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Jayarethanan Sinniah Pillai
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1. Introduction

The internationalisation of services is at the very core of economic globalisation. Service industries provide links between geographically dispersed economic activities and thus play a fundamental role in the growing interdependence of markets and production activities across nations. But under this broad umbrella of internationalisation of services is the idea of technology transfer in services in the form of service exports that has gained recognition among researchers in recent years. This latter point is the underlying theme of this paper. Many services considered non-tradable in the 1980s are now being traded actively, as advances in information technology (IT) expand boundaries of tradability.

For developing countries, especially those in Southeast Asia, the growing internationalisation of services and rapid technological changes in IT present both opportunities and challenges. Access to efficient services matters not only because it creates the potential for new exports (such as technological service exports) but also because it will be an increasingly important determinant of economic productivity and competitiveness. There are opportunities for developing new exports in services and attracting more-services related foreign investment. Technological progress will allow countries to leapfrog stages of development in building their info-infrastructures. This is due to the emergence of digital networks. One challenge facing the developing countries is the design of appropriate regulatory environments for service industries. Other challenges include undertaking necessary investments in modern IT networks and adapting educational systems to the information age.

As highlighted earlier, as technology transfer in services has been present in services exports, this paper provides a detailed case study of technology transfer in services from Singapore. The present paper aims to add new qualitative findings to an earlier paper by Hill and Fong (1991), which provided a penetrating analysis of technology exports from Singapore. Their paper discussed the comparative advantages rapidly developed by Singaporean firms, which enabled them to export their technological expertise in manufacturing. The present paper takes a step further.

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by studying technology transfer in services in the Port of Singapore Authority’s (PSA) port activities.

The qualitative analyses presented in this paper were obtained by way of official interviews conducted at the Port of Singapore Authority. In particular, Mr Subramaniam and Mr Peter Chiew of the International Business Division at PSA and Mr Swapan Das Sharma of Singapore Maritime Academy, form the main sources of views in this paper. Furthermore, a newspaper report (The Straits Times, 2000) and the PSA website (see references for details) provided the required evidences and materials in undertaking this paper.

The paper is arranged as follows: Section 2 overviews the historical development of the Singapore port, leading to the establishment of the Port of Singapore Authority in sub-section 2.1. Section 3 dwells on key definitional aspects of technology transfer and its application to services. Section 4 discusses the core competencies PSA in regard to the ability to export technological services. Section 5 discusses the internationalisation of PSA’s services. Section 6 briefly highlights a key project, among other projects, that has been successful under PSA technology transfer of port services. Section 7 concludes with a key summary of findings and inferences of the paper.

2. Historical Development of PSA

The modern port of Singapore traces its origin to the mouth of the Singapore River and it is here that the port developed and flourished. The Singapore River developed into the main commercial centre with a supplementary trading area for small craft at

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2 Mr MMJ Subramanium – Vice-President (Europe/West Asia), International Business Division, The Port Of Singapore Authority; Location of interview – PSA Building. Date and Time of Interview – 23rd January 2001, at 3 pm. Mr Peter Chew – Regional Manager, International Business Division, The Port Of Singapore Authority; Location of interview – PSA Building. Date and Time of Interview – 19th January 2001, at 2.30 pm. Mr Swapan Das Sarma – Director, Singapore Maritime Academy; Location of interview – At the Singapore Maritime Academy. Date and Time of Interview – 5th January 2001, at 4.00 pm.

the estuary of the Rochor and Kallang Rivers. When Stamford Raffles and his small battalion arrived off Singapore on 28 January 1819 with the intention of establishing a trading station for the British East India Company, one of his earliest tasks was to deploy a survey vessel to conduct a hydrographic survey of the port.

After Raffles established a trading station in Singapore in 1819, East Indiamen and Opium Clippers from India, an assortment of Chinese junks from Fukien, Hainan and Kiangsu, Wangkang and Tope from Thailand and Indo-China, Palari, Golekkan, Lambo and Leteh-ieteh from the Indonesian archipelago, and Tongkang and Pinas from the Malay Peninsula, all came to their respective anchorages off the Singapore River. Their cargoes were then transported by lighters to Boat Quay where the greater part of the business was conducted. Boatyards developed along the Telok Ayer Street waterfront. Commercial Square, now known as Raffles Place, developed as an adjunct to Boat Quay and until the reclamation of Collyer Quay in the 1860s, the buildings and premises reached the waterfront and had their own jetties for passengers and cargoes.

The administration of the Port was vested with the Master Attendant (Harbour Master). Besides laying down the procedures for reporting the arrivals and departures of ships, their passengers and cargoes, the regulations also stipulated the charges for repairing, watering and ballasting ships calling at the port. Provision was also included for a register of cargo vessels. Moreover, records of local shipping in the Master Attendant’s report book show that for the year 1822, 139 square-rigged vessels entered the Port of Singapore. In 1834, 517 square-rigged vessels totalling 156,513 net registered tons (n.r.t) were recorded. The increase of traffic in the Port created a lot of congestion in the Singapore River and the lighterage of cargo became a problem. The situation further worsened in 1845, when the Peninsula and Oriental Steam Navigation Company (P&O) inaugurated its first scheduled steamship service from Europe to the Straits of Malacca through Singapore, as there was no wharfage and coal, which were used for bunkering the steam vessels of that period. They had to be laboriously brought in by sailing lighters, stored along the Singapore River, and then brought out whenever a steamer arrived.

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5 Ibid.
6 Ibid.
Moreover, bad weather conditions held up bunkering operations and inevitably, several hundred tonnes of coals were lost when lighters were swamped by heavy seas. This led to another hydrographic survey done at Keppel Harbour (then known as New Harbour) in 1849 by the P&O Company, and to the opening of their coal-bunkering pier at Tebing Tinggi in 1852. Keppel Harbour, which later became the major gateway of the Port of Singapore, was thus opened. From the onset, ocean shipping favoured the Keppel wharves while coastal shipping continued to anchor off the Singapore River. The outer roads, situated in the extensive bay around which Singapore and to the east of the city, provided ‘a fine tune natural open anchorage suitable for ocean-going vessels of deep draught’.

Here, ships were serviced immediately. Development of Keppel Harbour was rapid, with Jardine Matheson, the Borneo Company and John Purvis and Sons opening up their wharves, warehouses and coal stores along the stretch east of Tanjong Aur (St James). When the Patent Ship and Dock Company opened Singapore’s first dry dock at Pantai Chermin, it was followed by the establishment of the Tanjong Pagar Dock Company in 1863. At Pulau Brani, the firm of Buyers & Robb opened the Bon Accord Dock while the British Navy established a coal depot there. Since its formation, the Tanjong Pagar Dock Company has been operating dry docks and wharves in Keppel Harbour and dominated the operation and shipping business in Singapore. In fact, the company possessed a wharf frontage of about 1¼ miles and warehouses for 200,000 tonnes of cargo and 250,000 tonnes of coals and kits properties, which extended over 375 acres.

With these developments, some 3,000 feet of wharves became available and as a succession of shipping lines inaugurated regular steamship services through the Port of Singapore, the tonnage of shipping rose from 375,000 n.r.t in 1860 to 650,000 n.r.t in 1870. The great impetus to the increase in steamship tonnage was the opening of the Suez Canal in 1869. The supply of raw materials and foodstuffs for industrialisation in Europe and the securing of markets for European goods in Asia greatly expanded Singapore’s early entrepot trade and commercial activities.

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1880, the total tonnage of shipping had risen to 1.5 million n.r.t with steamships aggregating 1.2 million n.r.t. With additional shipping lines like the Straits Steamship Co and East Asiatic Co inaugurating regular services, total shipping tonnage rose to 5.7 million n.r.t in 1900.

Increased shipping activities and the lack of adequate provision of infrastructure and shipping facilities by the Tanjong Pagar Dock Company led to the British government to expropriate the company in 1905 and set up a port trust. From 1913, the trust was known as the Singapore Harbour Board, which was constituted in the Straits Settlements Port Ordinance of 1912. The Board oversaw the construction between 1908-17 of modern port facilities, which made Singapore the ‘Second to none port out East’. By 1917 Singapore had 9,822 feet of wharfage, nearly 8,000 feet of which now offered ships over 30 feet of water. Facilities, such as the entire wharf frontage built originally of wood, were demolished and replaced with concrete structures. In addition, among other facilities, a bonded storage and cold storage were developed. In conjunction with these new facilities, quick dispatch at the wharves was facilitated by an abundant supply of casual labour. Between 1912 and 1920, entrepot trade through Singapore increased tremendously, with more facilities being added to the port, including the discovery of deep and sheltered water.

During the Pacific War (1941-45) about 70 per cent of the warehouses in Keppel Harbour suffered damage from bombing raids and much of the machinery and equipment in the dockyards fell into disrepair. Port waters became encumbered with sunken craft and maintenance of port installations and ancillary facilities came to a standstill. When the Singapore Harbour Board resumed control in 1946, it went about the reconstruction of the port. Once the restoration of the port facilities was complete, passenger and cargo services resumed with the shipping tonnages steadily mounting from 20.4 million n.r.t in 1947 to 82.9 million n.r.t in 1963. This trend of rapid growth continued well into the 1960s, with Singapore exporting the region’s primary commodities and distributing the manufactured goods from Europe and USA.

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13 Ibid.
Singapore became a self-governing state in 1959. The new leaders inaugurated an ambitious policy of intensive and rapid industrialisation to provide badly needed employment and to open up new avenues for economic growth. With its First Development Plan of Singapore for 1961-64, the Singapore government embarked on a policy of industrialisation. The government created a system of incentives to attract foreign and domestic capital into a wide range of new manufacturing enterprises, the development of a whole new infrastructure to support the envisioned industrial expansion, training of unskilled labour force, the development of competent local technical and managerial staff and the urgent awareness of the need to focus on the further development of the Singapore port. The first chairman of the port, Mr Howe Yoon Chong expressed it like this: ‘As Singapore’s industrialisation programme continues to grow, the parallel growth of the port and its services and facilities will continue to involve it as an inseparable partner of the country’s progress’.

Because of increased efforts on improving port activities, some 12,500 acres of swamps and mangrove at Jurong on the Southwest of the island were converted into what has since become a prosperous industrial town. Jurong Port, Singapore’s international gateway for bulk cargo was established to service Jurong Industrial Estate and the nearby shipbuilding and repairing industries. Since then, the number of vessels over 75 n.r.t entering and clearing increased from 10,800 and 34,500 n.r.t respectively in 1960 to 18,400 and 73,000 n.r.t in 1970 and to 24,900 and 155,200 n.r.t in 1980. The most significant port development took place on 23 June 1972, when a container berth was opened at Tanjong Pagar (at the East Lagoon). With that development, Singapore became the first port in Southeast Asia to accommodate a third generation container vessel, making it an important link in the emerging chain of global container ports.

2.1 The Establishment of the Port of Singapore Authority

After World War II, the administration of the port passed gradually to the Singapore government. In 1960 the government undertook a study to consider the restructuring of all port operations including the functions of the Singapore Harbour Board, the Marine Department and the Marine Branch of the Public Works Department. This was to ensure that all the port operations and decision-making came under one authority and to eliminate duplication of activities. The outcome of the study was the establishment of PSA on 1 April 1964 under the Port of Singapore Authority Act 1963. This consolidated single organisation operated as a statutory board under the Ministry of Communications and Information. PSA took over the functions, assets and liabilities of the Singapore Harbour Board, the operation of the pilotage services and the functions previously undertaken by the Marine Department. Its principal activities were to provide and maintain services and facilities in the port, to regulate and control navigation within the limits of the port and its approaches, to provide pilotage services, to provide and maintain adequate, efficient lighthouses and navigational aids in the territorial waters of Singapore and, most importantly, to promote the use, improvement and development of the port.

On 2 February 1996, some of the services of the PSA, the Maritime Department and the National Maritime Board of Singapore were merged to form the Maritime and Port Authority of Singapore (MPA), a statutory board under the Ministry of Communications and Information Technology (MCIT). This change was to create a more dynamic and integrated structure. MPA has full responsibility for the regulation of port and shipping services, while PSA manages and operates the container/cargo terminals and other business and commercial services. The key mission of the MPA is to protect Singapore’s strategic maritime interests and to promote Singapore as a major port and international maritime centre. MPA was formed at a time when all over the world, ports were being corporatised or privatised to give them the necessary flexibility and autonomy to reposition themselves.

The Singapore government corporatised PSA in October 1997. This corporatisation created many commercial incentives, which apply to private firms and increased the separation between Government Linked Companies (GLCs), such as PSA, and the Singapore government. The commercial incentives encompassed administrative reforms aimed at giving public enterprises a more commercial focus.
and reforms to establish a competitive environment. Importantly, the underlying motive was to give PSA greater responsibilities and autonomy over day-to-day decisions on investments, revenue and expenditure and commercial strategy, which previously were in the hands of the Singapore government. Furthermore, this separation ensured a level playing ground so that the GLCs do not have any competitive advantages or disadvantages relative to private organisation operating under similar market risks.

3. **Definitional Aspects in the Transfer of Technology and its Application to Services**

This paper accepts the broad definition of technology highlighted by Hill and Fong (1991), referring to technology as embracing not just production techniques in agricultural or manufacturing sectors, but also new products and a host of service activities associated with the supply of goods to the final consumer. It also accepts their broad definition of ‘technology exports’ as being any international flows of technical know-how, comprising the dissemination of production technology skills, marketing techniques, commercial know-how, product development and managerial capabilities. An important mechanism in these international flows of know-how is the foreign direct investment (FDI), in which the foreign investor introduces a new package of highly productive resources, which in the process generates increased productivity to the new firm. In addition, consulting services, technical agreements, licensing agreements and an array of other commercial relationships are formed by foreign investors to undertake productive activities on foreign soil.

It is important to note here that, the key factors in each of these cases are the international flows of know-how and the dissemination of these techniques within the recipient country. As a result, exporting of machinery or development plans would not be regarded as a service technology export. However, an exporter also sending skilled professionals or consultants to explain the operation of development projects or operational systems would constitute such an export. Thus, the idea of providing technological services for overseas projects or developments, also known as technology

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22 Ibid.
transfer, developed broadly in this section, would be followed closely throughout this paper. Furthermore, the technological services that are analysed as part of PSA’s service exports are the port management and consultancy services, educational and training services, operational headquarters and technical and engineering services. Section 4 provides evidences of foreign port organisations are rapidly keen obtain these services from PSA. Furthermore, Section 4 also provides evidence of overseas port and terminal projects that PSA is currently being involved.

Whilst the technology for producing a particular good or service is embodied in physical capital, it is also embodied in humans, who are needed to operate, maintain and adapt/develop physical capital (see figure 1 below). In addition, to run an enterprise (such as a maritime organisation) there is a need for managerial and marketing technologies, in the form of service expertise. Within the contexts of the MNCs, technology is that applied knowledge or expertise that is embodied in the capital equipments or organisations and personnel of the firm and may be stored in such media as operational manual, books and tapes.

Furthermore, technology can be divided into technical know-how and managerial know-how. Technical know-how refers to the type of technology that involves scientific and engineering skills and knowledge, which is normally required, though not necessarily, connected with specific industrial, production processes and service activities. Managerial know-how refers to the type of service technology that accrues to management and its organisational system or to the managerial process, whether this is pertaining to the general control and appropriation of resources, such as including technical know-how within the organisation or to a particular industrial process or a specific organisational function.23

Both types of know-how consist of two components, namely technical skills and technical culture. Technical skills refer to that part of the technical know-how that is embodied in people, normally in technicians and engineers. Managerial skills refer to that part of managerial expertise normally embodied in managers and other corporate executives. Technical culture, on the other hand, refers to the socio-cultural environment, which is peculiar to the organisation in which the technical skills are effectively employed. It must be made clear that the service technology expertise of PSA discussed in this paper refer to the technical and managerial skills and are often

23 Ibid., pp. 5-9.
organisation or process specific (in reference to managing port operations), which means that corporate skills are often specific to each individual corporation.

In specifying that skills are often specific to each individual corporation, the differentiation of know-how into two components of skills and culture is in accordance with their different embodiments. Skills are embodied in people even as culture is embodied in organisations and society (society groups and their artefacts).24 In this way the transfer of technology, an intangible resource can be observed in the transfer of personnel and organisations, including machines and other capital equipments, which embody technology. Although technology can be stored as knowledge in media materials as books, manuals, tapes and films, which are readily transferable from place to place, such knowledge cannot be readily applied. This is because they have to be retrieved and understood by workers and their organisations.25 Figure 1 attempts to visualise these concepts in a simple flow form.

Seen from the above perspective of the schema, service technology transfer is affected not only by the acquisition of machines used in providing services. What is important is the knowledge gained by the transferees when working on, maintaining, adapting and developing the machines, as well as from the overall technology. The level of technology used measures the extent of technology transfer in relation to the schema, achieved by an enterprise absorbing the foreign technology, firstly. Secondly, the extent of its indigenous capability – that is, transference to locals – in terms of operation, maintenance, adaptation and development, which includes management and marketing expertise and control. And thirdly, to the diffusion of such know-how to backward and forward linked enterprises, is a key to further success of the new technology.26 Furthermore, there are essentially three components of technology that are transferred, as implied in Figure 1. The first component refers to the technology embodied in physical assets, such as plant, machinery, equipment and intermediate products. The second component is the information, both technical and commercial, relating to such matters as process know-how, choice of technologies, engineering

24 It is important to note that every organisation of human group has its own sub-culture, which is unique to itself, even though sub-cultures are normally consistent with the culture of the larger society.
25 In other words, technological knowledge is different from technology.
design and plant construction, organisation and operation methods, quality control and market characteristics. Such information may be subject to proprietary rights or are freely available. The third component is the human skills, especially in the form of specialised professionals and engineers.

Although the above three components are all crucial for a successful technology transfer, service firms transferring these components critically focus on the third component – as it is from human beings – that all knowledge is generated and ultimately resides. And it is one of the key components that form the basis of technology transfer in services. This is because embodied physical capital can always be imparted but it is more difficult to impart human capital.

During the execution of any form of service activity, MNCs or small and medium enterprises (SMEs) have to transfer their knowledge to their clients (host country administrators or officials). Technology transfer is the assignment of a given technology (either protected through patents or licensing) from one economic agent to another. Mytelka (1979), among others, has insisted that for a technology to be effectively transferred the imported technology has to be effectively assimilated and mastered by the transferee. In services transfer, especially, effective assimilation and the understanding means that the transferee is able to independently conduct the service activity, such as plant operation and administration, survey, design, supervision or procurement, that the transferee was supposed to have learned from the transferor.

There are several levels of technology transfer in general. The first level refers to the transfer of the capacity to operate and administer any kind of embodied technology. The second level refers to the capability to invest in new productive facilities. The third level refers to the capability to improve processes and products. Whilst each of the above-mentioned levels requires different – and increasing – levels of skills within the transferee, the second level is probably most specific to PSA. That is, PSA transfers a whole set of capabilities that permits the transferees to conduct investment projects, create new production facilities and undertake efficient administrative and management processes.

Whilst considering the basics of technology transfer, it is also very important to note that appropriate service technology is transferred. When transferring appropriate

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service technology, foreign organisations have to realise that different forms of service technology exports may require different types and levels of technological learning. Such forms of transfer and learning are attributable to the idea of ‘revealed comparative advantage’ that was identified by empirical studies on Asian developing countries done by various academics.\(^{28}\) Based on the revealed comparative advantage concept, these studies have shown that foreign direct investment (FDI) by domestic enterprises is one way for Asian developing countries to export their industrial (and recently their service) technology. For an economy with no local capital-goods production in the relevant activity, technology exports may be based upon elementary learning which gives the capability to put together and efficiently (and cheaply) manage, a package based on imported capital goods and consultancy services.

Such exports will take the form of FDI for the production of standardised consumer goods or services and mature intermediate goods. In exceptional cases, however, they may also take the form of consultancy services in a particular activity based on long term experience of a given industry (for example, port management expertise of Singapore). For an economy which possesses a capital-goods base in the sector concerned, service technology exports may require elementary learning by the exporting enterprise where it is, again by FDI, producing standardised consumer or intermediate goods or services. However, host economies may require intermediate and advanced learning where service exports take the form of FDI for the production of capital goods, or of turnkey projects, consultancy and other services for the setting up and running, of diverse or complex production and service systems. Furthermore, the success of service technology exports will depend not only on technological learning, but also on the success of the enterprise in correctly organising its internal structure and coupling research, managerial, financial and marketing activities.

4. **Core competencies of PSA in regard to the ability to export technological services.**

This exploratory study of the Port of Singapore Authority (PSA) examines the wide range of engineering, consultancy, management and information technology (IT) services

ported by that organisation. It elaborates how PSA has been able to build expertise before starting to export its technological services through technology transfer.

The services provided by PSA play a complex role in the processes of change and growth at all stages of the development of port and container terminals in which the company has been involved. The company is not just a link in the process of innovative port and container terminal development but a part of the process of bringing together the ideas and skills, the available technologies and the needs and requirements of foreign port authorities. Engineering and technical services, management consultancy and construction (the supervision process) and information technology services are the core competencies that are discussed. These core competencies refer to, firstly, the provision of design services for the construction of port and container terminals. Secondly, they refer to the inspection and technical supervision of the physical construction of the deep-water harbour and container terminals, including the implications of environmental considerations. Thirdly, they refer to the installation and further enhancement of port and container technologies and the marketing of foreign ports through PSA’s international reputation and organisational connections. Finally, they refer to the testing, improvement and modification of port capacity, in terms of storage space, cargo loading and unloading capabilities (cargo handling technology), hydrography and other day-to-day administrative issues.29

Most of the port services provided by PSA are related to information technology or computerisation. This refers to the transfer of complete systems of software and training to overseas ports and container terminals. While the above-mentioned service activities form PSA’s main core services, the company exports other branches of engineering and technical services. This involves feasibility studies, the conception, design and continual development of the processes of foreign port and container terminals to enable host country ports to capture maritime market opportunities and optimise the use of host country maritime resources. These services are required for the development of the port and container terminals from the beginning and not purely for further technology or engineering enhancements of the existing port and container terminals.

29 Refers to the scientific study of seas, lakes, and rivers, especially the charting of tides and changes in coastal bathymetry measurement of water depth.
According to information obtained from interviews conducted in Singapore, respondents sighted that PSA plans, designs, constructs and installs advanced operating systems in port and container terminal projects. In addition, it undertakes concerted efforts to assimilate overseas or diffuse service technology knowledge and expertise to foreign port officials and employees. Foreign port authorities in most cases undertake the actual construction and part of the contract is for PSA to manage the foreign port and container terminals.\(^\text{30}\) In doing so, foreign port officials, professionals and technicians are able to learn the skills, methods or procedures to run a port effectively and efficiently, with both PSA and foreign port professionals designing and implementing continuous improvements in port operations management. In its advanced technology transfer activities, PSA infuses new knowledge into the maritime organizations of host countries that enables them to independently design, construct and manage future innovative port and container projects.\(^\text{31}\)

The essence of PSA’s service technology is its ability to manage complex port and container development, to provide services of consistent high quality and to do this on time and within budget, according to the joint venture agreements. The type and scope of service technology transfer in the course of PSA’s overseas projects depend on several interrelated factors: the service technology transfer objectives and plans of the client; the education and experience level of the recipient; the nature of the project and PSA’s role in project execution; the duration of the project; and the complexity of the port and container technology involved. In addition, the long-term utility of the transfer experience for the port clients depends on the attitude and motivation of the recipient during the transfer or learning process and the opportunity of the clients to utilise on a continuing basis the knowledge gained via port service transfer.

According to responses of officials at PSA, it is found that the most effective way to transfer services knowledge and enhance the ability of port administrators or officials and employees is through on-the-job training supplemented by specifically designed port operational and instructional programs. Furthermore, to accomplish advanced technology transfers, such as the installation of artificial

\(^\text{30}\) However, there are a few projects where PSA is involved in the actual construction of the deep-water container terminals, see Table 5.

\(^\text{31}\) Denotes the transfer of technology and practical expertise and importantly, the transfer of an understanding of the thought processes that go into the technical and commercial decision-making are carefully implemented.
intelligence systems and IT systems, integrated PSA-client project teams are used to carry out work assignments. The main aim of having such teams is to maximise knowledge transfer and to gradually transfer the leadership role in the port and container project from PSA to the client as PSA moves to an advisory or consultancy role. In the service knowledge transfer in a container terminal project, PSA has found the following elements important for a successful service technology transfer: the use of a project management team that involves to the maximum extent existing technical and port management resources of host nations; carefully planned and designed programs for services transfer; and the involvement of PSA’s IT, logistics and management consultants in technological engineering over the period of the venture agreement.

Disciplined work habits, intermediate port and container operational skills, such as the operation of third generation container cranes, planning skills and practical port management experience are among the by-products of PSA’s overseas port and container assignments. Moreover, advanced technological service transfer programs enhance the development of technological self-sufficiency and sophisticated professional skills within the foreign port organisation. It is for the latter type of contribution to technological expertise that PSA is approached by foreign port or maritime organisations.

PSA undertakes its overseas projects through two main subsidiaries. Under the International Business Division it operates Port and Maritime Services (Pte) Ltd, a wholly owned subsidiary, which provides expert and technological services to overseas ports. Set up in 1972, this company undertook the operations of tugboats, ferries, slop collection, garbage collection and repairs and maintenance of crafts. Later it expanded its role to provide comprehensive port, marine and computer-related consultancy services both in Singapore and overseas. In 1986, the company was renamed as PAM Services Pte Ltd. Similarly, Singapore Engineering and Consultancy Services (Pte) Ltd (SPECS) is another PSA company working in regional consultancy work. Set up in 1978, it specialises in providing port engineering consultancy services in Singapore and overseas. It was renamed in 1990 as SPECS Consultants Pte Ltd. The company today continues to share its expertise in port engineering design and the construction and maintenance of port

32 Artificial intelligence refers to a branch of computer science devoted to the development of computer programs that will allow machines to perform functions normally requiring human intelligence.

33 Logistics refers to the planning and control of the flow of goods and materials through an organisation or manufacturing or service process.
facilities with its international clientele, such as from China and Yemen. Through both these organisations, PSA aims to be a major global logistics owner-operator of port and container terminals and supporting logistics businesses with the aim of maintaining long-term growth, in terms of larger profits and increased overseas projects. PSA uses both subsidiaries to provide port and container services overseas because PSA requires vast amounts of resources to maintain overseas operations and PSA alone is not able to look after all the operations overseas and within Singapore. As a result, PSA has created these subsidiaries to look after the operations overseas, while it retains full control on decision-making.

In the course of project design, engineering and the actual construction, apart from hardware technology transfer, significant service technologies are transferred by PSA. These range from basic craft skills to sophisticated engineering, management and information technology services. In an advanced transfer of service technology, subsidiaries infuse new knowledge into host country organisations, which enables them to eventually design, construct and manage the running of the port and terminal projects independently. In effect, PSA transfers its skills to clients so that, in time, they can carry out the type of work that PSA does within Singapore.

4.1. Service Technologies Involved in PSA’s Engineering, Consulting and Management Services Exports

The service technologies employed by PSA span a broad range of professional engineering, information technology, consultancy, management and training disciplines. The professionalism of PSA’s staff can be seen from their profiles, which range from graduates to researchers and even academic advisors. Some have previously been involved in the government’s overseas industrial projects, such as the Batam Industrial Park, the Vietnam-Singapore Industrial Park and the Wuxi-Singapore Industrial Park. From an organisational perspective, service technology is the know-how or tacit knowledge that permits the application of technological findings to the creation of practical facility or the performance of a specific task through planning, engineering, information

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34 Advanced technology transfer refers to projects that require sufficiently long duration, especially when the engineering and construction elements of the job are likely to be repeated over time. Furthermore, it also refers to the transfer of technological, practical expertise and importantly, the transfer of an understanding of the thought processes that go into the technical and commercial decision-making.
technology and management. PSA’s ability to manage complex projects to produce results of high quality, efficiency and reliability, on time and within budget and PSA’s ability to arbitrage on the inefficiencies of other regional ports, has led to PSA offering its expertise in the transfer of service technology in its overseas port business.35

The development of a port and container terminal is an important example of a complex technical project carried out by PSA overseas. The time required from pre-project studies, to engineering and information technology designs, to the construction and the actual start-up of a port and container terminal can vary from 4-8 years, depending on where the port is located and on the regulatory conditions. From an operational and project management point of view, such a project represents hundreds of person-hours of consultation involving a design and management team of 100 to 150 professionals to prepare and study several port and container designs and specifications. The project is managed by a project management group, which involves PSA personnel and the host country port officials and administrators. Personnel from PSA’s the Strategic Business group, the International Business division and the Logistics division are represented.

Importantly, PSA’s ability to manage port projects on time and within budget is a technological and administrative feat.36 Foreign port authorities see this as a benefit in concluding agreements with the PSA. This is especially true for an international project, where, in addition to a PSA task group office in Singapore, there is a project coordination office in the host nation. Management skills and project control systems, on the part of PSA, are of a high order required to ensure the necessary planning, communication, coordination and control for a successful project. PSA’s know-how, accumulated since the 1970s through the development of the Port of Singapore, ranges from information technologies, design, planning and decision making on complex port projects. An example is the Pasir Panjang Container Terminal within Singapore, which involved solving engineering problems or scheduling multiple interrelated logistic activities.37 This port management knowledge is one of the competencies for which PSA’s services are engaged.

What follows are some of the core competencies that PSA is able to offer and other foreign port operators, such as Hutchinson-Whampao of Hong Kong, are

35 Interview with Mr Peter Chew of the International Business Division (PSA), 19 January 2001.
36 Ibid.
37 Multiple interrelated activities refers to the value added services such as distribution, product configuration, inventory management, supply chain etc.
trying to emulate. The demand for PSA’s services can further be analysed by studying the three main initiatives that PSA undertook to improve economic competitiveness and port efficiency during the development of the Port of Singapore. They are containerisation, computerisation and skills development. In each of these areas, PSA shows a competitive factor that other overseas port operators lack.\(^{38}\)

4.1.1. Containerisation

The achievements of PSA can be seen from the achievement of the domestic ports and container terminals. In 1999, PSA operated five port and container terminals in Singapore with a total wharf length of about 30 km. It has continually upgraded its port facilities ahead of demand. PSA sustains its competitive edge by planning investments in new port service, including freight futures, ship management and ship brokering.\(^ {39}\)

In 1966, PSA decided to construct a container complex within Singapore. At the time, the technique of handling cargo with containers and container ships was still relatively new and few ports had such facilities. Japan was the only country in Asia to have container ports. But, in hindsight, containerisation has been a worthwhile risk for PSA. From 14,000 twenty-foot equivalent units (TEUs) in 1972, when the first three container berths were opened at Tanjong Pagar Terminal, the volume of container traffic passed the one million mark by 1982.\(^ {40}\) The Brani Container Terminal began operating in December 1991 and is linked to the main port area by a four-lane causeway across the Keppel Channel. In 1996, the eighteen main berths and twelve feeder berths handled 13 million TEUs of cargo.\(^ {41}\)

The main share of the container business for Singapore is transhipment.\(^ {42}\) A ship unloads containers that are stored in the port until they are loaded on to another ship for a different destination. While the containers are in storage, they are the sole

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\(^{39}\) Refers to commodities or other financial products bought or sold at an agreed price for delivery at a specified future date, in relation to shipping industries.


\(^{41}\) *Ibid.*

\(^{42}\) The transfer of containers or bulk cargo from one vessel or vehicle to another.
responsibility of PSA. Thus, it is in the interest of the port to minimise the waiting and processing time of vessels whose fixed costs are high. The longer the waiting time, the less satisfied customers would be. PSA competes under these strained conditions by using information technology to support its operations (see below for examples).

One of the main reasons for the growing demand from overseas ports for PSA’s services is its ability to plan, develop and manage container terminals not only domestically but also overseas. A brief discussion of Pasir Panjang Terminal demonstrates the types of specialist container services that PSA supplies.

Pasir Panjang Terminal (PPT), in operation since 1993, is Singapore’s most advanced container terminal. It is the most advanced terminal in the world when compared with the best container terminals elsewhere such as the Port of Rotterdam in the Netherlands. Its quay cranes can handle the largest containerships, its towering bridge cranes are used for yard operations and PPT uses a paperless ‘Flow-Through’ Container Gate System. Such aspects make PPT an innovative, new-generation terminal. For instance, the award winning ‘Flow-Through’ Container Gate System reduced the processing time of container trucks from five minutes in 1988 to twenty-five seconds in 1999. The system is developed to achieve high levels of productivity and service for PSA’s customers. PPT was constructed with extensive input from its customers and from Singapore’s existing terminal officials. PPT also runs the world’s first remotely controlled bridge cranes, using artificial intelligence. This section in turn will now discuss the different types of specialist containerisation services that PSA offers to host nations, which have been developed and tested in Singapore.

In 1999, PSA introduced its PortCare Services, which consists of ReeferCare, ChemCare, BoxCare and ProCare. Through PortCare, PSA is able to improve the reliability of the shipment of its customers’ highly-perishable reefer cargo, manage their equipment professionally, handle their out-of-gauge cargo, such as lifts, escalators and helicopters, without problems, as well as ensure the safe and careful handling of their hazardous goods. With these specialised services, customers are reassured that their

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43 In 1999, PSA’s ‘Flow-Through’ Container Gate System was conferred an Innovation Award at the 11th UK Sea Trade Awards for its contributions to the port’s excellence.
46 Reefer refers to refrigerated transport vehicle, a refrigerated railway wagon or truck trailer.
cargo and equipment are well taken care of and will reach their markets in excellent condition and on time. This is made possible through two key factors: the proficient knowledge of handling such containers, and leveraging the indigenous advanced technologies and expertise PSA has developed since the 1970s.

PSA is the world specialist in the transhipment of reefer containers. It operates the world’s largest reefer port, handling some 800,000 reefer units annually. For instance, there are more than 4,000 reefer power points located across Singapore’s four terminals, capable of handling the entire reefer cargo. What makes PSA unique in the area of reefer care technology compared to its competitors such as Hutchinson-Whampao of Hong Kong is its computerised Reefer Monitoring System, which is designed to maintain pre-set temperatures at all times. This system allows its customers to monitor the temperature of the reefers 24 hours a day in the comfort of their offices, both in Singapore and overseas.

The uniqueness of PSA’s expertise in reefer technology can be highlighted from Australian shippers, who reaffirmed the value of transhipping via PSA. According to Australian Diary Corporation’s (ADC) Shipping Manager Sue Perry, the increasing sophistication and reliability of international relay port operators, such as PSA, have given ADC the confidence to use relay services for its sensitive time-critical cargo. Perry said, ‘PSA’s sophisticated IT system makes relaying a seamless process. They maintain constant communication with the shipping lines via the internet, providing ADC with real time access to their container whereabouts and temperature monitoring of all their containers.’ Direct shipping services were the traditional way of shipping reefers. However, PSA has developed integrated services which provide fast transit times, high productivity and the reliability ADC needs to be confident that its reefer cargo arrives safely and on time in overseas markets.

With ChemCare, PSA facilitates the movement of dangerous goods by offering operational support and technical advice to help its customers meet the required safety standards in Singapore and overseas. Pre-shipment inspections are conducted to ensure that goods are intact and properly labelled before they are shipped out, saving time and

48 Ibid.
50 Ibid.
51 Ibid.
effort in the crucial approval process. PSA’s emergency response team (both locally and overseas) is on call 24 hours a day to ensure the safety of its customers’ cargo within the terminals and on public roads. Furthermore, PSA goes a long way to assist its customers through other services, such as the reworking of damaged or leaky containers, safety assessment and certification, as well as the obtaining of safety clearance from the relevant government authorities.

BoxCare builds on the synergies reaped from PSA’s five port and container terminals to offer round-the-clock on-dock empty container depot facilities to its customers. The comprehensive range of services provided under BoxCare includes the checking, repairing, washing, painting and preparation of boxes for shipment. BoxCare handles more than 70,000 empty boxes annually. On the other hand, under ProCare PSA recognises that not all the cargo of its customers fits into standard 20 foot or 40 foot containers. For example, there are out-of-gauge cargo such as tractors, heavy machinery, helicopters, escalators and trains that cannot be containerised. Through its port experience, PSA has mastered the ability of handling such unconventional cargo carefully and efficiently. PSA is able to handle such out-of-gauge cargo in a seamless operation without any loss to vessel productivity, although problems did arise in the early parts of its implementation in terms of the lack of understanding how the system operated and how to handle such unconventional cargoes. However, it is a value-added service that few other ports are able to match. As a result, it attracts further demand for PSA’s services overseas.

4.1.2. Computerisation

Singapore’s major competitors in the region are the ports of the newly industrialising countries nearby, including Malaysia, Indonesia, Hong Kong, China and Taiwan. Although Singapore’s shipping and cargo handling business is growing, the country’s limited land area is a constraint on its ability to expand its port facilities to meet the growing demand of the region. In order to stay competitive and preserve or increase market share, PSA’s managers have devised ways to provide higher quality services at prices competitive with regional competitors, especially in Malaysia and Indonesia, where the cost of labour is much lower and the availability of land is much greater. Furthermore,

52 Ibid, p. 25.
since most of the shipments are in transit to some other port, there is a need to shorten port stays, reduce port charges and assure the safety of cargo in transit in order to attract more customers into the port. For those ships intending to use the port, sufficient information is gathered to coordinate the planning for their berthing and loading or unloading of containers and keep track of marine and water space resource utilisation. Close monitoring is necessary to eliminate unnecessary waiting time for berths and pilots at the boarding grounds.53

As a result, technology and automation have been regarded by PSA port managers and administrators as being critical for increasing operational efficiency and reducing costs. Starting with computerisation of basic issues such as payroll and billing, PSA built up in-house software development capability, which it later put to good use in developing efficient port and container systems, such as the computer integrated terminal operations system (CITOS) and computer integrated marine operations system (CIMOS). It started computerising its operations in the late 1960s. The first online information system for handling containers became operational in 1973. This sped up the process of locating containers and reduced the waiting time for port users to take delivery of their goods. To exploit the potential of IT for port operations and management, PSA identified and classified its activities according to cargo handling, marine operations, and distribution and warehousing. Within each group, a command system, a database that controls port activities by transmitting information to it, integrates the various related activities.

This command system, known as a Databox, was implemented in 1984 to link port users on-line to the port computer systems. This system was upgraded to the PortNet system (using a PC and a modem) in 1989. It was the world’s first electronic data interchange (EDI) system to be implemented on a national scale to link all parties involved in international trade.54 PortNet is a 24-hour real-time electronic link, which provided real-time port operations information, such as berthing schedules and status of containers, to shipping lines and agents. Due to increased improvements in information technology, additional information services, such as arrivals, departures, ships in port and databases were added later. It was further upgraded to allow government agencies such as the Singapore Trade Development Board and the Singapore Economic Development Board,

to interchange trade information and documents, submit declarations, plans and manifests electronically in order to expedite the approval of imports or exports, port operations, cargo clearance and statistics compilations.55

PortNet allows shipping companies and freight forwarders, to plan tight schedules and monitor their cargo. Since the introduction of PortNet, PSA has also established computer-to-computer links with major shipping lines (e.g. Maersk and NOL) and major container ports of the world. By establishing such electronic links with other ports, PSA is establishing itself as a teleport of the region. Being a teleport means that PSA together with the National Computer Board of Singapore, developed the capability to access third party databases, create electronic notice boards, and to track vessels via satellite. Overall, the benefits of PortNet included savings on hardcopy documents and telex transmission costs, fast turnaround of documentation, fewer errors with data captured at source without going through various levels of transcription.

The transformation of Singapore port into a ‘techno-port’ (short for technological port) has since gained further impetus. In order to handle all the services at the port 24 hours per day throughout the year, more than 300 computer applications are in use since PortNet was upgraded in 1990, in all facets of the PSA’s administration, planning and operations work. These operations are organised according to business areas and most of them are integrated in a port-wide communication system. Initially, during the upgrading stages, the upgrading was time consuming and costly. This was due to the retraining of existing staff. They were sent to computer appreciation courses in order to upgrade their computer programming skills. The Maritime Port Academy trained this staff on different information systems. Thus it created some degree of disruption in the terminal operations at PSA. Once that stage was passed, it rapidly aided productivity and efficiency to PSA’s daily activities.56

There are two main applications of computer systems. CITOS (Computer Integrated Terminal Operations System) is a system that supports the planning, command, control and execution of all container-handling operations. This system includes four expert systems designed for the planning of container operations of a

55 Ibid, p. 1791.

56 Interview with Mr Peter Chew of the International Business Division (PSA), 19 January 2001.
ship as soon as it enters the Singapore port. CIMOS (Computer Integrated Marine Operations System) manages the marine operations within the port waters. Within CIMOS, there are five knowledge-based expert planning systems to assist in resource planning for the port, coordinated by a supervisory module. These two IT applications have further enhanced PSA’s competitive advantage in areas such as allowing online transaction processing, improving container handling productivity, efficient use of scarce yard terminal resources and space, real time tracking of vessels and resources, active management of vessel movements, expert systems of resource allocation and deployment and integrated graphic displays of all information necessary for command and control. The next sub-section relates some of the key systems that PSA introduced in overseas port and container projects.

Sections 4.1.2.1 to 4.1.2.7 discuss the Container Integrated Command Systems (CICS), which were introduced in 1990 to improve port efficiency and marine traffic management. The objective of CICS is to enhance navigational safety, optimise marine services, monitor marine traffic in port waters and provide up-to-date information in port traffic. Other port operators, such as Hutchinson-Whampao of Hong Kong, have introduced such systems, but PSA has in the meantime further developed and enhanced the operation of the system through trial error, with the aim of achieving greater efficiency and productivity. As a result, the foreign port operators listed those indicated in Table 4, have sought to obtain CICS-related knowledge and skills from PSA.

4.1.2.1. Vessel Traffic Information System 1& 2 (VTIS 1 & 2)\(^{57}\)

The VTIS 1 system provides traffic surveillance of the Singapore Straits and port approaches using a computer-aided tracking system that uses five remote radars. Vessel movements monitored by these radars are relayed back to the control centre. The information is then combined and presented as high-resolution coloured graphic displays to give an overview of traffic in the Singapore Straits. This information is stored in a database.

VTIS 2 is similar to VTIS 1. It uses four radars for planning of the deployment of pilots, tugs, launches and the assignment of anchorage space. On the other hand, the VTIS 2 system has in-built information systems known as the Anchorage Usage System (AUS) and the Channel Utilisation System (CUS) for up-to-date planning of anchor slots for other vessels in order to minimise disruption to berthing/un-berthing schedules. The CUS and AUS are additions to the CICS that are much needed by overseas ports, which have busy waterways.

4.1.2.2. Marine Radio Data Terminal System (MRDTS)

The mobile Marine Radio Data Terminal System fitted on PSA vessels allows operational data to be transmitted by wireless telecommunication to the central database and back at split-second intervals. The MRDTS can be installed on tugs and launches, or carried by PSA pilots. This form of wireless transmission is able to provide real-time operations information to terminal staff at the port.

4.1.2.3. The Berth Allocation Expert System

Under this system, an exact wharf mark is assigned to each vessel for a specific duration. Support resources such as quay cranes are also allocated to the berth depending on the requirements of the vessels. Such allocation is very complex due to the presence of several terminals, the large number of vessels served daily (approximately 40-45 container ships), the priority given to some vessels, the possibility of bad weather and the limited amount of support resources. In addition, berth allocation plans have to be changed constantly due to early or late arrivals. Consequently, the allocation is subject to many constraints, is dynamic and must be done in real time.

The objective of the expert system is to increase the productivity of the allocators by giving them a tool to expedite allocation decisions or even completely

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59 Real time refers to the time in which certain computer systems process and update data as soon as it is received from an external source. The time available to receive the data, process it, and respond to the external process is dictated by the time constraints imposed by the process.
automate them. In terms of improving productivity, the system takes account of the number of vessels waiting to berth. It uses a sophisticated graphical user interface that allows the allocators to drag and drop scaled vessel icons to try to find the optimal berth utilisation solution for the given situation. These expert systems are based on heuristics, a method of solving a problem for which no formula exists, based on informal methods or experience. They employ a form of trial and error (iteration), which determines how to relax some constraints involved in the process, such as the shifting of alongside vessels.

4.1.2.4. The Stowage Planning Expert System

The stowage planning expert system is a series of complex planning activities performed for each container vessel, such as the unloading and loading sequence of containers, slotting in of containers inside vessels and working sequence of the cranes. These planning decisions are complicated because the containers loaded onto one vessel may go to several destinations. They therefore need to be stored in such a way that it will be easy to retrieve them in the next port of call. In addition, the hydrostatic stability of the ship is important for safety reasons. Finally, the whereabouts of the containers in the yard is important since the objective is to minimise material handling.

Sets of integrated expert systems are used to support stowage planning. The first system calculates the best sequence of loading and unloading of containers for each crane; that is, which container will be loaded or unloaded first, second, etc. The objective is to minimise container handling both in the yard and on the quay. The second system is used to determine the exact bay in the ship that each container will be placed in. As in the case of berth allocation, there is an option in the expert system

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62 Hydrostatic stability is the weight ratio between the container load and the container vessel matched against the ocean tide effect.

for a completely automatic plan that can be fine-tuned by the planner, or the system can be used in a semi-automatic mode to increase the productivity of the planners. The system displays an electronic bay plan of the ship. It uses a dual graphic display of the Stowage Planning Expert System to facilitate comprehensive planning. Concomitantly, PSA’s research and development section has developed an innovative way to implement the latter system in the overseas projects, by way of using a generic algorithm. There is also an ability to handle exceptions by using an expert system based on case-based reasoning.

4.1.2.5. The Yard Planning Expert System (YPS)

A variant of the Stowage Planning Expert System is the Yard Planning System that now supports yard planning, which used to be done manually. It involves more than just stacking containers in the yard. From designating specific yard space to specific vessels to assigning slots for containers, the YPS sorts containers in a manner that supports rapid vessel turnaround. It also optimises the use of space and maintains control of orderly yard activities. The YPS automatically integrates and matches the necessary information. Planning is done in real time and quickly. The tedious planning steps have been streamlined. All this results in better utilisation of yard space, ensuring that containers are easily accessible to avoid unproductive shuffling. This expedites the loading time of vessels since the containers are always there when needed (just-in-time) and errors are minimised. PSA has developed a supporting system to promptly respond to real-time changes in berthing plans, yard activities and planning inputs, which is incorporated in overseas port and container development projects.

4.1.2.6. The Resource Allocation System (RAS)

The RAS is a workstation-based expert system used for the deployment of all operations staff and container handling equipment (except quay cranes) in the

\[64\text{ Ibid.}\]
\[65\text{ Ibid, p. 150.}\]
\[66\text{ Ibid.}\]
container port. To achieve the shortest ship turnaround time, resources regarding quay crane equipments are supplied to match operational demands generated by the RAS. The system includes a graphical work tool for users to deploy resources. It produces a deployment plan for operations to be executed. Changes in the resource requirements for quay crane equipment are detected instantaneously and adjusted accordingly in the deployment plan during the deployment process. The accuracy of planning is improved by providing necessary and up-to-date information measuring equipment and manpower utilization. Details are provided to users to allow them to fine-tune their deployment strategies.

The above deployment plan is disseminated via a sub-system called Automated Deployment Dissemination System (ADDS) which allows the operations staff to obtain deployment details by using their pass smart card on a self-service machine. This ensures that staff receives up-to-date deployment information. The ADDS has been upgraded and made more intelligent by establishing linkages to the equipment maintenance system in order to be able to retrieve up-to-date equipment status and to the Yard Activity Forecasting module to automatically derive requirements. The Yard Activity Forecasting Module is also used to compute the amount of resources, such as quay and buoys, that need to be allocated. Information is passed on to the suppliers of contract workers to deploy their manpower to PSA equipment.

4.1.2.7. The Gate Automation System (GAS) and Container Number Recognition System (CNRS)

The GAS shortens the gate processing time of trucks to assure a more reliable and better service to port users. While there tend to be inherent problems in the GAS in terms of sudden power surges or mechanical faults etc, it does provide paperless and speedy gate access for hauliers and freight forwarders. GAS registers the container arrival at the gate, records its weight and either assigns a location or directs delivery of containers, all within 45 seconds. The CNRS is part of the GAS and its objective is to read the characters (only four letters and seven digits) painted on the container.

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Due to the deterioration of the paintwork on the container, a neural network technology is used. Here, a set of video cameras is employed, each camera is focused on a specific area of the container where the numbers should be. The cameras are connected to a personal computer, which grabs the pictures from the cameras and digitises them. This allows the neural network software to attempt to recognise each character with precision, against previously declared numbers. In this way, proper records are kept on incoming and outgoing container trucks. Cameras fitted on quay crane are also used to recognise the containers, which are hoisted up or lowered down from each vessel. Both these systems save time and increase the quality of the services provided by the Singapore port. This can be evident from the hauliers that drive through PSA’s container terminal gates in 25 seconds, a vast improvement over 1988’s average processing time of 5 minutes.\textsuperscript{69}

The above-mentioned key management and information systems are employed by PSA in Singapore. Even though all the IT systems can have inherent problems such as computer bugs which create stoppages, these systems have generally improved port operations immensely for PSA.\textsuperscript{70} These systems are in principle available to overseas projects in which PSA is involved. PSA’s main services at overseas projects have been related to port operations and management, port computerisation and information technology, construction, hydrographic and navigational aid services, geo-technic and hydraulic services, technical feasibility studies, architectural designs, civil and structural engineering, quantity surveying, container terminal development, ship repair, procurement and marketing. Due to the scarce first hand information on all of these stated services in each of the foreign projects, it may be best to enhance understanding of the nature of PSA’s overseas port and container work by reviewing some basic steps.

First of all, pre-project studies or pre-feasibility studies are undertaken for preliminary technical and economic evaluations, human resource evaluations, country sectorial analyses, port layout, supporting port industries, port employment, transhipment activities, assessing and/ or anticipating market trends and opportunities. These studies are done together with foreign port officials to ensure that the entire project is seen as a package, satisfying the venture agreements.


\textsuperscript{70} \textit{Ibid.}
Secondly, feasibility studies involving extensive IT evaluations, regional and/or location studies and economic and financial project evaluations are scrutinised for the viability of the port and container project. Thirdly, process design and project planning in the form of project process and container site selection, preliminary design and layout (such as ship berthing schedules), time schedules, cost estimates, master planning, procurement, personnel training, container and port systems improvement automation and logistics are developed and studied thoroughly to ensure that all the main points of the project are incorporated before the actual construction or installations. This follows through to construction management, where managing and administering contracts/subcontracts in the host nations, preparing construction budgets and schedules, staffing and organisation for construction, monitoring and performance are done to allocate responsibilities between PSA and foreign port authorities.

Fourthly, operating and general management services, such as information management, capacity planning, quality management, change management, procurement of materials, distribution, logistic and warehousing are discussed to develop a framework on how the port and container terminal operations can be developed or transformed. This is to ensure that the project is matched against international best practices in other ports such as Hong Kong or Rotterdam in the Netherlands, in port and container developments. This also allows for any new ideas regarding the improvement of the port and container operational efficiencies. Finally, start-up services such as hydrographic and navigational aid services, geo-technic and hydraulic services, civil and structural engineering, quantity surveying and operation tests and deficiency resolution are drafted to begin the operation of developing and enhancing a foreign port and consistent container terminal services.

In all foreign projects, PSA has proceeded with the transfer of services according to an Operational Efficiency Approach Method which it developed for this purpose. This method identifies the management capabilities that are in demand by overseas port operators. The method is similar to that followed by PSA in running the Singapore port. It is a five-prong framework to keep in pace with the technology, develop implementation programs, design and adapt a framework towards total quality management, spawn new ideas, generate re-engineering efforts, monitor and evaluate performances and regulate capacity. Figure 2 presents a flow-chart of the method.

Figure 2 relays all the necessary activities about information technologies required for the successful overall operation of a port and container terminal. The
method breaks the project down into understandable elements that are tailored to utilise host country capabilities. PSA has experienced that using the method clears any doubts that may exist at both PSA and the foreign partner about the success of the venture.⁷¹ In addition, this method keeps both parties on guard against unwarranted problems, such as the failure to control construction costs down or to monitor the progress of the construction of the terminal or port.

There is a significant design and engineering input of port services from PSA professionals, who are experienced in performing such services in overseas port projects as Table A1 in the appendix shows. The ports identified in Table A1 have engaged PSA for its achievements in Singapore and in Southeast Asia.⁷²

4.2. Skills development

Skills development has been a key component in PSA’s drive towards a knowledge-based port. To attain such status, the company had to upgrade its resources and develop new skills. Authors such as Pennings and Harianto (1992) have argued that the adoption of innovation is contingent upon an organisation’s repertoire of technical, strategic and administrative skills.⁷³ In addition, the kind of improvements in technological service can often be interpreted as a natural consequence of offering production: the result of an automatic learning-by-doing process.⁷⁴ Similarly, Bell et al. (1982) demonstrated that learning does not occur spontaneously and that performance can easily stagnate or decline in the long run. Firms fail to master technology and initiate a process of incremental innovation, because of the fact that

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⁷¹ Interview with Mr Peter Chew, PSA International Business Division, 19 January 2001.
⁷² Whilst information regarding the exact needs for each individual port were discussed sparsely during the interviews, the interviewees noted that the port services and development undertaken in the foreign projects were similar to those within Singapore and some of these professional services have been enhanced in PSA’s foreign port and container projects.
learning is neither automatic nor effortless.\textsuperscript{75} Even minor innovations require a spectrum of skills, knowledge and capacities for searching, selecting, assimilating and adapting techniques. Developing and maintaining these capabilities requires both a conscious effort by firms and the investment of significant financial resources.

Some forms of technology or knowledge transfer are inherent to all facets of engineering, IT, management and consultancy business. The scope of PSA’s service technology transfer activities has evolved since the late 1980s, and is determined largely by the requirements of specific port ventures and the presence of readily available professional skills and resources both in Singapore and overseas. Formalised training activity within PSA probably dates back to the rapid development of the Singapore port in the 1970s and the upgrading of port resources such as forklifts, cranes, quays or operating systems. The importance of skills in port services varies from the ability to use computerised operating systems such as expert planning systems (see above), to the ability to operate gigantic container cranes and the ability to take control of daily routine administrative tasks and responsibilities, in timely and efficient manner.

Back in the 1950s and 1960s, the first machines introduced were simple mechanical aids such as forklifts. The introductions of such labour-saving devices were not welcomed by the dockworkers who feared that the machines would rob them of their livelihood and as a result they were against changes. It was an important lesson, which PSA learned well. Educating staff to accept change is as important as explaining the mechanics of how the new technology works. PSA’s training department in conjunction with the local maritime training institutes produce their own videos so that potential users, such as port workers, can be informed well in advance of the new technology.\textsuperscript{76} In the 1970s and 1980s, increased usage of computer applications in all facets of port operations together with the acquisition of new and sophisticated machinery to further improve port productivity meant that existing workers were re-trained in new skills. There was an increased need for engineering and computer professionals and also employees with general skills. PSA


emphasised better labour management relations and the establishment of quality circles in which workers and management are represented.

In the 1980s, the use of formalised training and the development of training programs provided by PSA have grown both in Singapore and internationally, particularly in developing countries such as China, Malaysia and Indonesia. The supply of quality maritime workforce is a central component of PSA’s aim of developing Singapore as a nation of maritime excellence. According to interview respondents, providing such training expertise to foreign port administrators and staff is highly appreciated by overseas port authorities. Revolutionary changes are now taking place due to the ever-growing impact of IT innovation and applications in the shipping industry. The MPA (Maritime Port Academy) places great importance on having excellent training standards and facilities. Training to adapt to the new changes in the global economy, especially in the maritime world, has been high on Singapore’s maritime agenda for many years.

The Singapore Maritime Academy (SMA) was formed on 1 June 2000 by merging the Maritime Technology and Transportation (MTT) Department of Singapore Polytechnic and the National Maritime Academy (NMA) of the Maritime and Port Authority of Singapore, thus, creating a one-stop maritime education institute. SMA acts as a training institute for the PSA. The PSA managers have placed greater emphasis in helping students, including employees of PSA and foreign port employees and officials, to understand the various functions of information technology better and on how such technology can increase the efficiency of their work. The real strength of SMA, especially in the eyes of overseas port authorities, is the diversity of SMA’s teachers, which include engineers, maritime technologists, nautical experts and business and IT professionals. There is few other training and academic organisations around the world have been able to match.

SMA tailors its courses towards the increasingly sophisticated and diverse use of information technology systems adopted by the maritime industries. SMA

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78 Interview with Mr. Swapan Das Sarma, Singapore Maritime Academy, 5 January 2001, at the Singapore Maritime Academy.
claims to be among the best maritime education providers in the world. This was acknowledged by way of the Academy being the first in the world to obtain from the International Standards Organization, the ISO-9002 certification in Maritime Education and Training.79

In the venture agreements with overseas ports, PSA managers emphasised training of workers from host nations to support the PSA port officials, professionals and technical specialists in the foreign port projects. Similarly, PSA staff underwent refresher programs to be informed about the host nation work ethics, culture and management capabilities and general level of facilities. PSA has also introduced quality circles and productivity suggestion schemes to improve productivity and efficiency in its overseas projects and to induce greater cooperation and understanding among PSA port officials and host nation participants.

Currently, SMA has 120 full-time staff. Additional teaching support comes from the Mathematics and Science and the Language and Communications departments of Singapore Polytechnic. The academy also engages a number of part-time academics that add knowledge, depth and expertise to the existing pool of full-time academics. In addition, SMA’s Maritime Research and Development Centre provides state-of-the-art technological support to the maritime and maritime-related industries. Systems, such as CITOS were researched and developed at SMA for overseas port operations. During the 1990s, the academy has built up a large data bank of skill and expertise on IT and the academy is now very much involved in using IT applications and solutions to create computer-based training (CBT) packages, electronic performance support system (EPSS), and database development for simulators. Another area in which SMA has excelled in recent years has been in advising and teaching employees from foreign maritime organisations or shipping lines in Singapore and the region. In many cases, SMA has acted as a training arm for shipping companies, especially those involved in PSA’s service technology transfer to foreign ports.

The more advanced forms of engineering and information technology consulting was done by SMA researchers, both in Singapore and in foreign countries. On-site training activities were done by SMA teachers for both basic and advanced information technology activities. This form of training is provided to create a

79 Ibid.
realistic working environment for foreign port employees. For instance, host country port workers were sent to Singapore’s Pasir Panjang Container Terminal to study the overall running of the terminal. On acquiring the necessary knowledge, these workers travelled back together with PSA professionals to implement the acquired knowledge according to the needs of the host nation port and container terminal activities. Currently, about 2000 students (including workers from overseas) are studying at the Academy. International students from Malaysia, India, China, Bangladesh and a number of Arabian Gulf and African nations form 50 per cent of the total cohort.80

PSA’s expertise can be briefly explained on the basis of its work at the Aden Container Terminal (ACT) project in Yemen. PSA is responsible for the design of several facilities to provide managerial, administrative, IT and operations training to Yemen’s port officials and professionals who will be able to take over the position of PSA staff after the expiry of the venture agreement. That is, the Yemenis are able to develop the ability to train and develop their own training programs suited for their employees in the future. In addition, PSA has developed and enhanced the port operating systems, used in running the Singapore port, to suit the aims of ACT to become a transshipment terminal.

5. Internationalisation of PSA’s Technological Services

Having discussed the core competencies of service technologies that PSA has to offer to foreign port operators, this section will elaborate how these technological services are exported.

Engineering consultancy and IT services are business services that are close to, but different from the actual construction of facilities.81 Both these services aim at the optimisation, in terms of productivity and efficiency, of infrastructure and industrial projects through a set of activities, such as feasibility and pre-feasibility studies, surveys, general and detailed design, training, construction supervision, construction management and planning.

80 Interview with Mr. Swapan Das Sarma, Singapore Maritime Academy, 5 January 2001.
81 However, Appendix 1A contains some overseas projects, where construction was also part of the joint-venture agreement.
PSA has focused its international operations in areas that have the potential to become major hub ports, achieve high growth, in terms container throughput, and provide good profit potential, particularly in China, India, Southeast Asia and the Middle East.\textsuperscript{82} PSA’s level of participation in overseas projects has mainly been in the form of and in reference to Appendix 1A are:

- **Turnkey projects** – in which PSA agrees to fully design, construct and equip a facility and then turn the project over to host country authorities or to the host country firm. Tutocorin Container terminal in Tamil Nadu, India, is an example;
- **Equity investment or joint ventures** – in which PSA shares assets, risks and profits and participates in the ownership of a particular enterprise. The Port of Antwerp and Zeebrugge in Belgium has invited PSA to contribute their port operational and management expertise; and
- **Management services or contracts and consultancy services** – where PSA provides managerial assistance, technical expertise or specialised services to a host economy or foreign firm. Voltri Terminal Europa, in Genoa, Italy, is an example.

The training of foreign port personnel at the Singapore Port Institute (SPI) and the Singapore Maritime Academy is another mode of internationalisation of service activities, because it involves a cross-border transfer of knowledge by PSA on the basis of contractual agreements with foreign organisations. Both SPI and SMA offer courses on port management, operations, and technical and marine skills with modern training facilities.

In addition, PSA managers and administrators found that it was easy and effective to transfer knowledge and improve the abilities of foreign port employees through on-the-job training.\textsuperscript{83} Integrated PSA-host country organisation project teams usually carry out work on assignment, which enhances the technology transfer. The goal of an integrated team is to gradually transfer the leadership role in a project from PSA to a foreign port authority, while PSA moves increasingly to an advisory role. Executing a complex port and container terminal project requires many technical disciplines and

\textsuperscript{82} Major hub ports denote a focal point of sea traffic or busy shipping lane and busy port. For instance, Tuticorin Container Terminal in South India is strategically located at the East-West shipping routes.

\textsuperscript{83} Interview with Mr MMJ Subramanium, International Business Division of PSA, 23 January 2001.
management skills. Sustained long-term personal contacts are important for an efficient and successful diffusion of expertise.

The following elements were identified by Mr Peter Chew of PSA’s International Business as included in a technology transfer involving port and container terminal development: use of an approach to project management that involves the foreign country’s technical and management resources to the maximum extent; carefully planned and formalised program for technology transfer and multi-project engineering; management of port and container terminal development over an extended period of time, to allow for the planned progression and transfer of responsibility.84 PSA uses a project team for the work and encourages its foreign counterparts to do the same. The selected project teams incorporate the necessary skills required to handle the work and the problems encountered in project implementation. PSA makes sure that the teams are sufficiently small so that all team members share an understanding of the project goals. Teams preserve good internal communications and are sufficiently flexible to adapt to changing circumstances. A detailed design work of the port and container operational structure is then carried out in the overseas projects. Engineers, managers and consultants of PSA assist the foreign port team of professionals in developing a detailed design work to be performed by foreign port engineers and workers under the direction of the project teams. Technical support from PSA Corporation’s office in Singapore continues on an “as needed” basis.

In most of PSA’s joint ventures, the duration of a project allows for advanced service technology transfer. This refers to the transfer of technology and practical knowledge, and, importantly, the transfer of an understanding of the port and terminal operational procedures that go into the technical and commercial decision-making process. To sustain this type of technology transfer, however, requires that the foreign port officials have the necessary professional engineers and managers available for the time-consuming classroom and on-the-job training that is associated with these programs.

The identification of the competitive advantages that PSA has in service technology transfer in its port and terminal projects, depends on three interrelated factors. Firstly, the service technology objectives and plans of foreign port authorities. These are critical for a successful transfer. The long-term utility of the service transfer experience for

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84 Interview with Mr Peter Chew, International Business Division of PSA, 19 January 2001.
the host organisations and eventually the country, depends on the attitude and motivation
during the learning process and the opportunities of the foreign port organisation to utilise
the tacit knowledge gained via the service technology transfer on a continuing basis.
Secondly, the education and experience of workers and managers of foreign port
organisations are important to PSA because they give a good indication of the absorptive
capability and acceptance of new skills and port technology. When the local educational
system is inadequate, PSA is likely to incur higher costs in technology transfer, as it needs
to train the local workers and managers to facilitate the absorption of the new knowledge.
If the local educational level is too low, the costs of the transfer will be too high and the
transfer will take longer to proceed.

The third factor relates to the nature of the project. PSA’s role in project
execution, the duration and complexity of the technology involved are important because
these give a good indication of the progress of the project and identify any faults or errors.
A good personal understanding between PSA employees and foreign port officials is
required for a successful infusion of the service technology. It is important for recipients
of a foreign port organisation to be adaptable and willing to accept new knowledge and the
need to acknowledge what they know and what they still have to learn. The officials, such
as engineers and logistics personnel, of both PSA and the foreign port organisation must
understand the technology transfer effort and support it.

5.1. The Transfer of Service Technologies Involved in PSA’s Overseas Projects – An
Example of The Dalian Container Terminal in China

PSA and the Port of Dalian Authority (PDA) formed a joint venture company in 1996,
called the Dalian Container Terminal (DCT). Its purpose was to develop, manage and
operate the container terminal in Dayao Bay, Dalian. This was PSA’s first major
investment outside Singapore. The total project cost is RMB 4 million or S$750
million, and PSA has an equity stake of 34.6 per cent.

Geographically, Dalian is located at the tip of the Liaodong Peninsula. It is
the natural seaport for the whole of Northeast China. Two of these provinces in
Northeast China, Heilongjiang and Jilin are land-locked and only Liaodong has a
coastline. All three provinces depend on Dalian or the coastline to trade with other
parts of China and the rest of the world. Dalian is at the entrance to the Bohai Gulf.
Four relatively prosperous provinces surround the gulf, namely Liaoning, Hebei,
Tianjin and Shandong. There are dozens of other ports located inside the gulf. But only Dalian is endowed with deep-waters and has a natural deep-water harbour. It is protected from strong waves and currents. There are no rivers that discharge silt into its waters. After dredging, a container port with water a depth of 14-15 metres and beyond was developed.85 The other ports in the Bohai gulf are potentially feeder ports to Dalian.

A favourable factor welcomed by PSA is the strong political commitment of the Dalian Municipal Government to the project. The Dalian Municipal Government has a vision of developing Dalian into the ‘Hong Kong of the North’.86 The existence of relatively good rail, road infrastructure and communication infrastructure, made PSA officials realise that Dalian was an ideal place for the implementation of intermodalism. This means that containers can be transported by different transport modes such as in the form of container trailers by trucks, without being unpacked.87

The next step undertaken by PSA in 1997 was to send some of its most capable officers to Dalian to work together with counterparts nominated by PDA. Together, they critically reviewed the current situation and the possible improvements on the management and operating systems. Modern management structures and international practices in port management similar as those applied in Singapore had to be introduced. One of the main reasons why Dalian has chosen to collaborate with PSA is that PDA has confidence in PSA’s management expertise and experience, which competitors did not have.88 It must be noted that, already in 1996, the physical port and container infrastructures in Dalian were constructed and developed by the PDA. Therefore, the whole project by PSA was up and running in 3 years since the signing. As a result, PSA’s main activities involved sharing management and consultancy services with PDA through DCT, and the installation and enhancement of port technologies in Dalian. Gradually, appropriate IT systems modelled after Singapore’s CITOS and PORTNET architecture were installed in DCT.

PSA’s management emphasises the efficiency, productivity and high level of service DCT provides to customers. It believes in providing fast, reliable, consistent and predictable services. Mr Subramanium regards the development of

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85 Ibid.
86 Ibid, p. 3.
87 Ibid.
88 Interview with Mr Peter Chew, International Business Division of PSA, 19 January 2001.
DCT as a solution to ‘software transfer’, an intensive exchange program designed to offer PDA officials detailed exposure to PSA’s way of running the port in Singapore. From the port development point of view, the entire project represents 3 to 5 years of consultative, management and engineering development. Furthermore, Mr Subramaniam noted that an estimated management team of 150-250 people, of high-level management and consulting experience from the International Business Division, studied and prepared the entire project.

Since the joint venture agreement between PSA and Dalian City officials was signed in 1996, about 200 Chinese officials travelled to Singapore for training. Among others, they learned about land-use planning, environmental regulation, port operation and management procedures and diffusion of technology in the form of applying expert intelligent systems and other information and communication technologies to terminal operations. PSA’s intention was to change the attitude of the Dalian Port officials so that they adopt a pro-business rather than for their own personal benefit, to instill the relevance of transparency rather than secrecy, of predictability and consistency in the application and development of technology in the areas crucial to the running of a highly efficient container terminal. This is to create a sense of achievement and challenge in PDA’s activities.

Prior to PSA’s involvement in the DCT project, PDA handled about 420,000 TEUs in 1996. As a testimony to the impact of PSA’s efforts, DCT’s throughput in 1999 was 700,000 TEUs, a 32 per cent improvement compared to 1998. DCT maintained its momentum in the first half of 2000 by handling 366,241 TEUs, a 28 per cent improvement over the same period in 1999. This is a rapid growth in TEUs growth when compared to PSA’s Tuticorin Container Terminal in India and PSA’s Aden Container Terminal in Yemen. Tuticorin Container Terminal achieved a record year-on-year throughput growth of 33 per cent from January to March 2000, handling 34,701 TEUs during the three-month period. On the other

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90 Interview with Mr Peter Chew, International Business Division of PSA, 19 January 2001.
hand, Aden Container Terminal handled approximately 170,000 TEUs in the first nine months of 2000.93

Moreover, PSA’s joint venture with the PDA, earned the port the distinction of “Best Emerging Container Terminal” at the inaugural Lloyd’s List Maritime Asia Awards.94 DCT won two other accolades when it was voted the Best Container (High Efficient Operations) at the China Freight Industry Awards by China Shipping Gazette and the Best Container Terminal in Mainland China by Cargo News Asia in 1999.95 PSA and PDA are currently developing two 15 metre deep berths by 2005. When fully developed, PSA wish that DCT could handle a throughput of 2.3 million TEUs annually.96

During a visit of China’s President, Jiang Zemin to Dalian in August 1999, DCT was commended for its modern facilities, efficiency in container handling, as well as its contribution to container terminal throughput of the Port of Dalian, which was ranked seventh in China.

6. Conclusion

This exploratory study found that Singapore exports services in the form of technology transfer in the area of port and container terminal development expertise. Two factors seem equally crucial in technological service exports: the initial transfer of port and container technological services from Singapore to foreign port organisations; and the subsequent assimilation and adaptation of port and container management knowledge and technological skills. It is not only the general requirements of skills and technology that increasingly determine comparative advantage between Singapore and host nations. Rather, particular forms of skill and technology, based on specific investments in research and development, organisation and marketing, within industries, regardless of whether they are high or low technology, determine competitive advantage. Furthermore, the basis of competitive advantage in service technology exports by PSA is threefold: the low cost

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95 Ibid.
of highly skilled workforce in host country; the suitability of the technology to conditions in host nations; and the ‘packaged’ nature of technological service exports.

The main aim of this paper was to analyse PSA’s core competencies in port and terminal expertises and PSA’s capability to export these technological services. Section 4 discussed in detail the service technologies, mainly engineering, consultancy and management services. In keeping with the heterogeneity of services, service activities incorporate embodied or disembodied transfer of technology in the form of skills or/and knowledge to the recipients (adoption and diffusion of technology that may not only by means of physical/hardware or software technology, but the basic study of service functions). The export of skills in the form of management and consultancy capabilities of PSA, the installation and enhancement of technological systems and the training of foreign employees by PSA, can be taken to be technological service exports.

In terms of the core competencies, service technology can be transmitted across countries through a large variety of channels, ranging from official technical aid, migration, scientific communication and exports of equipment to licensing, direct investment, turnkey projects, joint ventures, training and consultancy services. PSA has chosen joint ventures, training, management, technical, engineering and consultancy channels to export its expertise in port and container terminal development. Furthermore, it is safe to assume that the revenues or profits earned by PSA from its joint ventures and equity stakes overseas are incorporated in the ‘other services’ component (as an inflow of earnings by a Singapore company) of the exports of services figure in Singapore’s balance of payments. Section 3 discusses the importance of the service export trade and highlights the importance of the ‘other services’ component.

From the indigenous development of port and container management skills (such as operational efficiency approach method) and technology systems (such as CITOS and CIMOS), to the corporatisation of PSA in 1997, PSA has developed itself into a key global player in port and container management and developer. With 13 overseas port and container projects to date, it is undeniable that PSA has the competencies in port and container management and development skills, and PSA transfers these technology knowledge skills through its service exports.

In concluding, two key points have to be noted. Firstly, it must be noted that technology transfer does not only take place in the form of industrial or production activities. As this paper has explored, technology transfer can also be viewed from the service perspective. And secondly whilst a voluminous literature on Asian economies
have shown that these economies have grown by importing foreign technology and knowledge, this paper has looked at the possibility of Asian economies, such as Singapore, developing the ability to transfer technological service activities through exports.
Figure 1: Schematic Framework of Service Technology

TECHNOLOGY

MACHINES

OPERATION

MAINTENANCE

ADAPTATION & DEVELOPMENT

OPERATURES

TECHNICIANS

ENGINEERS

PRODUCT DEVELOPMENT

Human Capabilities

PRODUCTION

MANAGEMENT

MARKETING RESEARCH & DEVELOPMENT

SKILLED

SEMI-SKILLED

UNSKILLED

MANAGEMENT

OPERATURES

SKILLED

SEMI-SKILLED

UNSKILLED

MARKETING RESEARCH & DEVELOPMENT

PRODUCT DEVELOPMENT

TECHNOLOGY
Figure 2: Singapore – Operational Efficiency Approach Method

**Efficiency Operations Improvement Program**

- **Improving and Automating Systems**
  - Transaction schedular and automation; expert information base; sensitivity analysis; goal-seeking, optimisation, priorities

- **Quality Management**
  - Staff suggestion scheme; quality circles; total quality management; process improvement; process capability; customer orientation; re-engineering; best practice; benchmark

- **Change Management**
  - Ownership; teambuilding; risk-taking; innovation; individual motivation; teamwork; job re-design; cost management

- **Information Management**
  - Timeliness; information flow and collation; data-mining; idea generation; analysis; dissemination; papers / seminars; media

- **Capacity Management**
  - Sub-process; characterisation; interaction; integration; synergy; performance monitoring; capacity planning; decision support
### Table A1: External Projects of Port of Singapore Authority

<table>
<thead>
<tr>
<th>Country</th>
<th>Services offered as per Joint-Venture Agreement</th>
<th>Year of Commencement</th>
<th>Joint-Venture Period (years)</th>
<th>Stake (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltri Terminal Europa, Genoa</td>
<td>• Manage and operate the terminal</td>
<td>May-98</td>
<td>60</td>
<td>95.0</td>
</tr>
<tr>
<td>Venice Container Terminal</td>
<td>• Operate the container terminal on both the Tyrrhenian and Adriatic Coasts of Italy; provide management and consultancy services</td>
<td>Oct-98</td>
<td>N/A</td>
<td>53.0</td>
</tr>
<tr>
<td>China</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>Description</td>
<td>Date</td>
<td>N/A</td>
<td>Value</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------</td>
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</table>
| Dalian Container Terminal | • Install and customise CITOS to efficiently integrate all aspects of terminal operations for a reliable and fast service  
• Develop a yard planning system with inventory and container tracking; use systematic and centralised work methods for port container management and operational procedures | Jul-96     | N/A  | 34.6  |
| Fuzhou Port          | • To provide advanced port management and install artificial intelligence systems found at Singapore’s PPT  
• Develop and manage new deep-water container terminals | May-98     | N/A  | N/A   |
| Guangzhou Container Terminal | • PSA will manage and operate three container berths at Guangzhou, Huangpu and Xingang  
• Facilitate the development of the Port of Guangzhou into an advanced container gateway port capable of handling container traffic from Guangzhou and the South China region | 17-July 2001 | N/A  | 49    |
<p>| India                |                                                                             |            |      |       |</p>
<table>
<thead>
<tr>
<th>Location</th>
<th>PSA commitments</th>
<th>Month</th>
<th>N/A</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipavav Port, Gujarat</td>
<td>• PSA will lend its expertise in the areas of planning, operations and management of the terminal</td>
<td>Aug-98</td>
<td>N/A</td>
<td>40.0</td>
</tr>
</tbody>
</table>
| Tutocorin Container Terminal, Tamil Nadu | • PSA will customise its innovative CITOS to efficiently integrate operations at the terminal  
• Enhance efficiency and effectiveness by installing real-time terminal management systems  
• To improve container handling facilities for India’s Southern Region  
• Facilitate development of South India trade market by providing flexible and reliable terminal services  
• Help to provide smooth flow of trade in the region by meeting the shipping and maritime industry’s needs | Dec-99 | N/A  | N/A  |
<p>| Yemen                          |                                                                                 |        |      |      |</p>
<table>
<thead>
<tr>
<th><strong>Aden Container Terminal</strong></th>
<th><strong>Mar-99</strong></th>
<th><strong>20</strong></th>
<th><strong>60.0</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• A green-field project*</td>
<td></td>
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<td></td>
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<tr>
<td>• Committing immense amount of resources into management, training of expertise of employees and sharing its expertise through a transfer of technological know-how</td>
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<tr>
<td>• PSA to tap on its strong relationships with major international shipping lines to bring them to Aden (marketing)</td>
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<tr>
<td>• Aim to develop the terminal for transhipment operations</td>
<td></td>
<td></td>
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<tr>
<td>• Equip the terminal to accommodate the world’s largest container ships, four quay cranes, eight rubber-tyred gantry yard cranes and 250 reefer points for refrigerated containers</td>
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<td></td>
<td></td>
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<tr>
<td>• Provide high level technological efficiency</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• Employ PSA’s IT applications</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>• Adapt the CITOS systems modelled after PSA’s real-time management systems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Create efficient berthing operations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Develop optimal container yard storage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• A dynamic</td>
<td></td>
<td></td>
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</tbody>
</table>
development of manpower and equipment
- Implement a support system called the Computer-Aided Mechanical Maintenance System (CAMMS) that could also be used for future analysis of performance statistics

<table>
<thead>
<tr>
<th>South Korea</th>
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<tbody>
<tr>
<td><strong>Inchon Terminal</strong></td>
<td></td>
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<tr>
<td>- To develop 3 berths to handle vessels with vessel drafts of 12.5 m at all times of the year</td>
<td></td>
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<tr>
<td>- To develop a total quay length of 900 metres</td>
<td></td>
</tr>
<tr>
<td>- Implementation of advance port operation and automation systems</td>
<td></td>
</tr>
<tr>
<td>- Provide container handling knowledge, IT expertise and operations know-how</td>
<td>2003</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Brunei</th>
<th></th>
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</thead>
</table>
| Muara Container Terminal | • To manage, operate and develop the terminal  
• To provide expertise in port and container terminal operations with the workforce  
• Increase productivity and service levels at the terminal  
• Impart advanced technologies and port management skills or techniques  
• Also to develop the terminal into a regional transhipment hub to serve the growing East Asian Region | N/A | 30 | N/A |
<table>
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<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitakyushu Port</td>
<td>• Details still in progress</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Portugal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Sines Container Terminal | • A green field project  
• To develop a new deep-sea container terminal  
• To develop, operate and manage the terminal | Jun-99 | 30 | N/A |
| Belgium | | | | |
| Port of Antwerp and Zeebrugge | • PSA will contribute its port operational expertise and experience and advanced technology application to further develop Antwerp and Zeebrugge into a leading container gateways for the European continent | N/A | N/A | 60.0-80.0 |
Notes: N/A- Not Available, PSA declines to disclose its stake in these ports.
* - Refers to rural areas, which have not been used.