories in a context of urban and regional development.

Methodology and research context

We adopted a multiple-strategy approach as the overall design (Denzin, 1970; Jick, 1983). The case-study strategy was adopted to analyse empirical data collected from field research. According to Yin (1994), in such an analytical strategy multiple sources of evidence are used for data collection. The rationale for the use of multiple data sources rests on the logic of triangulation. By exploiting the complementarity between quantitative and qualitative methods, triangulation can improve the validity and reliability of the data collected. We collected primary data from postal surveys and qualitative personal interviews with the Singapore subsidiaries of CTNCs. This information was complemented by secondary data collected from other sources such as company annual reports, business journals, official reports released by government agencies, and so on.

We chose postal survey, in the form of a self-administered questionnaire, as one of the research methods for primary data collection. We consulted *The Report on the Census of Industrial Production* (MTI, 1996) to identify a total of 205 establishments in Singapore's chemical industry cluster, ranging from the petrochemical industry to the pharmaceutical and healthcare industries. Petroleum-refining companies were excluded as the focus of this study is on chemical firms. Using the *Singapore Directory of Chemical Manufacturers and Supporting Services* (EDB, 1996b) and telephone verification with the companies, we identified foreign companies in the directory to segregate the sample population into two groups: foreign firms (CTNCs) and local firms or suppliers. A separate questionnaire was prepared for each group in order to gather different data on the relationship between foreign firms and local firms or suppliers. An overall response rate of 44 completed questionnaires, or 21.5% ($n = 205$), was achieved from the postal survey, with foreign and local chemical firms achieving a rate of 14 responses (15.7%, $n = 89$) and 30 responses (25.9%, $n = 116$), respectively.

The case-study strategy is also useful in the analysis of the context and processes involved in the phenomenon under study (Hartley, 1994). Although the postal survey is both cost-effective and time-effective, it does not really provide significant insights into the underlying processes of strategy formation and implementation. The corporate interview method offers greater accuracy and validity as it "allows a more comprehensive and detailed elucidation of the interplay among strategy, history, and circumstances" (Schoenberger, 1991, page 184; see also Clark, 1998; Schoenberger, 1997; Yeung, 1995). We conducted qualitative personal interviews with key management personnel from the Singapore subsidiaries of CTNCs. We then compared this first-hand information with findings from other sources. We asked questions similar to those in the postal survey during all personal interviews. We used these questions mainly as interviewing cues, because the qualitative method should "value participants' perspectives on their worlds and seeks to discover those perspectives" (Marshall and Rossman, 1989, page 11). We conducted a total of 6 (4 foreign and 2 local) in-depth interviews with top executives from the Singapore subsidiaries of CTNCs. We taped most of the interviews (up to 70%) after seeking consent from our interviewees.

Evolution of the global strategies of transnational chemical firms

Most of the large chemical firms in the USA, Germany, the United Kingdom, and Japan were established at the turn of the 20th century. The initial corporate capabilities of these firms were developed during their early years of incorporation and have been maintained since then (Chandler et al, 1998). Table 4 provides a summary of the evolution of the global strategies of CTNCs from three leading producing countries. The evolution of the global strategies of CTNCs supports the analytical framework developed in figure 1, in which it is postulated that successful firm strategy must be based on *accumulated* firm-specific capabilities. It is only through focusing on these long-established organisational capabilities that CTNCs can develop their competitive strength. Moreover, the configuration of their capabilities is very much influenced by country-specific circumstances and contexts.

Throughout the 1990s, CTNCs have been pursuing a grand vision of *growth*, although strategies vary with the products and the nationality of CTNCs. These CTNCs organise their firm-specific resources in relation to external conditions and strategies pursued in earlier periods. On the whole, chemical firms are more export-oriented than are other manufacturing firms (Sang and Dong, 1995). This characteristic deepens and intensifies international competition for market shares in the worldwide chemical industry. Responses to our postal survey show that 19 (63%, $n = 30$) of the Singapore subsidiaries of CTNCs considered *growing global competition* as a very important external condition (level of importance equal to 1). However, the nature of global competition differs among subsectors of the chemical industry because chemical firms

Table 4. Evolution of strategies by transnational chemical firms in the 20th century (sources: compiled from Arora et al, 1998, pages 71 – 101 and 415 – 457).

	Period before World War 2 to 1945	Postwar boom 1950s to early 1970s	Recession and recovery 1970s to present
	developing initial capabilities	globalisation and diversification	corporate restructuring
United States	Building on imported technological capabilities	Expanding production and technological capabilities into foreign markets	Reduction in capacity Focus on core capabilities
	Building commercialisation capabilities	Diversifying into new product lines	Shift to high-value-added products
Germany	Building technological capabilities through internal R&D[a]	Adoption of new technological capabilities from foreign producers, that is petrochemicals technology	Reduction in capacity Focus on core capabilities Shift to high-value-added products
Japan	Import technological capabilities Developing incremental process-improvement capabilities	Import new foreign technologies for commercialisation that is petrochemicals technology Continuing to build on incremental process-improvement capabilities	Reduction in capacity Building new core capabilities that is distinctive product-development capabilities Shift to high-value-added products for example fine and specialty chemicals

will only compete with each other on the basis of their own products. For example, as a producer of chemical products for industrial end-users, USSpecialty[3] is actually competing in the applicability of its products. It is not part of the same competitive field as petrochemical firms that produce bulk chemicals (our interview). Being able to *tap into potential regional market* was also considered a very important external condition by 15 (50%, $n = 30$) respondents. In fact, 26 (87%, $n = 30$) of the respondents regarded this as an important external condition. According to interviews conducted with some of the subsidiaries, 'regional market' refers either to the Southeast Asia region or to the entire Asia–Pacific region. Many CTNCs use Singapore as a base to tap into the regional market. More importantly, such a strategic decision is influenced by a wider context—namely the huge market potential offered by regions surrounding Singapore. This has been a major factor leading most CTNCs to establish operations in Singapore. What, then, are the major strategies of CTNCs in Singapore? We examine four of them here.

Focusing on core competencies

Having undergone a tough period of recession, growth has begun to find its way back onto the agenda of CTNCs in the 1990s. The growth strategy pursued by most CTNCs may represent a fundamental change within the world chemical industry itself. CTNCs are found to be more focused in what they do. More specifically, CTNCs perform only core functions and competencies in which they have a competitive edge; they are distributing all other activities to outside supplies (Willmott et al, 1996). Our postal survey found that 25 (85%, $n = 30$) subsidiaries of CTNCs were focusing on their core competencies. However, core competencies vary with individual CTNCs and how each defines them. Generally, a core competency of a firm is defined as 'a single differentiating ability and source of competitive advantage" (Willmott et al, 1996, page 16). This differentiating ability refers to the organisational capabilities of firms and encompass individual experiences, personal competencies, and technical skills. Possession of these distinctive core competencies will, therefore, provide a firm with a base for strategies to be built on (Bogner and Thomas, 1994; Nohria and Ghoshal, 1997). The core competencies of CTNCs can be deciphered from the O advantages of their OLI configurations (see figure 1). For example, 18 (60%, $n = 30$) of the sampled CTNCs claimed to possess some form of 'special advantage' over other chemical firms in Singapore. Higher technical capabilities (50%) and better product quality and services (40%) are two of the most common 'special advantages' possessed by these CTNCs in Singapore. As global strategies of CTNCs are based on these firm-specific capabilities, in the next two subsections we focus on each of them specifically.

Specialising for global competitiveness

In order to cope with growing competition within the polymer markets during the late 1950s, DuPont adopted a strategic move to search for new markets by diversifying into product lines in which its existing capabilities gave it little competitive strength. This had led to the creation of a New Ventures Program (Chandler et al, 1998; Taylor and Sudnick, 1984). When the New Ventures Program had failed to deliver its intended results by the late 1960s, DuPont became one of the first chemical firms to realise that a firm's strategic options were limited by the potential of its existing firm-specific capabilities (Burgelman and Sayles, 1986; Fast, 1979; Hounshell and Smith, 1988). This example reiterates the importance of chemical firms staying focused on their core competencies. Core competency, in this case, is based on products manufactured by chemical firms. The reason for this is that certain firm-specific capabilities have been

[3]All company names of our interviewees reported in this paper are disguised to maintain confidentiality and anonymity.

built around these so-called core products. CTNCs are able to develop their core competencies by expanding or reinforcing these product-specific capabilities. In our survey, 19 CTNCs in Singapore (63.3%, $n = 30$) responded that they were quite specialised in the products they manufacture. To a large extent, the decision to pursue product specialisation is determined by the context of competition. As mentioned above, CTNCs today are generally faced with rising global competition regardless of their subsector within the chemical industry. Given this wider context, CTNCs have decided to adopt global strategies that are based on manufacturing their core products.

There are many ways in which CTNCs can organise and enhance their product-specific capabilities in order to gain a competitive edge within the global chemical industry (see figure 1). The following case study illustrates how CTNCs configure their product-specific capabilities to enhance the global competitiveness of their specialised core products. Often, CTNCs choose to manufacture specialised products to deliver a top-quality product to their customers. CTNCs can then offer their customers a single type of value which their competitors find hard to duplicate (Willmott et al, 1996). Such is the strategic intent of USPetrochem1 in its bid to becoming the leading supplier of catalysts to refineries and petrochemical plants in the region. According to its managing director, "to be competitive, we have to have good products, which means products that have high productivity, long life time and meet customer needs" (our interview, 15 February 1999). To achieve this objective, the Singapore subsidiary has set up a technical and sales department to acquire the latest information on the requirements and needs of its customers, that is the refineries and petrochemical plants. This is necessary because customer needs differ. Quality products can only be manufactured by finding out the detailed requirements of customers, such as the range of their products and feedstocks.

Having close relationships with customers is also seen as a crucial avenue through which product-specific knowledge is obtained. As USPetrochem1 is both a subsidiary and a supplier of a major global refining company, it has a very strong in-house knowledge of what refiners require. Its intrafirm trade with the parent company in the USA represents only a small portion of its total business, compared with other major customers such as Mobil, Exxon, and BP. As such, locating in close proximity to its major customers in Singapore and the region generally not only strengthens USPetrochem1's relationship with them, but also allows USPetrochem1 to respond quickly to their changing needs. More importantly, such closeness with customers has enabled USPetrochem1 to maintain its product quality as customer needs are met more efficiently. Customer satisfaction and trust are built up this way. The locational advantage of proximity is therefore based on such social processes as interactive learning with customers and interfirm cooperative relationships (see figure 1).

Innovation and the development of technological capabilities

Chemicals are a science-based, high-tech industry which can be traced back to the British dyestuff manufacturers of the 1850s (Arora et al, 1998). Innovations through the discovery, adoption, and commercialisation of new technology constitute a critical component of the evolution of the chemical industry. The development of firm-specific technologies capabilities is still regarded as a vital component in every global strategy deployed by the CTNCs. To understand better the technological capabilities of CTNCs in Singapore, we asked our respondents to identify their main sources of technology. A total of 22 (73.3%, $n = 30$) respondents preferred to acquire product or process technology directly from their parent companies. In fact, only 6 (20%, $n = 30$) CTNCs name R&D activities as a main function carried out by their subsidiaries in Singapore. This result confirms that the globalisation of R&D by today's TNCs remains rather

limited: most key R&D activities continue to be located in the home countries (Cantwell and Janne, 1999; Patel, 1995; Patel and Pavitt, 1991; Zander, 1999). In addition 26 (86.6%, $n = 30$) of the subsidiaries develop their technical capabilities through internal R&D. As explained in figure 1, CTNCs may vary in their configuration of technological capabilities. Such variations occur because CTNCs are manufacturers of different chemical products and processes, each requiring a unique set of technological capabilities. Their technological capabilities can also be considered product-specific capabilities.

We have selected two case studies to illustrate the different global strategies that CTNCs adopt to configure their technological capabilities. In the case of USPetrochem1, strong technological capabilities have provided the company with a competitive edge over its rivals in the Asia – Pacific region. Like most CTNCs in Singapore, the technical capabilities of USPetrochem1 are derived from the direct import of process technology developed within its parent company. According to its managing director in Singapore, "[our products] are developed by our laboratories in Houston and Amsterdam. We are part of a much bigger organisation based in Houston, which has the central R&D [facilities]" (our interview, 15 February 1999). Its basic process technology has provided the foundations for USPetrochem1 to carry out R&D activities in Singapore. Specifically, it is searching for new applications for existing catalysts and is developing catalysts for specific refineries. A major advantage of locating R&D activities in Singapore is proximity to local and regional customers. As noted by its managing director,

> "Each refinery differs in terms of its configuration, feedstocks, and product life. At the moment we go to refineries, for example, in Japan and Korea to make our recommendations. They may want new catalysts to be demonstrated in our central R&D facilities. [However], if the guys in Korea want to follow up, they [would] have to travel to Amsterdam or Houston. We feel that by locating [R&D activities] in Singapore, we are closer to customers" (our interview, 15 February 1999).

In the second case, USSpecialty, the role in Singapore is mainly focused on the trading of chemical products manufactured in places other than Singapore. Thus, the subsidiary's technological capabilities are also imported directly from its parent company. As in the case of USPetrochem1, a technical department has been established within USSpecialty. But, unlike USPetrochem1, the main function of this department is to provide technical support in the form of after-sales services to its local and regional customers. The differences between USPetrochem1 and USSpecialty in the ways they organise their global technological capabilities are reflected in the expectations they have of their employees. For example, USPetrochem1 is looking for local graduates to fill its R&D laboratory, plant, and technical and sales service department. Its operations in Singapore recruit a wide variety of graduates, ranging from PhD, chemists to do R&D work, to mechanical engineers who can handle the machinery within the manufacturing facilities (our interview). According to the general manager of USSpecialty, however, their recruitment is largely focused on engineering and material science graduates who choose to venture into the commercial aspects of their profession, namely sales and marketing (our interview, 25 February 1999). After being recruited, these sales engineers acquire firm-specific technologies through in-house training, thus completing the organisation of the subsidiary's technological capabilities in Singapore. With such a configuration, USSpecialty is able to compete effectively in the region via the provision of excellent technical and after-sales services to its customers.

Tapping into overseas markets: establishing a regional presence

The potential offered by foreign markets has always been a major factor inducing CTNCs to expand their operations overseas. This strategy is often deployed in response

to growing levels of competition within the home markets of CTNCs. Ever since CTNCs from advanced industrial nations began to globalise in the 1960s, competitive pressures in the domestic markets have increasingly come from exports from foreign competitors. As mentioned earlier, in the 1970s competition from producers in developing countries led to domestic market saturation and eventually severe overcapacity among established producers in developed countries. In our postal survey, 22 (73.3%, $n = 30$) of the CTNCs in Singapore indicated that their market orientation is toward the regional market; 21 (70%, $n = 30$) subsidiaries also use Singapore as an export base for their products. Although CTNCs have been establishing extensive operations within the region, each is using a different approach. With the aid of the analytical framework shown in figure 1, these strategies may be conceptualised as an asset-building or capability-building venture through which individual CTNCs attempt to configure their firm-specific resources to fit their strategic intent of operating in the region.

With the maturing of the North American and European markets, many US chemical firms have based their future growth plans in Asia. One such firm is USPetrochem2, which has opened a manufacturing complex in Singapore—its first in the Asia – Pacific region (*The Business Times* 1996). Like most CTNCs, USPetrochem2's investment in Singapore is mainly focused on the manufacturing of its core products—oxo chemicals, in which it is a world leader. The company's chemical complex in Singapore employs world-class state-of-the-art technology to maintain the reputation of its core products. Driven by domestic market saturation, USPetrochem2 is investing in the Asian region to tap into growing markets. Oxo chemicals are used in coatings for motor cars and household appliances, lacquers for furniture, and paints for houses and office buildings. According to its chairman and chief executive officer, the demand for these end-user products has been rising in a region with huge growth potential. By building an oxo-chemicals-manufacturing complex in Singapore, his company will be able to serve its expanding customer base throughout the Asia – Pacific region (*The Straits Times* 1996a). Since 1991, USPetrochem2 has been experiencing rapid growth in the Asia-Pacific region, a region which accounts for 11% of USPetrochem2's global sales. This proportion will continue to increase as the company's strategic plan is to derive half its business and 30% of its assets from outside the USA. According to USPetrochem2's ex-president, "We realise we have got to put assets in Asia in order to be part of the tremendous growth" (Taffe, 1996, page 36). As a producer of catalysts for petroleum refineries and petrochemical plants, USPetrochem1 have also located their production facilities in Singapore to serve the entire Asia – Pacific market. According to the president of one of its joint-venture partners, "The establishment of a multi-million plant in Tuas [an industrial estate in Singapore] was 'the first step' in his company's strategic plan to supply products and services to the Asia – Pacific region from Singapore" (*The Straits Times* 1996b). In short, the global strategies of CTNCs have evolved in accordance with the ways in which they (re)organise their firm-specific assets or resources. What, then, are the spatial implications of these different configurations of firm-specific capabilities for urban and regional development? We now consider the contributions of CTNCs to the development of Singapore's chemical industry cluster.

Transnational chemical firms and the development of Singapore's chemical industry cluster

CTNCs can shape the development of industrial clusters by tapping into them for sources to develop some of their OLI advantages. First, firm productivity can be enhanced by clusters as they provide superior or lower cost access to *specialised inputs and employees* (Porter, 1998a). This is particularly important to CTNCs because clusters

enhance their global competitiveness by enabling product specialisation. For these CTNCs, their product-specialisation strategy is often implemented on the basis of manufacturing quality core products. They source for quality and efficient inputs that can enhance the performance of their products. In the case of the SCIC, 17 (56.7%, $n = 30$) subsidiaries of CTNCs noted in the postal survey that they are buyers of specialised products and services from other chemical firms. More specifically, 16 of the respondents (53.3%, $n = 30$) considered the availability of raw materials an important advantage in establishing their operations in Singapore. To Porter (1998b), a cluster not only enhances productivity via the acquisition and assembly of inputs, but also facilitates complementarities and cooperative relationships in the activities of cluster participants (for example products, knowledge, and learning). In the case of another firm, JAPSpecialty, the availability of raw materials is considered a very important advantage for its operation in Singapore. It acquires raw materials from the trading offices or local agents of foreign chemical firms in Singapore. Two major benefits can be derived from such a local sourcing arrangement. First, proximity to suppliers allows the company to order easily and take delivery of its raw materials supplies. Storage costs are also lowered as raw materials are kept within the storage facilities provided by local suppliers.

The second, and perhaps the more important, advantage of having local suppliers is the complementarities that exist between JAPSpecialty's products and its raw materials. Being a major supplier of water-treatment chemicals in the region, the company relies on its product-specific features of high product quality and efficient technical service to maintain its competitive edge. For JAPSpecialty to be able to provide high value-added products and services to its customers, the company depends on the efficiency of its suppliers. According to the general manager, "by having local suppliers, we can be quite sure that the follow-up is there and we can get a consistent supply of raw materials" (our interview, 2 March 1999). The point here is that the benefit of spatial proximity to JAPSpecialty is not the availability of raw materials per se, but rather the trust and cooperative relationships with its suppliers.

In the area of specialised employees, clusters also offer sourcing advantages to firms that are located within them. These advantages are derived from the lower search costs of recruiting, and the more efficient matching of jobs to people (Porter, 1998b). This advantage is crucial for CTNCs that require employees with the right kind of skills to take up technical jobs in their foreign subsidiaries. In fact, these specialised employees have a vital role to play within the overall global strategies of CTNCs: by taking in qualified local employees, foreign subsidiaries of CTNCs can localise their technological capabilities in order to execute their global strategies more effectively.

Our survey findings reveal that 21 of the respondents (70%, $n = 30$) consider the recruitment of graduates of local universities, polytechnics, and institutes of technical education a very important approach in maintaining their talent pool. Other recruitment methods have also been used by these Singapore subsidiaries to source for qualified employees. For example, USPetrochem1 has made use of the Industrial Attachment scheme organised by two local universities to seek specialised employees. Using this scheme, it is able to observe potential employees for a longer period of time, and the students are exposed to technologies that are specific to what the company is doing. This definitely helps USPetrochem1 in its search for the right candidate. In its search for specialised employees, USPetrochem1 has tapped into a cluster resource—local universities. By participating in the Industrial Attachment scheme with the chemical engineering faculty of a local university, USPetrochem1 can reduce the search and transaction costs involved in recruitment. More importantly, the scheme enables USPetrochem1 to find *the* most suitable candidate for its operations in Singapore,

thereby facilitating the localisation of its technological capabilities. The recruitment and training of local graduates by CTNCs' subsidiaries have clearly contributed to the expansion and upgrading of employees within the SCIC. This is important for the future development of the SCIC, as the presence of a pool of specialised employees, who are equipped with the 'right' industry skills, will help in attracting other CTNCs to locate their activities in the SCIC.

Just as clusters can enhance a firm's productivity, they can also provide innovative advantages via the concentration of buyer knowledge and relationships in the firm (Porter, 1998b). The availability of extensive market, technical, and other *specialised information* is another important factor input demanded by firms located within clusters. Specialised information is accumulated from supply and technological linkages, and from repeated personal interactions relationships and community ties which facilitate the fostering of trust between cluster participants. Cluster firms often discern buyer trends faster than do isolated competitors, giving them the advantage in undertaking product-specific innovative activities. Results gathered from the postal survey show that 20 subsidiaries of CTNCs (67%, $n = 30$) are carrying out innovative activities in Singapore. The ease in which new market trends and needs can be appreciated through interaction with other chemical firms is considered by 11 of these subsidiaries to be an important factor that affects their abilities to innovate. For subsidiaries which have set up R&D facilities in Singapore, physical proximity to local and regional customers has given them a tremendous advantage in obtaining the latest information about customer needs via frequent site visits and face-to-face contacts (see also Gertler, 1995; 1997). This has definitely provided these subsidiaries with enormous opportunities to carry out innovative activities. The potential advantages of the SCIC in perceiving both the need and the opportunity for innovation are significant.

For example, in order for JAPSpecialty to meet the ever-growing demand for high-technology products and close-proximity technical support, they have set up their first R&D centre outside Japan, in Singapore, to provide value-added products and services to customers in Asian countries. Although JAPSpecialty has developed over 3000 high-performance water-treatment chemicals to meet a wide range of market needs, ongoing product development and R&D work are still conducted to maintain the high standard to water-treatment results. Frequent interaction with customers has helped the company reformulate its treatment programmes. As the general manager commented, "upon receiving first-hand knowledge of our customers' new products, we will evaluate them by doing research to see how they can be incorporated into our treatment program" (our interview, 2 March 1999). Similar sentiments are shared by local chemical firms which view customers as an important source of information on the latest market trends and needs. For another firm, SINPetrochem, customer feedback is essential when it comes to accurate information. According to its general manager:

> "We cannot depend only on written articles because there's a dated life span. We also talk to our customers. They often provide us with reasonably accurate feedback on market trends. This is because some of our customers have competitors who are coming in too, and the reliability of their market intelligence is quite high" (our interview, 5 March 1999).

Specialised information gained from interacting with other cluster participants has provided opportunities for CTNCs to create increased economic value for their customers via R&D activities in the SCIC. By acquiring specialised information on the latest market trends and technological developments, CTNCs are able to improve the quality and reliability of their products, thereby enhancing the attractiveness of the SCIC. The presence of these CTNCs that have 'made it' may induce other CTNCs to locate their activities in the SCIC, thus contributing to its further growth and development.

Clusters are also excellent sources of *accessing public goods and institutions*, factor inputs that are too costly for individual firms to acquire. Some of these public goods may be better termed quasi-public goods, as they are built by private institutions and investments (Porter, 1998b). Some of these quasi-public goods are similar to conventional public goods in that they are closely linked to government and other public institutions. These include specialised infrastructure, educational and research programmes, information, trade fairs, and other forms that will benefit a cluster. One of Singapore's key strengths in attracting foreign investors is its ability to provide a ready supply of prepared industrial land, fully serviced with the necessary utilities. For the chemical industry, our postal survey showed that 20 (66.7%, $n = 30$) of the respondents considered the availability of specialised infrastructure a major advantage for establishing operations in Singapore. Infrastructure development assumes new dimensions when 16 state agencies have embarked on a S$7.2 billion megaproject to amalgamate seven southern offshore islands of Singapore into a 2790 ha self-contained petrochemical complex, known as the Jurong Island Chemical Complex (JICC—see figure 2) (EDB, 1995; Ng, 1997). Key infrastructure will be made available on the JICC to sustain the growth of this world-class well-integrated petroleum, petrochemical, and chemical complex. Tenants will have access to common-user facilities such as jetties and berths, storage and terminalling, plant utilities, and industrial gas plants.

In our postal survey, all 7 (100%, $n = 7$) CTNCs tenants or future tenants of the JICC believed that the presence of key infrastructure was an important factor in their establishment of operations on Jurong Island. They cited the benefits of sharing costs from common facilities on Jurong Island. According to one interviewee, having access to efficient, reliable, and cost-effective centralised storage and terminal facilities on Jurong Island has alleviated the need for his company to invest in duplicate infrastructure. The JICC, with its excellent infrastructure, has presented CTNCs with many advantages when they use Singapore as a base to tap into the regional market. Mr Oliver Meurzec, Managing Director of Elf Atochem South East Asia, said that the Jurong Island concept is "brilliant and vital". He elaborated:

> "Singapore has no reason to be a major producer. There is no feedstock such as gas or oil, no technology and no market. [However], the disadvantage of not having feedstock was balanced by the advantage of having an efficient logistics system and using its central location to supply to the region ... . The shared resources, massive size and the attractive government subsidy has put this facility in a very competitive position" (Koh, 1998, page 2).

His views were echoed by Mr Roger Farr, Celanese Singapore's General Manager for South Asia. He commented that despite the Asian economic crisis, "Jurong Island's central concept of shared costs from common facilities" was the motivating factor behind the German chemical firm's decision to go ahead with its plan to build two additional plants on Jurong Island (Koh, 1998, page 2).

Conclusion

In this paper we have adopted a firm-based approach to examine the development of Singapore's chemical industry cluster. We have extended Dunning's OLI eclectic framework to incorporate conceptually the global strategies of CTNCs. This is a resource-based perspective in which global strategies are viewed as deliberate choices by CTNCs to acquire and organise resources and capabilities to achieve an objective or set of objectives. We have integrated Porter's cluster theory with the OLI framework to provide a locational dimension to the global strategies of CTNCs. Such integration is possible because clusters in general are a source of competitive advantages for firms in competing in a far more complex and dynamic global economy. Instead of such

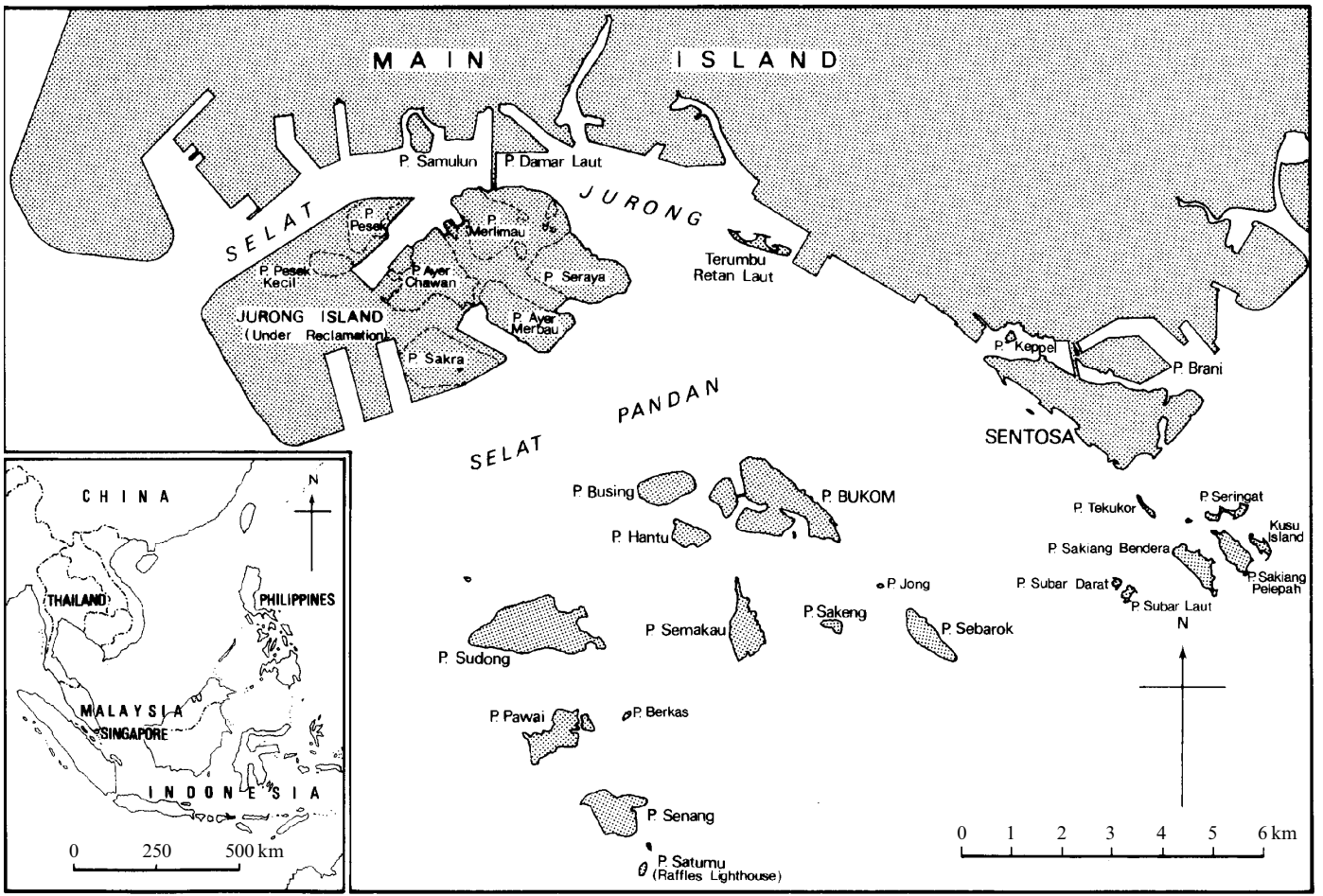

Figure 2. The Jurong Island chemical complex in Singapore.

traditional locational advantages as the supply of cheap labour, the competitive advantages of the cluster now rest with more productive use of inputs that require continuous innovation, collective learning, and interdependencies in specific localities. Dunning (1998, page 51) has also postulated that, except for some labour-intensive or resource-intensive investments, TNCs "are increasingly seeking locations which offer the best economic and institutional facilities for their core competencies to be efficiently utilised".

By tapping into the factor inputs and tacit learning processes of chemical clusters, CTNCs can, in turn, influence the development of these clusters. In terms of their sheer numbers, the entry of CTNCs into a cluster will contribute to its expansion quantitatively. CTNCs also play an important role in cluster upgrading by improving the quality of the factor inputs and learning milieu of the cluster. For example, the supply of specialised employees will increase as a result of the appropriate training provided by CTNCs. In the foregoing analysis, the global strategies of CTNCs have been evaluated and found to be a major factor contributing to the development of the Singapore chemical industry cluster. Since the early 1960s, Singapore has relied heavily on foreign capital for its industrial development. This is especially true for the chemical industry, as Singapore lacked both the expertise and capital to strike out on its own. Throughout the city-state's industrialisation, the government has been quite successful in attracting major foreign producers to locate their operations in Singapore. The growth of the chemical industry can be attributed to the various industrial and foreign investment policies implemented by the government. In act, development would seem to be impossible in resource-scarce Singapore, if it were not for the deliberate economic planning undertaken by the government (Low, 1998; see also Perry et al, 1997; Yeung, 1998b). In sum, the government should adopt an active role in developing specific industrial clusters by removing obstacles, relaxing constraints, eliminating inefficiencies, facilitating collective-learning processes, and, ultimately, building institutional capacities. If cluster development is to be reinforced by inbound FDI, efforts should be focused on attracting different companies in the same field, with supporting investments in specialised training, infrastructure, and other aspects of the business environment. The ultimate aim is, therefore, to develop the SCIC into a 'critical mass' with *enduring* competitive advantages that both CTNCs and local chemical firms can tap to ensure success in an increasingly globalising world economy.

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References

Amin A, Thrift N (Eds), 1994 *Globalization, Institutions, and Regional Development in Europe* (Oxford University Press, Oxford)

Arora A, Gambardella A, 1998, "Evolution of industry structure in the chemical industry", in *Chemicals and Long-term Economic Growth: Insights from the Chemical Industry* Eds A Arora, R Landau, N Rosenberg (John Wiley, New York) pp 379 – 413

Arora A, Landau R, Rosenberg N (Eds), 1998 *Chemical and Long-term Economic Growth: Insights from the Chemical Industry* (John Wiley, New York)

Barney J, 1991, "The resource-based model of the firm: origins, implications, and prospects" *Journal of Management* **17** 97 – 98

Bartlett C A, Ghoshal S, 1989 *Managing Across Borders: The Transnational Solution* (Century Business, London)

Bathelt H, 1995, "Global competition, international trade, and regional concentration: the case of the German chemical industry during the 1980s" *Environment and Planning C: Government and Policy* **13** 395 – 424

Bathelt H, 1997, "Continuity and change in the chemical industry: technological structure, flexibility and proximity" *Geographische Zeitschrift* **85** 193 – 212
Bogner W C, Thomas H, 1994, "Core competence and competitive advantage: a model and illustrative evidence from the pharmaceutical industry", in *Competence-based Competition* Eds G Hamel, A Heene (John Wiley, New York) pp 111 – 144
Brown R, 1998, "Electronics foreign direct investment in Singapore: a study of local linkages in 'Winchester City' " *European Business Review* **98** 196 – 210
Burgelman R A, Sayles L R, 1986 *Inside Corporate Innovation: Strategy, Structure and Managerial Skills* (The Free Press, New York)
Cantwell J, 1991, "A survey of theories of international production", in *The Nature of the Transnational Firm* Eds C N Pitelis, R Sugden (Routledge, London) pp 16 – 63
Cantwell J, Janne O, 1999, "Technological globalisation and innovative centres: the role of corporate technological leadership and locational hierarchy" *Research Policy* **28** 119 – 144
Chandler A D Jr, 1990 *Scale and Scope* (Harvard University Press, Cambridge, MA)
Chandler A D Jr, Hikino T, Mowery D C, 1998, "The evolution of corporate capabilities and corporate strategy and structure within the world's largest chemical firms: the twentieth century in perspective", in *Chemicals and Long-term Economic Growth: Insights from the Chemical Industry* Eds A Arora, R Landau, N Rosenberg (John Wiley, New York) pp 415 – 457
Chapman K, 1991 *The International Petrochemical Industry* (Blackwell, Oxford)
Clark G L, 1998, "Stylized facts and close dialogue: methodology in economic geography" *Annals of the Association of American Geographers* **88** 73 – 87
Cooke P N, 1999, "The co-operative advantage of regions", in *The New Industrial Geography: Regions, Regulation and Institutions* Eds T J Barnes, M S Gertler (Routledge, London) pp 54 – 73
Cooke P N, Morgan K, 1998 *The Associational Economy: Firms, Regions, and Innovation* (Oxford University Press, Oxford)
Denzin N K, 1970 *The Research Act in Sociology: A Theoretical Introduction to Sociological Methods* (Butterworth, Sevenoaks, Kent)
Dicken P, 1998 *Global Shift: Transforming the World Economy* (Paul Chapman, London)
Dunning J H, 1988 *Explaining International Production* (Unwin Hyman, London)
Dunning J H, 1992, "The competitive advantage of countries and the activities of transnational corporations: a review article" *Transnational Corporations* **1** 135 – 168
Dunning J H, 1993a *Multinational Enterprise and the Global Economy* (Addison-Wesley, Reading, MA)
Dunning J H, 1993b *The Globalization of Business: The Challenge of the 1990s* (Routledge, London)
Dunning J H, 1993c, "Internationalizing Porter's diamond" *Management International Review* **33** 7 – 15
Dunning J H, 1995, "Reappraising the eclectic paradigm in an age of alliance capitalism" *Journal of International Business Studies* **26** 461 – 491
Dunning J H, 1998, "Location and the multinational enterprise: a neglected factor?" *Journal of International Business Studies* **29** 45 – 66
Eckstut M, 1996, "A strategy for the future" *Europe Chemical News* **65** 21 – 26
EDB, 1995, "Jurong Island: new age infrastructure" *Singapore Investment News* June, http://www.sedb.com.sg/experience/ex_sj1995.cfm
EDB, 1996a *The Chemistry Industry of Singapore* Economic Development Board, 250 North Bridge Road, #24-00 Raffles City Tower, Singapore 179101
EDB, 1996b *Singapore Directory of Chemical Manufacturers and Supporting Services 1996* Economic Development Board, 250 North Bridge Road, #24-00 Raffles City Tower, Singapore 179101
Ellison G, Glaeser E L, 1999, "The geographic concentration of industry: does natural advantage explain agglomeration?" *American Economic Review* **89** 311 – 316
Fast N, 1979 *The Rise and Fall of New Venture Divisions* (UMI Research Press, Ann Arbor, MI)
Gertler M S, 1995, " 'Being there': proximity, organization, and culture in the development and adoption of advanced manufacturing technologies" *Economic Geography* **71** 1 – 26
Gertler M S, 1997, "Between the global and the local: the spatial limits to productive capital", in *Spaces of Globalization: Reasserting the Power of the Local* Ed. K Cox (Guilford Press, New York) pp 45 – 63
Gray H P, 1996, "The eclectic paradigm: the next generation" *Transnational Corporations* **5** 51 – 65
Hartley J F, 1994, Case studies in organizational research", in '*Qualitative Methods in Organizational Research: A Practical Guide* Eds C Cassell, G Symon (Sage, London)
Hirschman A, 1958 *The Strategy of Economic Development* (Yale University Press, New Haven, CT)

Ho K C, 1994, "Industrial restructuring, the Singapore city-state, and the regional division of labour" *Environment and Planning A* **26** 33 – 51
Hodgetts R M, 1999, "Conversation with Michael E Porter: a 'significant extension' toward operational improvement and positioning" *Organizational Dynamics* **28** 24 – 33
Hoskisson R E, Hitt M A, Wan W P, 1999, "Theory and research in strategic management: swings of a pendulum" *Journal of Management* **25** 417 – 456
Hounshell D A, Smith J K Jr, 1988 *Science and Corporate Strategy: DuPont R&D, 1902 – 1980* (Cambridge University Press, Cambridge)
Jick T D, 1983, "Mixing qualitative and quantitative methods: triangulation in action", in *Qualitative Methodology* Ed. J van Maanen (Sage, Newbury Park, CA) pp 135 – 148
Knickerbocker F T, 1973 *Oligopolistic Reaction and Multinational Enterprises* (Harvard Business School, Boston, MA)
Koh W, 1998, "Jurong's chemical reaction" http://www.asiapages.com/direct/text/jurong.htm
Lee S A, 1973 *Industrialization in Singapore* (Longman Cheshire, Melbourne)
Lim C-Y, Lloyd P J (Eds), 1986 *Singapore, Resources and Growth* (Oxford University Press, Singapore)
Lloyd P, Dicken P, 1977 *Location in Space* (Harper and Row, London)
Low L, 1998 *The Political Economy of a City-state: Government-made Singapore* (Oxford University Press, Singapore)
Malmberg A, Maskell P, 1997, "Toward an explanation of regional specialization and industry agglomeration" *European Planning Studies* **5** 25 – 41
Markusen A, 1995, "Growing pains: thoughts on theory, method, and politics for a regional science of the future" *International Regional Science Review* **17** 316 – 326
Marshall C, Rossman G B, 1989 *Designing Qualitative Research* (Sage, Newbury Park, CA)
Martinelli A (Ed.), 1991 *International Markets and Global Firms: A Comparative Study of Organized Business in the Chemical Industry* (Sage, London)
Mascarenhas B, Baveja A, Jamil M, 1998, "Dynamics of core competencies in leading multinational companies" *California Management Review* **40** 117 – 132
Maskell P, Malmberg A, 1999, "Localised learning and industrial competitiveness' *Cambridge Journal of Economics* **23** 167 – 185
Mathews J A, 1999, "A silicon island of the East: creating a semiconductor industry in Singapore" *California Management Review* **41** 55 – 78
Mirza H, 1986 *Multinationals and the Growth of the Singapore Economy* (Croom Helm, London)
MTI, 1986 *The Singapore Economy: New Directions* Ministry of Trade and Industry, Singapore
MTI, 1991 *The Strategic Economic Plan: Towards a Developed Nation* Ministry of Trade and Industry, Singapore
MTI, 1996 *Report on the Census of Industrial Production* Ministry of Trade and Industry, Singapore
Mussati G, Soru A, 1991, "International markets and competitive systems", in *International Markets and Global Firms: A Comparative Study of Organized Business in the Chemical Industry* Ed. A Martinelli (Sage, London) pp 19 – 46
Ng W H, 1997 *Guide to the Petrochemical and Chemical Industry in Singapore 1997* (The Strategist, Singapore)
Nohria N, Ghoshal S, 1997 *The Differential Network* (Jossey-Bass, San Francisco, CA)
OECD, 1997 *Globalisation and Small and Medium Enterprises* (OECD, Paris)
Patel P, 1995, "Localised production of technology for global markets" *Cambridge Journal of Economics* **19** 141 – 153
Patel P, Pavitt K L R, 1991, "Large firms in the production of the world's technology: an important case of 'non-globalisation'" *Journal of International Business Studies* **22** 1 – 21
Perry M, Tan B H, 1998, "Global manufacturing and local linkage in Singapore" *Environment and Planning A* **30** 1603 – 1624
Perry M, Kong L, Yeoh B, 1997 *Singapore: A Developmental City State* (John Wiley, Singapore)
Peteraf M, 1993, "The cornerstones of competitive advantage: a resource-based view" *Strategic Management Journal* **14** 179 – 191
Pettigrew A, 1985 *The Awakening Giant: Continuity and Change in ICI* (Basil Blackwell, Oxford)
Porter M E, 1980 *Competitive Strategy: Techniques for Analyzing Industries and Competitors* (The Free Press, New York)
Porter M E, 1985 *Competitive Advantage: Creating and Sustaining Performance* (The Free Press, New York)
Porter M E, 1990 *The Competitive Advantage of Nations* (The Free Press, New York)
Porter M E, 1998a *On Competition* (Harvard Business School Press, Boston, MA)

Porter M E, 1998b, "Clusters and the new economics of competition" *Harvard Business Review* **76** 77 – 90
Prahalad C K, Hamel G, 1990, "The core competence of the corporation" *Harvard Business Review* **68** 79 – 91
Rangone A, 1999, "Resource-based approach to strategy analysis in small – medium sized enterprises" *Small Business Economics* **12** 233 – 248
Rodan G, 1989 *The Political Economy of Singapore's Industrialization: National State and International Capital* (Macmillan, London)
Royse S, 1996, "Eagle eyes turn focus on Asia" *European Chemical News* **66** 31 – 32
Sang D C, Dong H S, 1995 *Investment Demand of the ASEAN Chemical Industry* (Korea Institute for Industrial Economics and Trade, Seoul)
Schoenberger E, 1991, "The corporate interview as a research method in economic geography" *Professional Geographer* **43** 180 – 189
Schoenberger E, 1997 *The Cultural Crisis of the Firm* (Blackwell, Oxford)
Schmitz H, Nadvi K, 1999, "Clustering and industrialization: an introduction" *World Development* **27** 1503 – 1514
Scott A J, 1998 *Regions and The World Economy: The Coming Shape of Global Production, Competition and Political Order* (Oxford University Press, Oxford)
Storper M, 1997 *The Regional World: Territorial Development in a Global Economy* (Guilford Press, New York)
Taffe P, 1996, "Chasing the tiger" *European Chemical News* **66** 34 – 36
Taylor G D, Sudnik P E, 1984 *Du Pont and the International Chemical Industry* (G K Hall, Boston, MA)
The Business Times 1996, "Eastman Chemical to build US$400M plant on Pulau Sakra" 12 April
The Straits Times 1996a, "US firm to build $282m chemical complex here" 12 April
The Straits Times 1996b, "Catalyst products maker plans $127m investment" 7 August
United Nations, 1998 *International Yearbook of Industrial Statistics* (United Nations Industrial Development Organization, Vienna)
Wernerfelt B, 1984, "A resource-based view of the firm" *Strategic Management Journal* **5** 171 – 180
Willmott A, Phillips S, Watkins D, 1996, "Growth lies in firm focus" *Europe Chemical News* **65** 16 – 18
Wong P K, 1991, "Technology development through subcontracting linkages: lessons from Singapore", in *Enhancing Intra-industry Linkages* (Institute of Strategic and International Studies, Kuala Lumpur) pp 49 – 59
Yeung H W C, 1995, "Qualitative personal interviews in international business research" *International Business Review* **4** 313 – 393
Yeung H W C, 1998a, "Capital, state and space: contesting the borderless world" *Transactions of the Institute of British Geographers, New Series* **23** 291 – 309
Yeung H W C, 1998b, "The political economy of transnational corporations: a study of the regionalisation of Singaporean firms" *Political Geography* **17** 389 – 416
Yeung H W C, Olds K, 1998, "Singapore's global reach: situating the city-state in the global economy" *International Journal of Urban Sciences* **2** 24 – 47
Yin R Y, 1994 *Case Study Research: Design and Methods* (Sage, Newbury Park, CA)
Zander I, 1999, "How do you mean 'global'? An empirical investigation of innovation networks in the multinational corporation" *Research Policy* **28** 195 – 213