### Project Number:
**項目編號：**
2015.A6.063.16A

### Project Title:
**項目名稱：**
Developing A Globalised Industry under the Context of Territorial Policy - The Development of Aviation MRO Industry in Singapore and Hong Kong
利用區域政策發展全球化產業的經驗─新加坡和香港發展飛機維修產業的比較研究

### Principal Investigator:
**首席研究員：**
Dr CHAN Man Hung Thomas
陳文鴻博士

### Institution/Think Tank:
**院校／智庫：**
The Hong Kong Polytechnic University
香港理工大學

### Project Duration (Month):
**推行期(月)：**
10

### Funding (HK$):
**總金額(HK$)：**
611,225.00

---

This research report is uploaded onto the Central Policy Unit’s (CPU’s) website for public reference. The views expressed in this report are those of the Research Team of this project and do not represent the views of the CPU and/or the Assessment Panel. The CPU and/or the Assessment Panel do not guarantee the accuracy of the data included in this report.

Please observe the "Intellectual Property Rights & Use of Project Data" as stipulated in the Guidance Notes of the Public Policy Research Funding Scheme.

A suitable acknowledgement of the funding from the CPU should be included in any publication/publicity arising from the work done on a research project funded in whole or in part by the CPU.

The English version shall prevail whenever there is any discrepancy between the English and Chinese versions.
Public Policy Research Funding Scheme:

Developing A Globalised Industry under the Context of Territorial Policy - The Development of Aviation MRO Industry in Singapore and Hong Kong

利用區域政策發展全球化產業的經驗 - 新加坡和香港發展飛機維修產業的比較研究

Project No.: 2015.A6.063.16A

Submitted by:
Chan Man Hung, Thomas (Principal Investigator)
30 April 2017
Abstract

The study will examine the development trajectory of aviation MRO industry in Hong Kong and Singapore, and investigate how Hong Kong and Singapore upgraded this local business into a global scale via different approaches. The interplay between MRO providers and their respective island-state government will be studied as to explore how enterprises tap into the territorial institutional advantages for business expansion. Emphasis will be placed on the role of government and the contributions of territorial and industry policies in facilitating the development of aerospace industry. The study is not a quantitative or empirical-formal one, but explorative in nature and hopes to provide the groundwork for more vigorous study later.

Since the late 1990s, the governments of Hong Kong and Singapore have emphasized the development of advanced industries as an essential part of their growth strategies. While Hong Kong’s attempt to drive economic growth with innovation and technology in recent decades was not successful, Singapore managed to establish several fast-growing advanced industries. The difference in the trajectory and the subsequent outcomes of the development of innovation and technology industries in the two island-states may stem from the path dependence and the lock-in effect of the industrialization that started early in the 1950s in Hong Kong and 1960s in Singapore; and the role of government and active government and public sector in the promotion of both the relevant capabilities for the industries and the industries themselves.

The major difference between Hong Kong’s and Singapore’s catch-up arise from the latter’s adoption of a strategy by focusing on the development of its sectoral system of innovation. The government sets up rules to appropriately coordinate and facilitate as well evaluate the interactions between actors in the system. As a step to effectively utilize the technologies acquired and hence the development of priority industry, Singaporean government has turned itself into an important investor in domestic manufacturing sector. However, before the sectoral system of innovation can function well, it needs a target as the basics of all rules: designing a product. The corresponding technological capabilities are obviously “tacit knowledge” and can only be acquired and accumulated through the process of product design. Therefore, the appropriate starting point for latecomers to build up an advanced sector is to concentrate resources on developing a particular product with market potential. In the case of Singapore, of course, an industry policy package with aircraft as a core was formulated.

As it would take a very long time to accumulate the necessary experiences and knowledge to develop a complex and sophisticated product like aircraft, the crucially important decision was then taken of not developing and producing complete aircraft. A more rational strategy has been adopted to target the high value services associated with MRO, modification, upgrading and technology insertion. With the liberalization that increases competition between airlines and drives the need for acceleration in cost cutting, that independent MRO sector emerges as a growing business and invites OEMs to venture into it for additional revenues and higher profit margins.

The demand for military products and services and the expanding SIA commercial aircraft fleet gave room for the rise of two state-owned MRO enterprises: ST Aerospace and SIA Engineering. The rapid expansion of SIA also fueled the development of the domestic airport, and the further development of Singapore into a global aviation hub, as well as a regional financial centre. This has in turn provided an important basis for a stable demand for MRO with advantages brought by scale economies. To satisfy the astonishing market demand for equipment and parts, leading aerospace OEMs and suppliers carry out a variety of MRO-
related manufacturing activities in the territory. Singapore government took this chance to integrate the MRO service with manufacturing activities.

Of course, we should not ignore that the de-regulation of aviation industry in the US in the late 1970s and the support of market resources and technology knowledge from the US were keys for Singapore’s success in expanding demand for MRO. Anyway, in recent decades, Singapore has already successfully become one of the leading global players in global aeronautical MRO industry.

Hong Kong now bears no favourable comparison with Singapore MRO industry, although Hong Kong is still one of the leading players in the global MRO market. Without government’s direct involvement like the case of many other industrializing economies including not just Singapore, the monopolizing firm of HACEO has not the motivation and interest in invest in Hong Kong to capitalize on its first mover advantage in the greater China and even the booming Asia. It simply expands horizontally in major airports in the China Mainland and behave like any other footloose foreign firms with little local commitment, apart from its own profitability. It is also pity that HAEKO has not triggered the development of an advanced manufacturing sector in Hong Kong as part of the innovation and production/value chain for the much-expanded MRO businesses. Until now the government has not seen MRO or aerospace industry as the target for innovation and high tech industries to be promoted and for public supports.

The strategy of HAEKO is more for horizontal expansion by expanding beyond China to the US by acquiring Timco and has even lately abandoned line maintenance in the US to focus more on cabin and seat manufacturing and fittings. This seems to confirm the preoccupation of Hong Kong firms to avoid heavy and long term investment in technology upgrading and knowledge innovation, focusing instead on shorter-term market opportunities. Unfortunately, the US investment of HAEKO seems to turn out losses rather than profits for the whole group. HAEKO also divests its stake in Singapore Aero Engine Services Private Limited (SAESL), a joint venture of SIA Engineering with Rolls Royce, in 2016. It helps Singapore to get rid of the legacy Hong Kong factor, coming into direct competition in China, the Asia Pacific region as well as globally. Hong Kong is losing their comfortable captive market.

The persistent investment and policy efforts of the Singapore government guaranteed that MRO industry and the aerospace industry in the city state could expand and upgrade attracting many world class OEMs to build up a more extended local value chain system for MRO and aerospace. It is the consolidation of the local industry and services supported by strong and aggressive local system of knowledge, innovation and human capital training that ST Aerospace and SIA Engineering could expand their markets globally. A local industry turns global and in the process the local industry is transformed into a globalized industry serving the local economy and society. The Hong Kong MRO firms could still benefit from the proximity to the great emerging market of China, but without an active role by the government, the story of the MRO firms in Hong Kong is just the ups and downs of particular firms with little spill-over impact on the local industry, economy and society.

The aerospace industry should be regarded as belonging to the arena of post-industrial catch up. However, aerospace industry in general and MRO industry in particular are closely regulated and certified by standards set by the developed economies and their leading corporations. This has constituted a strong institutional barrier to late comers.
China has not been able to build its MRO firms for military services into competitive ones for civilian MRO. There is still a long way for it to build the market for its large aircraft to set up separate MRO standards and regulations from the existing OEMs’ from the developed economies. Hence its MRO industry is still subject to the market regulation and pressures originated from the dominating OEMs. These lead to the fact that MRO industry in China is still underdeveloped and deficient in the more technology intensive subsectors; and that the market has been dominated by foreign joint ventures. The Chinese industry just like other late comer economies are still in the process of industrial catch up, developing mostly by imitation and under the dominating market controls of major players from the develop. Similarly Singapore is still in the catch up stage in the aerospace industry. MRO provides it a breakthrough key, but whether it is sufficient enough to establish sustainably the aerospace industry of Singapore (despite a higher output value than Brazil) remains to be seen, and with great doubts. The Hong Kong case has not implications for other late comers in the development of aerospace industry and the overall industrial catch up. It shows only a case for the evolution of business MRO at the firm level and probably also the lessons to be learnt for the absence of industrial policy and government supports not only for the industry alone but more significantly at the level of the local innovation system.

Based on the findings, three policy recommendations are formulated for the reference of the SAR Government. First, for an easier task that could be achieved is to expand the education and training establishments for MRO and related professionals and technicians. Second, Hong Kong should promote actively the integration of the regional market for MRO by removing all regulatory barriers to facilitate a cross border system of innovation and business cooperation and integration. Last but not least, Hong Kong government should take the initiative to propose a regional cooperation mechanism for the development of MRO industry at the regional level.
摘要

本研究將檢視香港和新加坡航空維修業的發展軌跡，並察看這兩個城市如何通過各自的方法把這盤本地生意擴大至世界級規模。兩地政府及飛機維修公司之間的互動將會被深入研究，從而探尋企業如何利用當地體制優勢促進業務擴展。重點將置於政府的角色以及區域和產業政策對支援航空產業發展的貢獻。本研究帶有探究性質，旨在為日後更深入的研究提供基礎，而非進行量化或實證分析。

自 1990 年代後期，香港和新加坡政府均強調先進產業的發展乃推動經濟增長的重要一環。然而在近一、二十年裡，香港以創新和科技驅動經濟增長的戰略難言成功，新加坡卻成功建立起幾個快速成長的先進產業。兩地不同的發展軌跡，以及創新和科技產業發展的差異，源於早期工業化路徑依賴和鎖定效應(20 世紀 50 年代初的香港和六十年代初期的新加坡)，以及政府和公共部門在促進行業發展和行業本身相關能力方面的作用。

香港與新加坡追趕的主要區別，在於後者採取戰略重點發展其產業創新體系。政府制定規則適當的統籌、支援和評估系統中各方之間的相互作用。為有效利用所獲技術及發展優先產業，新加坡政府把自己打造成國內製造業的重要投資者。然而，在產業創新體系運行良好之前，需要將目標作為所有規則的基礎，這個目標從設計產品獲取。設計產品的技術能力顯然是「隱性知識」，只能通過產品設計過程獲得和積累。因此，後進者建立先進部門的適當起點是集中資源開發具有市場潛力的特定產品。新加坡就圍繞飛機制定了產業政策。

由於需要很長時間才能積累必要的經驗和知識，來開發飛機此等複雜而精密的產品，那麼新加坡決定不開發和生產完整的飛機。它採用了更合理的策略，只瞄準飛機維修、改裝、升級和技術插入相關的高價值服務。在自由化下，隨著航空公司競爭加劇，逼迫航空公司加快削減成本，獨立的 MRO 產業得以成為新興行業，並吸引 OEM 進行投資，以獲得更多收入和更高的利潤率。

軍事產品和服務的需求，以及 SIA 不斷擴大的商用機隊，為兩家國有 MRO 企業——ST Aerospace and SIA Engineering——崛起創造空間。新加坡航空公司的迅速擴張也推動了國內機場的發展，使新加坡進一步發展成為全球航空樞紐以及區域金融中心。而這又為飛機維修業提供穩定的需求，形成規模經濟的優勢。為了滿足市場對設備和零部件的驚人需求，航空 OEM 龍頭和供應商在新加坡展開了與飛機維修相關的製造業務。新加坡政府藉此整合飛機維修服務與製造活動。

當然，我們不應該忽視上世紀 70 年代末美國航空業去監管化，以及美國的市場資源和技術知識，對新加坡成功擴大對飛機維修產業的市場起著關鍵作用。無論如何，近幾十年來，新加坡已成功晉身為全球航空飛機維修產業的領頭羊之一。

今時今日，儘管香港仍然是全球飛機維修市場的領袖，但與新加坡相比起來，已不見得有任何優勢。有別於許多其他工業化經濟體的情況一樣 (不僅是新加坡)，沒有政府的直接參與，在香港具備壟斷地位的 HACEO 沒有動力和興趣投資香港，把它在大中國乃至亞洲的先發優勢兌換成實質價值。它仿如其他外國公司一樣，只是在中國大陸的主要機場水平擴張，除了關心自身的盈利能力，對本地少有承擔。而且令人遺憾
的是，HAECO 在香港並沒有觸發先進製造業的發展，作為飛機維修業務創新鏈和生產/價值鏈的一部分。直到現在，政府還沒有將飛機維修業或航空航天工業作為創新和高新技術產業的目標，大力推廣和爭取公眾的支持。

新加坡政府的持續投資和政策，保證了當地的飛機維修業和航空航天工業能夠擴大和升級，吸引許多世界級的 OEM 建立更為擴大的本地價值鏈體系。通過強大而進取的地方知識、創新和人力資本培訓體系，ST Aerospace 和 SIA Engineering 可以在全球拓展市場，鞏固當地的工業和服務。當地產業轉向全球，在此過程中，當地產業轉變為服務於當地經濟和社會的全球化產業。香港飛機維修公司仍然可以憑藉接近中國市場的優勢而受益，但缺乏政府積極作為，香港飛機維修公司的故事只不過是個別公司的起伏跌宕，對當地產業、經濟和社會少有外溢影響。

航空航天工業應被視為後工業時代追趕的舞台。但是，整個航空航天工業，尤其是飛機維修業，受到發達經濟體及其主要公司制定的標準的嚴格監管，需要獲取它們的認證方能參與。這對後進者構成了難以跨越的制度性障礙。中國還沒有能夠將為軍事服務的飛機維修公司轉化為具競爭力的民用飛機維修企業。要製造出大型飛機，在現有的發達國家 OEM 之後單獨制定的飛機維修標準和法規，還有很長的路要走。因此，其飛機維修業仍然脫離不了主要 OEM 的操控和壓力。這導致了中國飛機維修業在技術密集型行業中發育不良，同時令市場陷入外資合資企業主導的困局。就像其他後進者一樣，中國的飛機維修業仍處於追趕過程，主要是通過模仿並置於市場領袖的壓制下。同樣，新加坡的航空航天業仍處於追趕階段。飛機維修為當提供了突破口，但是不足以立可持續的新加坡航空航天產業（儘管產值高於巴西）仍有待觀察，尚存巨大疑惑。至於香港的例子，則在航空航天業發展和整體工業追趕方面，則對其他後進者沒有太多啟示。它只是展示商業飛機維修在企業層面上演變的某一個案例，極其量只能作為不制定產業政策的教訓。政府不僅對行業單一地支持，更重要的是在本地創新體系層面提供支持。

基於以上的研究結果，本研究提供三條政策建議供香港政府參考。第一，可考慮擴大飛機維修及與相關專業技術人員的教育培訓編制，這項工作相對容易完成。第二，香港應主動撤除障礙，打造一個跨界的創新、商業合作與整合的體系，促進區域飛機維修市場的一體化。第三，香港政府應倡議建構一個區域合作機制，以在區域層面促進飛機維修業的發展。
Table of Contents

1. Preamble ................................................................. 1
2. General theoretical background ...................................... 6
3. General background to the industrialization of Singapore and Hong Kong .................. 9
4. The Singaporean trajectory of the development of the MRO industry ......................... 20
5. Trajectory of Hong Kong’s MRO industry ......................... 30
6. The outstanding achievements of Singapore and Hong Kong MRO industry .......... 36
7. The new global model of MRO ........................................ 38
8. Challenges to and responses from Hong Kong and Singapore in the coming decades .... 45
9. Conclusion ....................................................................... 51
10. Recommendations to the Hong Kong Government ..................................................... 54

Appendix: Subsidiaries and affiliated companies of HAECO, SIA Engineering and ST Aerospace ................................................................. 57
1. **Preamble**

1.1. **The aim of the project**

The Study will examine the development trajectory of aviation MRO industry in Hong Kong and Singapore, and investigate how Hong Kong and Singapore upgraded this local business into a global scale via different approaches. The interplay between MRO providers and their respective island-state government will be studied as to explore how enterprises tap into the territorial institutional advantages for business expansion. Emphasis will be placed on the role of government and the contributions of territorial and industry policies in facilitating the development of aerospace industry. Policy implications will be drawn from the strategies of ‘developmental state’ adopted by Singaporean government and ‘laissez-fair’ by Hong Kong government in fostering or hindering the knowledge-oriented, institution-sensitive industry.

1.2. **Research methods**

The research methods used for the study are mainly literature survey, interviews and participation in MRO industry conferences, data analysis and firm case studies.

There have been limitations in the collection and access to crucial information at the government, industry and firm levels. The government of Singapore, like its counterparts in many other industrializing countries which have also attempted various approaches of developmental state, has released little detailed information about its strategy and policies, not to mention the rationale and specific reasons for their formulation. The relationship between the government and state is often obscure with little public information or analyses. This is especially the case in Singapore as the major champions of the MRO industry of the island state are state-owned firms and which have also engaged in military MRO. The dual nature of the MRO industry is also found in other industrializing countries, in which MRO activities have normally begun with services to the countries’ military aircrafts and subject to a broader development strategy (import-substitution manufacturing and/or overseas procurement) of the national security system. The dual nature imposes further

---

1 The concept of developmental state was first raised based on the experiences of the Japanese economy in its rise to compete with the US, the manufacturing leader of the world up to the 1980s. It represents a development strategy based on the active intervention of the state rather than a free play of private firms as represented by the experiences of UK, USA and other capitalist economies in the past century. It has so far evolved into an established alternative development strategy for latecomer economies, since the publication of a World Bank work, *The East Asian Miracle: Economic Growth and Public Policy* (Oxford University Press, 1993) and after the continuous developmental success of Korea, Taiwan, Singapore and China Mainland.
obstacle to the public availability of information. In addition, it is also not easy to amass firm-level data and information. Apart from publicized information for the publicly listed firms in Singapore and Hong Kong and causal journalist reporting, one could only rely on peer comments and some interviews to understand the performance and strategies of the firms, their competition locally and globally and their relationship with the respective governments. Interviews have proven to be difficult.\(^2\) The study has combined few interviews (as the number of MRO providers are few in the two island economies, reflecting the oligopolistic nature of the industry) with participation in MRO industry conference to gather information and improve understanding of the Global and local performance of the MRO industries. The industry conferences were attended by practitioners and intended for intra-industry communications and discussion. They proved to be more informative and down to earth for this study, a very good counterbalance to official news release type of information provided by the governments and firms.

There have been few sectoral studies of the MRO industry in its evolution in the academia. Probably it is because of the difficult access to information of the industry. Recently many industrializing countries have started to set up their own MRO industry even from the scratch. They should have policy arguments for the new ventures. Unfortunately their policy documents for the MRO industry have not been available to the general public.

The study is not a quantitative or empirical-formal one. The MRO industry has always been peripheral, but integral, to the manufacturing and transport services of aerospace industry. It has evolved through a detachment and spilling off from airlines and OEMs (Original Equipment Manufacturers). It is also highly regulated and certified and thus having a very high institutional barrier to entry. As such the number of firms engaged in the industry is relatively small and they are divided into tier hierarchy with strong dependence relationship between firms in different tiers. The more appropriate approach to the study of the development/evolution of any one national/local MRO industry would be qualitative, relying on the analytical weaving of disparate data and information into a convincing narrative. This study is explorative in nature and hopes to provide the groundwork for more vigorous study later.

1.3. General conceptual approach

1.3.1. The general approach of the study is to see the local MRO industry not narrowly restricted to the industrial boundary, but rather as a part of the local sectoral

\(^2\) In a previous project on MRO in China, the researcher had found it extremely difficult to set up interviews with major MRO providers in China on technical issues. Difficulty is not found only in China or Hong Kong, but overseas. A Dutch scholar, Daniel Vertesy, complained while doing his doctoral research on ‘Interrupted innovation: emergent economies in the structure of the global aerospace industry’, ‘Aerospace manufacturers work hard to hide valuable information on innovation and production’ in his ‘Propositions to the thesis’.
innovation system that is embedded in the national innovation system and is in interaction with the global market forces in the sector and beyond. The focus is not just on local firms as firms in the liberalized world are foot-loose and are in many cases subsidiaries of and joint ventures multinational corporations that may have little legal or moral commitments to local territorial development. Even for firms that are registered locally and independent of multinational or transnational corporations, they may not also be committed to longer term local territorial development under the corporate motive of profit maximization or optimization unless they are bound by ownership to the state, so that interests of territorial state would override the profit motive of the corporate entities. In other words, the profit motive of private firms may often be in conflict with the interests of the territorial society, which normally treasures local employment, knowledge development, and other socio-economic attributes over a longer duration than the short-term preoccupation of the private firms. The latter is sticky, while the mobile is mobile at least potentially and possible under the liberalized local and global economic regime. It is out of the consideration of the latter that the concept of sectoral system has been developed.

1.3.2. Industries are seen as sectoral system. The building blocks of a sectoral system consist of regimes of knowledge and technologies, demand conditions, actors and networks, and most important institutions. These elements interact in non-predetermined ways. As such the interactions generate a variety of outcomes in innovative and market performance, growth and industrial structure and dynamics that are also evolving over times sometimes with discontinuities and interruptions, causing the decline of particular local sectors(s) even despite of aggressive government support and intervention.

1.3.3. A concept of post-catch up is also introduced in this study to address the technology intensive and institution-sensitive nature of the MRO industry. The concept emerges mostly from the experiences of Korea in recent decades and is related to a new entry strategy for industrial upgrading.

---

3 Keun Lee & Franco Malerba, Catch-up cycles and changes in industrial leadership: windows of opportunities and responses of firms and countries in the evolution of sectoral systems, Research Policy, 46 (2017), pp. 338-351.
6 Take the technological frontier semiconductor industry as an example, the Korea had impacted on this industry along with other industrialized countries, but the strategies each adopted by Korea, Japan and even the USA and Europe are different. One may see the Korean attempt is post industrial catch-up in competition with industrialized countries, but even among the industrialized countries their respective strategies are not identical, indicating that at least there may be different strategies possible and available for the development of particular industries (as the technological frontier one of semi-conductor in this case but may also be found in other industries at different product cycle stages). See Robert C. Leachman & Chien H. Leachman, Globalization of semiconductors: do real men have fabs, or virtual fabs? In Martin Kenney & Richard Florida, eds., Locating...
1.4. Definition of scope

1.4.1. This project focuses on the maintenance, repairs and overhaul (MRO) of commercial aircrafts. MRO is an integral part of the aerospace industry and is basically an aftermarket business. It consists of four major sub-sectors: line maintenance, component maintenance, engine maintenance and airframe heavy maintenance. Aircraft modification or conversion is also included.

a) Line maintenance is comprised primarily of maintenance checks that are conducted to ensure the aircraft is fit for flight, but do not remove the aircraft from service. These include ‘A’ and ‘B’ level checks as well as day-to-day operational maintenance such as troubleshooting, defect rectification and component replacement including pre-flight checks, transit checks, daily checks, and weekly/overnight checks. They are normally conducted on site and are labour intensive in nature with typically 85% of total costs accounted for by labour.

b) Component maintenance is the maintenance, preventive maintenance and alteration of individual components installed on an aircraft, such as on the airframe, engine or propeller. Because a typical aircraft is comprised of thousands of components from dozens of Original Equipment Manufacturers (OEMs), the component maintenance market is extraordinarily fragmented. This problem is compounded by the varying complexity of the numerous components which have to be certified by OEMs and a large part of the activities is performed by the OEMs. Component maintenance also bears the heavy financial burdens of inventory stockpiling and management to provide quick delivery to globalized locations.

c) Engine maintenance includes off-wing and preventive maintenance, as well as alterations that restore an engine to designed operational specifications. As a result of the increasingly-specialized knowledge required for maintaining advanced engines, engine MRO work has to be certified by the engine OEMs and mostly done by them directly. This is essentially a material intensive process with labour only accounting for 15-20% of total cost. Large elements of it call for highly specialized equipment and tooling. It is thus a highly capital and technology intensive and skill intensive.

d) Heavy maintenance includes regularly-scheduled inspections, preventive maintenance and alteration of the entire aircraft including airframes, components and accessories. The comprehensive airframe maintenance involves work carried out on a regular, scheduled basis to inspect, maintain, repair, and conduct preventive maintenance for the airframe’s structure and cabin interior and is

represented by C and D checks. It is highly skill labour intensive. Industry estimate two-thirds of heavy maintenance costs are labour costs.\(^7\)

e) Modification is varied like conversion work of passenger aircraft and passenger product modifications (interiors and in-flight entertainment systems). The aircraft manufacturers have to approve conversion processes, parts and procedures.\(^8\)

1.4.2. Figure 1 illustrates the relative shares of the different sub-sectors of global MRO in 2013 and a projected composition in 2022 as reported by IBM.

![Figure 1: Global MRO Spend](image)

The disproportionate share of engine overhaul in total MRO business is a function of the higher technological sophistication of the sector as well as the oligopolistic nature of the sector market, which are dominated by engine OEMs through their technological controls and property right protection by means of certification sanctioned by regulatory bodies at international, national and local levels and the pricing controls over engine parts\(^9\). Line maintenance is the least technology and skill labour demanding and thus has the most competitive sectoral market (with low entry barriers) and the lower share in the total value added created in MRO businesses. However, the whole MRO industry is basically governed by strict government regulations, which provide an additional entry barrier to each of the sectoral markets. Even for line maintenance it is different from traditional labour intensive

---


\(^9\) Costs of engine repair parts (from major OEMs like GE, Pratt and Whitney and CFM International, etc.) have been rising at an average rate higher than the MRO revenues as a whole. This is a typically oligopoly pricing. McFadden and Worrells, op. cit.
manufacturing industries and services. A major constraining factor for MRO is that under current government regulations (e.g. US Federal Aviation Regulations), aircraft maintenance is ultimately the responsibility of the airline in terms of airworthiness responsibility. No matter it is done in house or offshore it does not relieve the airlines’ of the responsibility. Line maintenance is therefore, despite its labour intensive nature, still done mostly in-house by airlines or airline-affiliated MRO firms.

1.4.3. Composition of MRO in China

Table 1: Composition of MRO in China in 2010

<table>
<thead>
<tr>
<th>Total MRO revenues</th>
<th>US$ 2320 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Of which, engine repair and overhaul</td>
<td>40%</td>
</tr>
<tr>
<td>line maintenance</td>
<td>20%</td>
</tr>
<tr>
<td>heavy maintenance &amp; conversion</td>
<td>20%</td>
</tr>
<tr>
<td>components</td>
<td>20%</td>
</tr>
</tbody>
</table>

Source: 中国民用航空局飞行标准司, 民用航空维修行业“十二五”发展指导意见, June 2011.

Table 1 is the sub-sector breakdown of the total MRO revenues in China in 2011. It represents the pattern of a developing country that relies on offshore maintenance. MRO providers within China at that time managed only 25% by value of the MRO demand generated, and in particular over 70% of engines repairs of Chinese airlines had to be performed overseas.11

1.4.4. Maintenance constitutes around 10% of the total operating costs of airlines12 and contributes over 10% of the total value added of aerospace industry. The actual share of maintenance in national or local aerospace industries depends on the specific paths of development, e.g. whether comprehensive or not and whether manufacturing takes precedence over maintenance, taken by the economies concerned. Singapore is probably the more extreme case for late comer industrialization that targets MRO as the main driver for local aerospace industry with it constituting 90% of the industry’s value added.

2. General theoretical background

2.1. Product cycle theory and the flying geese model

10 McFadden and Worrells, op.cit.
11 中国民用航空局飞行标准司, 民用航空维修行业“十二五”发展指导意见, June 2011.
2.1.1. Conventional theory of product life cycle as exemplified by the works of Raymond Vernon is founded upon the assumption of a linear transition of products through a process of standardization and maturity driven by efficiency improvement by means of increasing economy of scales and lowering production costs. From this basic assumption products could be replaced by industries and the theory could be developed into a staged industrial development for nations. Either the competitive pressure from the standardization and diffusion of products and industries to new locations with lower production costs or innovations or a combination of both has created also a linear pattern of industrial upgrading and catching-up for leaders and followers. The process is aided by trade and investment with technology transfers included to a certain degree. Using the post-war industrialization of Japan, Akamatsu developed the flying geese model as a further elaboration of the product life theory to explain the evolution of intra- and inter-industry cycles. Kojima further adopted the model on regional transmission of industrialization in East Asia and the flying geese pattern of industrial diffusion and/or catch-up include Japan as the head geese, followed by newly industrializing economies of Korea, Taiwan, Hong Kong and Singapore and extended further to Southeast Asian economies at the bottom\(^{13}\).

2.1.2. Ozawa further elaborated the flying geese model for the “alignment of nations along the different stages of development”:

a. A policy for industrial upgrading (IU) from low value-added (low productivity) to higher value-added (higher productivity) industries.

b. A policy for import-substitution-cum-export-promotion (IS-EP)—i.e., to replace imports with domestic output and later to promote exports.

c. A policy to transplant comparatively disadvantaged industries or industrial segments onto other countries (mostly nearby developing Asian countries) so as to retain higher value-added industries at home, a process that may be identified as comparative advantage recycling (CAR) and adaptive efficiency enhancement (AEE) at home.\(^{14}\)

Figure 2 shows evolution of product cycle from consumer goods to capital goods that incorporates Akamatsu’s the first two alignments of industries that could be translated into alignment of nations. It appears that there is a linear sequencing for the evolution that has often been interpreted as staged development model.

---


2.1.3. In a more recent treatise, Ozawa pointed out the misconceptions with regards to the flying geese model:

a) Japan is not the lead goose, but the US is;

b) There has not been a master plan. It is more a historical accident – not purposeful, well ordered and coordinated;

c) It is not a unique Asian phenomenon. Similar patterning could be found in the European past – ‘America started off as a copier and stole British technology. Thus the hierarchical order could be altered.\(^\text{15}\)

Upon this new interpretation, Ozawa argued on the basis of the actual performance of latecomer countries in Asia that ‘the progression can be modified, its order sidetracked and its pattern made non-monotonic and non-linear. … The consequence is no longer an exact duplication of moving up the ladder of development, but stages co-mingling and even stages skipping occur.’\(^\text{16}\) And in the case of the leading goose of the USA and subsequently Japan, there is also a chance of the interruption of the process of continuous industrial upgrading, for example, in the form of financialization and de-industrialization, creating further disruptions to the options of industrial catch-up for the follower economies.

2.2. Industrial catch-up or post industrial catch-up – alternatives for latecomer industrialization


\(^\text{16}\) Ibid., p.51.
Korea has been a typical case of late-comer industrialization or industrial catch-up spearheaded by a developmental state. It has been so successful that it has not only graduated into the club of developed nations of OECD, but even entered into the world technology frontiers in some industrial products and sectors, including semiconductors, TFT-LCD, and smart phones in the 1990s. Its R&D spending as a ratio to GDP has risen to 4.03% in 2011, the second highest among all nations, and total expenditures was US$ 12.6 billion, the 6th largest in the world despite its smaller population. However, it is faced with the catching-up pressure from behind of rapidly industrializing countries like China. At the same time its success in the catching up of some of the industries left it with no readily available model or practice to imitate, nor existing technologies that it could import for further advancement. The double squeeze in the global market has thus obliged it to find a dissimilar approach to further industrial development and innovation. It is out of this context that Korean scholars differentiate industrialization strategy of late-comers into a catch-up phase and a post catch-up phrase. The MRO industry never belongs to the rank of traditional labour intensive industries for the industrial cat-up phase. It could well be an industrial sector befits the post catch-up phase. Korea has recently also include the MRO industry as part of its general efforts to upgrade its aerospace industry. According to the Korean scholars, the technology and organization paradigm of industrial catch-up is top down developmental state policies that are mostly based on imitation to become fast followers. Broadly speaking, the catch up innovation activities focus on expanding the production output by applying existing technologies to the acquisition and assimilation of imported technologies and to improve them. Post catch-up strategy includes emergent innovation from the late-comer through the combination of existing technologies and new technological trajectories. However from case studies, Choung, Hwang & Song have suggested accumulation of technological capabilities with knowledge embedded in it would be the foundation for any transition to post catch-up development. More specifically they sum up some characteristics. Firstly, for post catch-up development, late-comer firms enter at all stages of the product life cycle. Secondly, different entry stages demand different policies and favour different types of firms. Thirdly, the transition is a organized evolution process with co-evolution of different innovators and institutions essential for the success. It breaks the rank of the flying geese as well as the product cycle assumption inherent to it. Its success offers an alternative option to late comer industrialization.

3. **General background to the industrialization of Singapore and Hong Kong**

3.1. The development of advanced industries has been widely seen as a tool to boost economic growth of countries and regions all around the world, because the “high-end” activities involved can generate a relatively higher level of revenue in general. The


18 Ibid., p. 165.
exclusiveness of implicit knowledge or know-how, the astonishing amount of expenditure required by research and development activities, the huge potential of productivity growth and the scale economies lead to high entry barriers into the sector, and the oligopolistic or even monopolistic competition result in high level of profit. Whether a place can obtain a favourable position in the value distribution hierarchy in the world economy is determined by its own proportion in the world’s “high-end” economic activities. This explains the income disparity between the developed and less developed countries and regions nowadays. To make sure the places they administered will be the “winners” in the fierce global competition, governments around the world put much effort on shaping robust skill-based and technologically advanced industries with strong market leaders that continue to drive innovation. They are not satisfied with merely following the steps of others along the ladder of success in industrialization like under the flying geese model. Competitive pressure has created a strong motivation especially on the part of the government, which is probably more intended towards the mindset of a developmental state in a democratic political setting, to leapfrog the staged transition of industrial upgrading.

3.2. Hong Kong and Singapore are no exception from other developing economies. Since the late 1990s, the governments of both cities have emphasized the development of advanced industries as an essential part of their growth strategies. In 1998, the Committee on Singapore’s Competitiveness under Singapore government released a Competitive Report containing measures with an objective to transform the city into an advanced, knowledge-based economy. Singapore positioned the city as the a production base of foreign multinational enterprises and local enterprises for high value-added products and as a hub for providing manufacturing-related services for their subsidiaries in the region, and put much effort on developing competencies in various parts of the manufacturing value chain. Almost at the same time, Hong Kong tried to stimulate the development of hi-tech industries. Soon after the establishment of Hong Kong SAR, the first Chief Executive, Tung Chee-wah, proposed to inject HK$ 500 million to government funds to encourage commercialization of technologies in business sector. In the Policy Address of the next year, he further proposed to set up a fund of HK$ 5 billion to support any programmes that help the application of new technologies in the commercial sectors. He also made a proposal to set up the Hong Kong Applied Science and Technology Research Institute as a means to enhancing Hong Kong’s competitiveness in technology-based industries. Unfortunately and probably being the chief cause of the subsequent failure to deliver, the SAR Government has never attempted to develop a list of targeted advanced industries for promotion. As such either the government or investors inside and outside Hong Kong have not been provided with a

---

clue to the particular industries or products that would attract possible policy and fiscal support from the government. Nor is there a chance for the formulation and development of specific institutional supports and changes that would render a favourable environment for new industries. This is in great contrast to the Singaporean experience. Former Chief Executive Donald Tsang’s policy of 6 major industries at the end of his term in office in 2014 did not help as the 6 industries were hardly new industries or industries; they were mostly areas with ambivalent and overlapping industrial boundaries. Again he did not establish any industry specific programmes or measures for their promotion.

3.2.1. As expected, Hong Kong’s attempt to drive economic growth with innovation and technology in recent decades was not successful. The development of Cyber Port and Science Park did not help much to build up a strong foundation for the development of advanced industries. Hong Kong has not had a government department specializing in formulating comprehensive strategies and sectoral policies to foster the development of innovation and technology until the recent establishment of Innovation and Technology Bureau in 2016, almost 20 years after the establishment of the SAR Government to replace the Colonial administration of Britain. It is still yet to produce a strategy development document for Hong Kong’s innovative industries. Its effectiveness of providing support for the key players to collaborate on innovation activities is still an unknown. Now, our city is facing risk of a prolonged period of slow growth. It is particularly obvious when China’s economic growth is slowing down. The engine of growth of the local economy seems to be gradually losing power. The real growth of GDP of Hong Kong in the past few years fell below the 10-year average figure (3.9%).22 Most notably, Singapore’s GDP is expected to overtake Hong Kong’s by 2025, despite its much smaller population– Singapore has already surpassed Hong Kong in terms of per capita GDP at the dawn of the millennium!

3.2.2. One should not think that Singapore’s catching up is just by chance. The city managed to establish several fast growing advanced industries in the past two decades. Engineering, together with other new key industries including chemicals and electronics, became the focus of Singapore government in the 1990s. Compared with Hong Kong, where more than 92% of GDP comes from services, Singapore’s economic structure are much more diversified and balanced. Manufacturing’s contribution to the economy is as large as one-fifth of GDP, and almost 90% of its value added comes from the new key industries.23 As Singapore hosted a wide range of businesses particularly in higher value-added activities, the city has succeeded to yield a higher growth.

3.3. The difference in the trajectory and the subsequent outcomes of the development of innovation and technology industries in the two island-states may stem from:

23 Department of Statistics of Singapore.
a) Path dependence and the lock-in effect of the industrialization that started early in the 1950s in Hong Kong and 1960s in Singapore;

b) The role of government and active government and public sector in the promotion of both the relevant capabilities for the industries and the industries themselves.

3.4. Industrialization in Hong Kong started in the 1950s with the relocation of China’s labour intensive industries, mostly consumer goods industry in textile and garment, from various Mainland cities. It may be considered as historical accident, an historical outcome shaped by events occurring outside the territory of the colonial state, but as the borderland of the China Mainland, it may also be inevitable for economic and political spillovers from the Mainland to go mostly to Hong Kong, which until the 1950s had not an effective border controls or registration of Chinese crossing the boundary with the Mainland. The industrial relocation from the China Mainland differed from the foreign direct investment in manufacturing in latter days as it was the entire production system, with firms, labour, technology in the form of equipment, capital and management as well as the inter-firm relationships and overseas market connections, being relocated altogether. The relocation was facilitated by massive migration with the population of Hong Kong jumped from less than 1 million in the late 1940s to almost 3 millions within one decade. Starting from relocated textile industry, local industry was incorporated in the flying geese model dominated by exports to the USA and evolved gradually according to the traditional product life cycle theory. In the early 1960s, according to the government, Hong Kong had become the largest manufactured product supplier in the developing world, at a time when Europe and Japan were still in post-war reconstruction and other developing countries caught in the struggle for political independence. By the 1970s Hong Kong had moved towards higher value added and more technology demanding electronics industry and was at the head of the newly industrializing economies of Korea, Taiwan and Singapore. Hong Kong was the first of the Asian economies, apart from Japan, to enter into electronics manufacturing with FDI from US firms.24

3.4.1. Although at the peak at around 1980, manufacturing was the largest economic sector in Hong Kong providing half of the local employment, the achievement had little to do with the support of the colonial government, which had adopted a laissez-faire policy with no industrial policy. Public finance resources, despite fiscal surpluses and large accumulated reserves, of the government was also constrained without any conscious efforts to improve local infrastructure and human resources to keep abreast with the demand of the fast growing metropolitan city and the increasing competition to its industry and trade from other newly industrializing economies that used developmental state as the main instrument for industrial catch-up and a more balanced and sustainable local economic development. The keeping of Hong Kong

---

government reserves in London as part of British foreign exchange reserve further prevented investment in local industries and capabilities by government. Without the participation of the public sector and facilitating measures introduced by the government as well as the demonstration effect therefrom, investment in manufacturing had been kept low, disallowing any chance of investment led industrial upgrading and improvement within and beyond the existing industrial establishments. Even diffusion from few foreign direct investments had not created the normal outcome of spill-over effects on local industries. The transition from labour intensive light industries to capital and technology intensive industries is fundamentally a process of development of industrial and business capabilities and knowledge. R & D spending of an economy could be a good indicator of its advantages or chance for transformation. In the early 1990s, R & D expenditure as a ratio of local GDP was 0.1% in Hong Kong against 2.17% in Korea, 1.73% in Taiwan and 1.12% in Singapore. R & D activities had almost been non-existent in Hong Kong. As studies have shown, most manufacturing firms in Hong Kong used mature or even obsolete production equipment and technologies to combine relatively cheap inputs to produce goods designed by overseas firms. This was the worst type of export-oriented industrial processing (other known as the OEM approach) with little learning even through emulation and adaptation to local conditions. At its peak in the early 1980s, Hong Kong had lost its advantages of first mover over Korea, Taiwan and Singapore, which all started industrialization 15 years or more behind Hong Kong. Manufacturing activities in Hong Kong had started to migrate to other low-cost production localities in Southeast Asia and mostly devastatingly to China in the 1990s. The relocation was so complete that Hong Kong had experienced a drastic deindustrialization in the new century. Without R & D and competitive human capital, once it lost its cost advantages, Hong Kong could not keep any higher valued added production process locally for supporting and coevolving with the relocated production phases. Nor it has any chance to build upon the leftover stocks of knowledge and human capital for any new industrial ventures. It represents the most extreme case of deindustrialization that is not caused by wars or calamities. Tables 2 illustrates the clear pattern of deindustrialization of Hong Kong in macroeconomic data. In the case of the two indigenously developed manufacturing industries from the transplanted industrial resources from the China Mainland, Clothing and electronics,

25 Ibid., p.65
26 Motorola’s investment in semiconductor in Hong Kong around 1980 attracted a clustering local firms, but with insufficient technological know-how to meet Motorola’s requirement, these firms failed to obtain production contracts from Motorola and had to be content with designing and producing low-ended integrated circuits, most for local customers including the toy industry. Ibid., p.61. Despite its early move compared with Korea and Taiwan, Hong Kong had never developed a local semiconductor industry around large foreign leaders and soon dissipated with no further investment from Motorola and others from both overseas and locally. The laissez faire policy of the colonial government, including the reluctance to develop local technologies capabilities and human capital from education and science and technology investment, was responsible for missing the golden opportunity of industrial upgrading and transformation.
27 Ibid., p. 69.
both saw their peaks of local employment in 1988.\textsuperscript{29} They were unable to rescue the rapid industrial decline in the territory. The recommendations for reverse value chain, reverse product life cycle imitation, and process capability specialist strategies in the 2000s\textsuperscript{30} were just wishful thinking and had practically no impact in the local industrial scene.

Table 2: The role of manufacturing in the local economy of Hong Kong, 1980-2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Manufacturing share in local GDP</th>
<th>Manufacturing share of local labour force</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>23.7%</td>
<td>50.1%</td>
</tr>
<tr>
<td>1985</td>
<td>22.1%</td>
<td>36.1%</td>
</tr>
<tr>
<td>1990</td>
<td>17.6%</td>
<td>27.7%</td>
</tr>
<tr>
<td>1995</td>
<td>8.3%</td>
<td>18.4%</td>
</tr>
<tr>
<td>2000</td>
<td>4.8%</td>
<td>6.2%</td>
</tr>
<tr>
<td>2005</td>
<td>2.9%</td>
<td>4.7%</td>
</tr>
<tr>
<td>2010</td>
<td>2.0%</td>
<td>3.3%</td>
</tr>
<tr>
<td>2015</td>
<td>1.2%</td>
<td>2.7%</td>
</tr>
</tbody>
</table>

Source: *Hong Kong Statistical Yearbook*, various years. GDP figures have been available only since 1980.

3.4.2. The result had thus been a truncated process of industrialization, not an elevation to a higher stage of economic development as the government and many scholars have argued. The territory has along with the loss of the hardware of the industrial apparatus, seen its accumulation of industrial knowledge and innovation capability in manufacturing over the past decades also dissipated.

3.5. The Singapore development trajectory of industrial catch-up – sectoral focuses as a means to overcome the dictation of product life cycle theory

3.5.1. Given their similarities in the size of territory and population as well as the openness of the economy which is the legacy of the British colonial rule and their respective role in the 19\textsuperscript{th} Century - 20\textsuperscript{th} Century Treaty port system in Asia, it is interesting and meaningful to do a comparison between Hong Kong and Singapore, aiming at finding out why Singapore MRO industry, together with other fields in the economy, can finally outperform Hong Kong. The two outcomes led by two different development paths demonstrate that comprehensive industry policy is necessary for the development of advanced industries. Undoubtedly, Singapore and Hong Kong were latecomers with inferior technological capabilities in the mid-20\textsuperscript{th} Century. The product life cycle theory implies that those latecomers can only produce “matured”


\textsuperscript{30} Yu Fu-Lai, Tony, op.cit.
products with the help of mass production techniques after standardization. And it forms the basis of the traditional hierarchical order in Asia depicted by the flying geese model. Due to the followers’ lack of the capacity to develop new product concepts, they can only benefit from the transfer of production of commoditized goods from the leaders. However, the effectiveness of such passive industrial upgrading as a means to foster the long-term economic growth of the followers is questionable. They can never be the first mover and cannot enjoy the super-profit brought by the monopoly at the early stages of the cycle. The reality produces the situation on the opposite: they usually have to face fierce market competition with other late-comers, which would definitely suppress the rate of profitability. This put the latecomers at an unfavourable position in the hierarchy of global value distribution.

3.5.2. Clearly, to catch up with advanced industrial countries and regions, latecomers cannot just sell mature products to the international markets, nor to become the manufacturing base of multinational enterprises occupying the lowest-value-added segment in the global production network. They have to overcome the dictation of product cycle theory. The only hope falls on formulating policies that effectively break the rank of the flying geese, rather than simply moving up the ladder of development. This requires the latecomers to accumulate technological capabilities to overcome the barriers on the path of industrial development.

3.5.3. Similar to Hong Kong, Singapore adopted an outward-orientation industrialization policy at its earliest stage of development and turned itself into a regional manufacturing production base for export markets through the intermediacy of multinational corporations and their agents. The share of manufacturing sector in total local output grew from 16.6% in 1960 to almost 30% in 1979. The expansion of manufacturing activities might still not be comparable with the rate and scale of Hong Kong in the same period. However, the performance of sector was already good enough to provide employment opportunities to Singaporean people. The industrial sector accounted for about 27.5% of the employment in the same year. It was reported that there has been full employment since 1970 and the city virtually eliminated absolute poverty.

3.5.4. A major characteristic of the Singapore’s manufacturing sector at that period was its heavy reliance on foreign multinational enterprises. In the 1970s, wholly and majority foreign-owned enterprises contributed more than 70% of the output and about 84% of the exports of Singapore’s manufacturing sector. The dominance of foreign multinationals was maintained through 1980s and 1990s. This is because Singapore does not have significant indigenous technological contribution to the manufacturing activities. The fast growth of industry was actually based on the exploitation of

32 Ibid.
33 Ibid.
relatively cheap and unskilled labour by foreign capital. A variety of labour-intensive industries were established to supply low-value-added products to overseas consumers. Even in the mid-1980s, the production lines of factories in Singapore were still producing products that are designed abroad. In a way, Singapore had followed the footsteps of Hong Kong but lacked the massive relocation of industries from the Mainland and the foundation for local industries to evolve, albeit at a slow pace, with industrial upgrading.

Table 3: Foreign owned entities in manufacturing industry of Singapore, 1968-92

<table>
<thead>
<tr>
<th></th>
<th>1968</th>
<th>1975</th>
<th>1992</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total output (in US$ billion)</td>
<td>21.75</td>
<td>126.10</td>
<td>772.75</td>
</tr>
<tr>
<td>Wholly or majority foreign-owned</td>
<td>46.1%</td>
<td>71.3%</td>
<td>74.2%</td>
</tr>
<tr>
<td>Total exports (in US$ billion)</td>
<td>n/a.</td>
<td>72.00</td>
<td>469.06</td>
</tr>
<tr>
<td>Wholly or majority foreign owned</td>
<td>n/a.</td>
<td>84.1%</td>
<td>84.5%</td>
</tr>
</tbody>
</table>


3.5.5. The role played by the US-based capital in the development of manufacturing sector of Singapore is particularly noteworthy. During 1965-1969, the sharp increase of investment of the US-based multinational enterprises not only led to the emergence of the US as the largest investor in Singapore’s manufacturing sector, but also triggered a structural change in the economy of the city. A significant proportion of the fund was pumped into the electrical and electronics industry, with an objective to keep up with the boom in demand for consumer electrical appliances and electronic components in America and western European countries. The US’s investment to the sector was doubled between 1967 and 1968, and the volume further increased by almost 2.5 times in the following year.

3.5.6. As a result, the electronics industry became the mainstay of Singapore’s manufacturing industry in the following years, in terms of both output and job vacancies. Nevertheless, operations in the industry in general involved only assembly of goods, rather than high-value-added upstream activities. Since the 1980s, the multinational enterprises have begun to produce computer components and peripherals in Singapore. Particularly, the investment of the US multinational enterprises promoted the upgrading and diversification of production in Singaporean electronics industry, and this could be reflected by the higher capital expenditure and output per worker. It is at this time that local industry in Singapore was catching up with Hong Kong. The trend did help the city’s manufacturing sector to take on a more hi-tech look, but it did not have significant impact on Singapore’s status in the

hierarchy of global value distribution. Technological progresses were still mostly observed in developed countries where specialized in R&D activities and product design.36

3.5.7. The example of electronics industry had alerted Singaporean decision makers. Although such industrialization can foster domestic economic development and create job vacancies for citizens, the prosperity of Singapore was not guaranteed in the long-run, let alone catching up the leaders in the flying geese model. Because low-skilled manufacturing activities were extremely footloose, Singapore might face the risk of deindustrialization, probably like in Hong Kong starting from the 1980s. Once the enterprises face the pressure of rising wages and rents, they might transplant their manufacturing activities to low-cost production localities as a means to maintain the competitiveness of their products in the international market. A big wave of international industrial transfer did appear after the adoption of “open door” policy of the mainland of China beginning from the early 1980s.

3.5.8. Singaporean government’s history of formulating concrete policies to promote high-value-added industries may be dated back to 1970. With growing shortages of labour and later of other resources, multinational enterprises began to relocate to nearby regions of low-cost localities, 37 and created the condition and motivation for Singaporean government’s commitment to foster the development of high-value-added production and processes were gradually reinforcing. Tax concessions to pioneer and non-pioneer industries were first adjusted. In the late 1970s, policies like the Product Development Assistance Scheme were introduced, aiming at developing domestic applied research and product developing capabilities, as well as indigenous technology. 38 Of course, incentive programmes and preferential policies are not a sufficient condition for industrial upgrading. If a strong high-value-added strategy could simply be based on them, then Hong Kong should have been developed into the world’s leading hi-tech centre. One should not forget that Hong Kong government did put effort on providing innovating firms with subsidies and cheap spaces. Of course, the dream has never come true: high-value-added manufacturing has never become the pillar in Hong Kong economy. Instead, the evolution of Hong Kong’s industry was interrupted by deindustrialization and financialization.

3.5.9. The major difference between Hong Kong’s and Singapore’s catch-up arise from the latter’s adoption of a strategy by focusing on the development of its sectoral system of innovation. To develop complex, hi-tech industries, latecomers generally face difficulties in overcoming substantial initial physical and human capital barriers.

Adoption and diffusion of new knowledge and technology are most important in the process. Its degree of success is also critical to the future introduction of new products and efficiency-improving process, as they are all knowledge-based and knowledge-intensive. Efforts have to be made to establish a learning system which facilitates the actors to acquire existing technologies and good practices. Thus, a coordinated and cross-sector targeting by industrial, science, technology and innovation, higher education, and trade policies is crucial. Obviously, this cannot be achieved without a significant degree of government intervention.

3.5.10. The development of a sectoral system of innovation is far more than mere fiscal allocations. R&D activities have been closely and systematically monitored in Singapore. The government sets up rules to appropriately coordinate and facilitate as well evaluate the interactions between actors in the system. Economic Development Board (EDB), which is responsible for explicit innovation and FDI strategies, together with National Science and Technology Board (NSTB), which is responsible carrying the strategies into two-year technology plans, has regularly met with the private sectors since 1987. Under this corporatist, tripartite structure, information exchange and idea flows between the state agencies, employers as well as employees were intensive. This has allowed the innovation system of Singapore to adapt to changes and competitive challenges in an effective way. With the support of the innovation system, Singapore has begun to offer strong incentives to boost the total R&D expenditures to above 2% of GDP, the average level of OECD economies, since the first decade of the millennium.

Table 4: Performance of innovation system of Singapore, 1990-2014

<table>
<thead>
<tr>
<th>Year</th>
<th>ERD/GDP (%)</th>
<th>Researchers in Science and Engineering</th>
<th>Hi-tech Exports’ Share in Mfg. Exports (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>0.81</td>
<td>4,329</td>
<td>39.9</td>
</tr>
<tr>
<td>1995</td>
<td>1.10</td>
<td>8,340</td>
<td>54.1</td>
</tr>
<tr>
<td>2000</td>
<td>1.82</td>
<td>14,483</td>
<td>62.8</td>
</tr>
<tr>
<td>2005</td>
<td>2.16</td>
<td>21,338</td>
<td>56.9</td>
</tr>
<tr>
<td>2010</td>
<td>2.01</td>
<td>28,296</td>
<td>49.9</td>
</tr>
<tr>
<td>2014</td>
<td>2.19</td>
<td>32,835</td>
<td>49.3</td>
</tr>
</tbody>
</table>

Source: National Survey of R&D in Singapore, various issues, Agency for Science, Technology and Research; World Development Indicators Online

3.5.11. Another attempt on coordinating the interactions between actors is to remove barriers to the flow of knowledge and know-how embedded in the people. For example, Singaporean government has cooperated with private enterprises to set up advanced training centres to support the development of higher value-added industry since 1973. It has also carried out education reforms in higher education. Most notably, in the

---


early 1970s, Singapore University started to expand its facilities and launched a number of master programmes in engineering.

3.5.12. As a step to effectively utilize the technologies acquired and hence the development of priority industry, Singaporean government has turned itself into an important investor in domestic manufacturing sector. Three government-wholly-owned holding companies were established to channel the majority of investments. One of them were Sheng-Li Holding Company which engaged in aerospace industry. It was formed under the Ministry of Defense in January 1974.

3.5.13. Here a question is raised: Will the sectoral system of innovation automatically foster the growth of new industry and generate economic value as expected? The answer is “no”! The innovation system needs a target as the basics of all rules: designing a product. This is because the value of any technologies can only be realized in form of products. Hong Kong gives us a lesson of innovation without target.

3.6. The ability and experience to effectively utilize the technological knowledge, i.e. the “technological capabilities”, is obviously “tacit knowledge” and can only be acquired and accumulated through the process of product design. As the higher education institutions in Hong Kong do not deal with the challenge of practical application, a simple increase of research and development expenditure would not enhance the technological capabilities of the city, let alone any fundamental change on the development track of advanced sectors in Hong Kong.

3.7. Many people may think that knowledge of science forms the foundation of innovation and technology development, and thus fundamental research is a key of the development of advanced sectors. It is true that the knowledge and training provided by colleges and universities are important to nurture creative professionals who are latter involved in R&D activities, but the development of science does not necessarily lead to new technologies. In fact, the relationship between science and technology is not one-way or linear in its development. Just at the opposite, science and technology are intertwined. The role of science as an independent process of disclosing knowledge has been gradually weakening. Instead, it is becoming a response to the technological advancement led by developing and manufacturing of products. The field of aerospace is simply one of the best examples. The concept of aircraft was first developed and realized, and improvement of product generates a series of scientific problems, stimulating the search of solutions and hence the rise of aerodynamics. And it is in the process of solving the practical industrial problems that new ideas and new technologies have been founded, enriching the pool of the fundamental research and knowledge.

---

42 路風 (2006), 《走向自主創新：尋求中國力量的源泉》，桂林：廣西師範大學出版社。
3.8. Therefore, the appropriate starting point for latecomers to build up an advanced sector is to concentrate resources on developing a particular product with market potential. In the case of Singapore, of course, an industry policy package with aircraft as a core was formulated. The choice of sectors can be path dependence. The product concerned could range from labour-intensive type of simple products to sophisticated and complex products which involves numerous parts and components and maybe bettered named as systems. The choice of industrial products is actually represent the motive for industrial upgrading, moving up the industrial ladder and trending towards products of greater complexity. Greater complexity means also greater parts, components and sub-systems embedded, the production of which would involve more and more producers. This is the reason that modern manufacturing has moved from vertical integration to horizontal integration in the form of value chain system that is also expanding across national boundaries into globalization. Aircraft or aerospace industry produce a product of complex system that is more advanced than automobiles and involved thousands of production processes and services. From electronics industry to aerospace industry it represents a big quantum jump. It may be more difficult and ambitious than the Korean venturing into automobile and semiconductor industries after the 1970s.

3.9. Industrial upgrading through targeting more complex products may create a national or regional system of production and services, but if it is not coming out of organic growth of local industries and knowledge/innovation system, there would be gaps in the value chain system, which need to be filled up by borrowing from outside (imports and joint ventures) and massive investment to create the new capabilities and agencies for the task. The “end products” also provides a goal for the R&D activities of firms involved and other local institutions.

4. The Singaporean trajectory of the development of the MRO industry

4.1. The conventional wisdom tells that the best industrial upgrading is to enter into the core of the activities of the new industry. It is apparent that Singapore should penetrate the aerospace industry from the upstream, i.e. aircraft designing and manufacturing. Most importantly, designing aircrafts based on own technological knowledge can generate intellectual property and the ability to utilize and protect them. This guarantees that the domestic manufacturers gain independence on the technological path and will not be controlled by its foreign competitors or counterparts. Even Singapore manufacturers immediately do not have technological capabilities to produce all the parts and processes, they are still able to make cost-reasonable choices on purchasing the substitutes from local or overseas specializing firms, and thus to keep their products competitive in the international markets. In the long-run, in theory at least, the domestic demand of parts and processes will stimulate R&D activities in the downstream. Local complementary capabilities will eventually be developed.
4.2. Entering a new industrial sector from the downstream could hardly fulfil the prerequisite of continual survival of manufacturers, i.e. its technological independence and innovation capabilities. China’s experience in the development of indigenous automobile industry offers a good lesson. With an aim to enhance the technological capabilities of domestic automobile industry, Chinese government adopted a “market for technology” policy in the 1980s. It was hoped that Chinese manufacturers, by sharing the market resources with their foreign counterparts, could acquire the advanced technology knowledge from them. The learning process was designed based on a wishful linear model: Foreign technologies were introduced through assembly of overseas-designed automobiles, and hence strengthen the ability to design and produce parts; As an automobile consisted of thousands of parts, it was hoped that the knowledge accumulated from the production of parts would transform into technological capabilities and capacities of manufacturing a complete automobile locally. The strategy has proven to be a failure by now. First, as technological capabilities were the tacit knowledge to utilize the explicit technology knowledge, they could only be acquired through product development and design – i.e. learning by doing the whole process, not by specializing only in the assembling. Second, localization of parts manufacturing could only enhance manufacturing capabilities. Domestic parts manufacturers simply produced parts designed overseas and only for those less complex ones, implying that the newly-built parts manufacturing sector would also be actually controlled by the foreign enterprises, and the local industry could not develop the capabilities for the core components and parts and the technologies embedded in them.  

4.3. The characteristics of aircrafts and economic environment faced by Singaporean aerospace sector are very different. It is might not be wise for Singapore to adopt the “perfect strategy” which takes the development of aircrafts as a product to build up technological capabilities and an advanced manufacturing sector. Singaporean government has to think of a “second-best choice”.  

4.3.1. First of all, it would take a very long time to accumulate the necessary experiences and knowledge to develop a complex and sophisticated product like aircraft, and it is not easy, if not impossible, for a small economy with limited resources, to leapfrog from industrial processing of electronics industry to aerospace industry, which is also undergoing rapid technological upgrading and changes. There are also formidable barriers for the entry into the aerospace industry that is increasingly under oligopolistic controls in the international market. The objective of Singapore to develop the aerospace sector is to foster sustainable economic development by industrial upgrading. Singapore’s wish is to quickly change its status in the value distribution hierarchy in the global economy.

43 路風 (2006), 《走向自主創新：尋求中國力量的源泉》，桂林：廣西師範大學出版社。
4.3.2. The product of aircraft is extremely expensive to develop and to build. Singapore will need access to a large enough market to recoup the huge development and manufacturing costs. By entering into the aerospace industry Singapore forced to look beyond the domestic market for the eventual delivery of the products and for funding beyond the fiscal ability of the city-state. However, with the developed countries like the USA and the EU still dominating in the aerospace industry and there is still no sign for them to migrate to more advanced industries so that they could invite developing economies to fill up the gap left in the aerospace industry. By entering into the aerospace industry Singapore in fact has to face the fierce competition and obstruction from the established firms and their national and regional governments. The failure of Indonesia is a good lesson for Singapore.44

4.3.3. One may suggest that Singapore can actually cooperate with the foreign manufacturers. By setting up a joint venture, Singapore gives part of the profit of developing aircrafts away to foreign countries in exchange for access to foreign market. However, such strategy would not help. If Singapore has the ability to design and manufacture aircrafts, then the rational choice of foreign market players should be to keep the aerospace sector of Singapore as weak as possible, rather than cooperation. By doing so, the high profit of manufacturers in developed countries could then be guaranteed. If Singapore does not have sufficient technological capabilities to develop complete aircrafts, the foreign partner will simply introduce its own technology into the joint venture and protect it rather than transfer it to the joint venture and Singapore. As a result, all the aircrafts manufactured by the joint venture would be based on the design of foreign partner, and Singapore would not have chance to improve the related R&D activities. Under such situation, Singapore would not gain any independence to utilize the technology and innovate because the city had no property rights. Without consent of foreign partners, Singapore could not make any amendments even if they detected any flaws in original design of aircraft. In this case, Singapore would repeat the story of China’s automobile industry in the last century, and become a low-value-added assembling plant of the western first movers.

4.3.4. Its strategic imperative, therefore, necessarily focuses on the dynamic of continuously creating, maintaining and refreshing a sustainable competitive advantage in aerospace. From the outset, the crucially important decision was then taken of not developing and producing complete aircraft. Instead, an alternative and probably more rational strategy has been adopted to target the high value services associated with MRO, modification, upgrading and technology insertion.45

4.3.5. It should be noted that Singapore’s MRO sector could get a certain degree of independence on technological path. In theory, Singapore would have to face a risk

---

that the original equipment manufacturers (OEMs) could shut MRO service providers completely and dominate the MRO market. However, this scenario never comes to be true. Before deregulation liberalization in recent decades, MRO had been performed mostly in house by airlines. Entry of OEMs into the MRO sector had been small because the market was captive and outlay investment had been huge. Only with the liberalization that increases competition between airlines and drives the need for acceleration in cost cutting, and the rise of low cost carriers, which do not have the luxury of having in house MRO facilities, that independent MRO sector emerges as a growing business, and in the process invites OEMs to venture into it for additional revenues and higher profit margins.

4.3.6. The government plays a substantial and sometimes crucial role in shaping the development of local MRO industry. Government offers incentives and institutional facilitation for local technological learning at the firm level and through local education and science and technological organizations. Local airlines are normally state-owned and/or state regulated and their development depends essentially on all kinds of direct and indirect government supports, as they rely on public goods, like land, air space, cross-border institutional and policy cooperation and coordination. Despite the global orientation of airlines and aerospace industry, they are also highly localized and bound by local regulations enacted and sanctioned by the government. The government and its policies are therefore a crucial factor in the development of aerospace industry including the MRO sector within it.

4.3.7. After its independence, Singapore has to have its own military force. This has created the demand for military products and services. The Republic of Singapore Air Force was a crucial client for maintenance and upgrade services for its fleet. The government set up a holding company, Sheng-Li Holding, to oversee the development of national defense industrial capacity. In the early 1980s, former aviation contractor firms were reorganized to establish Singapore Aircraft Industries (SAI), a holding company under Sheng-Li Group. The subsidiaries of this state-owned firm engaged in various areas of aerospace industry, and they had benefited the expansion of fleets of the national air force and their maintenance. At the beginning of the 1990s, the military segment still made up of two-third of the business of Singapore Technologies Aerospace (ST Aerospace), the aerospace arm of the Singapore Technologies Holdings (formerly Sheng-Li Group), which was privatized for raising capital for further expansion by that time. Perhaps the most important subsidiary of SAI was SAMCO which was specialized in avionics and systems overhaul. The company quickly accumulated capabilities to re-engine and upgrade fighters and gained opportunities to collaborate with various famous foreign aerospace companies, particularly those from the US, by accomplishing the refurbishment programmes commissioned by Republic of Singapore Air Force throughout the 1980s and 1990s.

Certainly the relative smooth accumulation of technological capabilities has also been facilitated by the defense cooperation between Singapore and the USA and its allies. As warned by Vertesy, mere military push is not an accurate explanation for the development of a local aerospace industry, but it has been instrumental to the eventual establishment of capabilities to compete in a dynamic commercial segment.\footnote{Vertesy, D., \textit{Interrupted Innovation: Emerging economies in the structure of the global aerospace industry} (Doctoral Thesis). Maastricht University, Maastricht, 2011.} Capabilities including skilled engineering labour acquired in the military segment could be readily transferred and used in the civilian segment of the market.

4.3.8. The national carrier, Singapore Airlines (SIA), was established by Teamasek Holdings, another wholly state-owned holding enterprises set up by the government around the time of the launch of Sheng-Li. SIA operated a fleet of just 10 aircrafts to 22 cities in 18 countries by 1972, the year of its establishment.\footnote{"Singapore Airlines to make history with new 'Capital Express' service", Website of Wellington Airport, 20 January 2016, \url{https://www.wellingtonairport.co.nz/news/singapore-airlines-to-make-history-with-new-capital-express-service/}.} The Singaporean government focused on expanding the international route network due to the fact the city lacked a domestic air transport market. It signed a series of air services agreements with the governments of counties including Australia, New Zealand, Indonesia, Malaysia, Japan, India, Taiwan, Korea and the Philippines during 1973-1997, paving the rights for further negotiations for air traffic rights.\footnote{"Singapore Airlines", Singaporeanforpedia, website of National Library Board of Singapore, \url{http://eresources.nlb.gov.sg/info/pedia/articles/SIP_1705_2010-08-10.html}.} Under comprehensive commercial strategy and high standards of operational excellence, SIA succeeded to grow into one of the most admired international airlines in the world. The fast pace of expansion could be seen from the exceptional financial performance of SIA. Between the financial years of 1972-1973 and 1983-1984, the earliest years of its operation, the revenue of the group increased eight-fold. Up till now, SIA as a group has always been profitable in all of its years of operation. It was also remarkable that SIA’s freighter subsidiary, Singapore Airlines Cargo, was ranked the sixth in terms of freight tonne-kilometres delivered in 2013, even though the group was not in the world’s top 10 in fleet size or in terms of the number of destinations.\footnote{Fwa T.F. (ed.), (2016). \textit{50 Years of Transportation in Singapore: Achievements and Challenges}. Singapore: World Scientific Publishing Co. Pte. Ltd.} The expansion efforts were complemented by enlargement and renewing of the SIA’s fleet. Today, SIA is operating one of the industry’s youngest fleets of 106 aircrafts with an average age of seven years and eight months,\footnote{The website of Singapore Airlines, \url{https://www.singaporeair.com/en_UK/au/flying-withus/our-story/our-fleet/}.} covering a total of about 60 destinations in more than 30 countries.

4.3.9. The expanding SIA aircraft fleet gave room for the rise of SIA Engineering, which later became the largest competitor in domestic MRO industry for ST Aerospace. SIA Engineering was originally the Engineering Division of the airline, and has been responsible for the airline’s engineering works for decades. In the 1990s, this state-
owned enterprise expanded its MRO operation aggressively, probably to take advantage of the booming MRO demand in the post-deregulation eras. With its six hangars and 22 in-house workshops in Singapore, it is now providing 50 airlines passing through the city with complete MRO services and integrated MRO solutions. The enterprise also acquired the status as a separate subsidiary in 1992 with an objective to increase presence abroad. Various countries and regions, including the US and Hong Kong, quickly became the strongholds of its internationalized business. As a result, Singapore now has two world-class leaders in heavy maintenance of aircrafts, and the prospect of Singapore’s aerospace sector would not depend on the survival of only one home-grown MRO firm.

4.3.10. The rapid expansion of SIA also fueled the development of the domestic airport, and the further development of Singapore into a global aviation hub, as well as a regional financial centre. This has in turn provided an important basis for a stable demand for MRO with advantages brought by scale economies. Singapore faced a limitation of space for future expansion of its original civil airport, Paya Lebar Airport, in the early 1970s. A piece of newly-reclaimed land located at the eastern edge of Singapore near the original Changi Airbase was selected for the new airport, Changi Airport. By the time of its opening, Changi Airport was ranked with Narita Airport in Tokyo of Japan as the largest airport in Asia. The heavy investment on infrastructure finally turns into an invaluable asset rather than a financial burden of the city. The development of Changi Airport is financially sustainable, and its profitability can be comparable to those hi-tech firms. It is now not only the home of SIA, but also a base serving more than 100 airlines to approximately 380 cities in about 90 countries and territories worldwide. Although the total traffic of Changi Airport still falls behind Hong Kong International Airport as it is further away from China and other prosperous East Asian destinations, it is already the sixth busiest airport in the world in terms of international passenger traffic. The fast growth in both passenger and cargo air traffic, of course, was foreseen in planning by Singapore, and therefore Changi airport was built with the world’s largest column-free hangar at that time to satisfy the growing demand for maintenance of the fleets of the airlines.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>freight (million ton-km)</td>
<td>68.2</td>
<td>544.1</td>
<td>1652.5</td>
<td>3,686.9</td>
<td>6,004.9</td>
<td>7,571.3</td>
<td>7,121.4</td>
<td>6,154.4</td>
</tr>
<tr>
<td>Passengers carried</td>
<td>1,248,900</td>
<td>3,826,900</td>
<td>7,046,400</td>
<td>10,779,300</td>
<td>16,704,341</td>
<td>17,744,017</td>
<td>24,859,825</td>
<td>33,290,544</td>
</tr>
<tr>
<td>Registered carrier departures</td>
<td>21,300</td>
<td>32,500</td>
<td>30,500</td>
<td>51,600</td>
<td>71,042</td>
<td>77,119</td>
<td>131,722</td>
<td>176,912</td>
</tr>
</tbody>
</table>

Source: World Development Indicators Online.

53 Airports Council International’s figures.
4.3.11. One should not ignore that the de-regulation of aviation industry in the US in the late 1970s was a key for Singapore’s success in expanding demand for MRO by taking advantage of the globalization of airline markets. At that time, the US broke down the domestic regulatory structure and initiated the liberalization of international services on a bilateral air service agreement basis based on “Open Skies” agreements, which allowed the countries involved to freely provide services between each other. Although progress on open market was rather slow, international controls did move towards “Open Skies” formulations. Remarkable recent effort has been made on forging consensus on the ASEAN Open Skies Agreement and it eventually became valid in April 2016. The long run impact of the “Open Skies” agreement could be demonstrated by simple economics. Capacity constraints in the regulated market are eliminated by the “Open Skies” agreement, and barriers for airlines to restructure network of routes and coordinate activities are removed. Competitive pressure stimulated the airlines to concentrate their traffic at international hub airports to lower operating costs. This will push up the demand for aviation services and the number of aircrafts making stop at Singapore,\(^{54}\) and hence create a favourable environment for further expansion of local MRO demand.

4.3.12. Furthermore, the development of Singapore’s MRO sector could not be so successful without the support of market resources and technology knowledge from the US. Of course, the US operators provided ST Aerospace with significant demand. The demand was large to use all the hangars in Singapore. ST Aerospace has induced to establish presence in the US as a means to further expand in the world’s largest MRO market and to take advantage of the massive cost reduction drive of US airlines to regain profitability through outsourcing of MRO activities. However, particularly important, the US has also provided Singapore with primary channels to acquire the necessary technological knowledge through foreign direct investments and licensing. In addition, the US signed a bilateral Airworthiness Agreement with Singapore in 1981 to mutually accept national certificate. MRO activities cannot be carried out without stable supply of equipment and parts. Undoubtedly, the US was one of the most important sources of aerospace parts for Singapore. Although the scale of local aerospace production was increasing over years and the city managed to stimulate the exports of its products, the volume of part imports is still significantly larger than domestic output. In 2015, Singapore’s total aerospace imports was amounting to over US$17 billion, about 87% larger than the value of local production. Singapore has long been the top market for the US aerospace parts. According to the statistics released by the US government, parts represented just over 80% of the imports of the city’s aerospace products between 2005 to 2014; 65% of Singapore’s part imports came from the US.\(^{55}\)


\(^{55}\) International Trade Administration of the U.S. Department of Commerce.
Table 6: Singapore’s Aerospace Market, 2010 and 2015

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total market size</td>
<td>8,255</td>
<td>13,582</td>
</tr>
<tr>
<td>Total local production</td>
<td>5,650</td>
<td>9,263</td>
</tr>
<tr>
<td>Total exports</td>
<td>6,420</td>
<td>13,072</td>
</tr>
<tr>
<td>Total imports</td>
<td>9,025</td>
<td>17,391</td>
</tr>
<tr>
<td>Imports from the US</td>
<td>5,315</td>
<td>8,744</td>
</tr>
</tbody>
</table>

Source: International Trade Administration of the U.S. Department of Commerce.

4.3.13. To satisfy the astonishing market demand for equipment and parts, leading aerospace OEMs and suppliers from all around the world are increasingly willing to tap the Singaporean talents to carry out a variety of MRO-related manufacturing activities in the territory under the protection of intellectual property offered by Singaporean government. They began to take actions with an aim to work more closely with key customers and suppliers to enhance their own global positions. The establishment of regional headquarters by the transnational aerospace enterprises in Singapore will also increase the demand for locally-produced smaller parts and engineering services. Thus, Singapore government took this chance to integrate the MRO service with manufacturing activities. The provisions of financial incentives encouraged the emergence of aerospace industry clusters consisting of MRO service providers as well as suppliers of parts and component at Loyang near Changi and Jurong. To further the development of a locally integrated aerospace cluster, Singapore puts much effort on launching a new dedicated aerospace park, the Seletar Aerospace Park, for functions of MRO and manufacturing; business and general aviation activities; as well as research and education. Ready-built facilities have been introduced to accommodate new entrants. The Business Aviation Complex inaugurated in November 2011 was a popular one. It was assigned to provide light industrial, engineering service and warehousing. Over 70% of this seven-storey building was occupied within the first months of its operation. Since 2007, the Seletar Aerospace Park has attracted more than 130 enterprises, including Rolls Royce. This world’s leading engine manufacturer established its first facility outside the UK to produce hollow titanium wide chord fan blades there. The manufacturing of the specialist component would create employment opportunities for the city, but more importantly, the company’s presence encouraged the diffusion of foreign technology knowledge. Rolls Royce set up an Advanced Technology Centre in its Seletar Campus to support the manufacturing activities there and delivers solutions to its own R&D network. It also cooperated with A*Star (formerly named as NSTB), National University of Singapore and Nanyang Technological University in the fields of R&D and talents training.

56 Aerospace Factsheet 2012, EDB of Singapore
4.3.14. Thanks to the vibrant MRO service and related manufacturing activities, the growth of aerospace-related R&D activities in recent years were significant. A growing pool of research talents are nurtured by a number of industry-oriented research institutes and universities. This serves to educate relevant expertise and talents and creates a platform for further innovations and knowledge generation.

4.3.15. Policies concentrating on the MRO segment and one manufacturing cluster has a vital role in the emergence of aerospace industry in Singapore and the state’s catching up with the developed countries. As a result, in the first half of the 1980s, Singapore’s aerospace industry outperformed other latecomers. The value-added was higher than that of Brazil, where the government focused on local aircraft design. Singapore was also able to boost the level of labour productivity of the aerospace industry surpassing that of the US.  

4.3.16. In recent decades, built upon the initial groundwork of the past, Singapore has already successfully become one of the leading global players in global aeronautical MRO industry. Comprehensive nose-to-tail MRO services, including airframe maintenance, engine overhaul as well as aircraft modifications and conversion, are provided to international airlines by domestic and foreign leading players. As the city manages to capture the fast-growing demand for aviation-related services from the Asia-Pacific market, the development of its MRO sector outpace other competitors in the region. The area and population of Singapore was just approximately 2% and 20% of those of Taiwan respectively, which also has an independent military establishment larger than Singapore, and thus the city’s gross output of the aeronautical industry was undoubtedly lower in the mid-1990s. However, after 10 years, the output value of Singapore’s aeronautical industry has already become three times of Taiwan’s, of which 90% coming from MRO business. Singapore’s MRO output is now over a quarter of the whole region’s total, and takes the first place in the rapid-growing Asia’s MRO market, surpassing even Hong Kong, the traditional MRO hub of the region. Two local MRO enterprises, ST Aerospace and SIA Engineering Company Limited, have managed to grow into the five largest airframe maintenance companies in the world in terms of man-hours work.

4.3.17. Thanks to the MRO sector with about one-tenth of the world market in hands, the contribution of aerospace industry to domestic economy of Singapore is undoubtedly significant. Since the 1990s, the industry has grown at an average rate of 10%. A record output of S$8.7 billion was recorded in the year of 2012. The aerospace sector provides more than 19,900 jobs to the city, of which about 90% are skilled jobs.

During 2009-2015, the real growth of value added per worker in manufacturing increased by 5.9%, along with an average 5.5% growth of nominal median monthly income of full-time employed residents, demonstrating the exceptional capability of capturing value of a pool of skilled, well-trained and experienced personnel. The gap between the median gross monthly income of full-time employed residents in manufacturing and of those outside was enlarging as a result, increasing from S$298 to S$1,488.

4.3.18. Evidence shows that the aerospace manufacturing activities generate considerable spillovers to the rest of economy. The input-output tables, estimation conducted by Singapore shows that an increase of S$1 million in final demand for manufacturing will generate S$81,000 value added of non-manufacturing and 0.65 nonmanufacturing jobs.

4.3.19. It is embarrassing that Hong Kong was once actually the major MRO hub in the region before the rise of Singapore. It was reported that the quality and the efficiency of MRO services provided by Hong Kong was unmatchable by neighbouring countries and regions. Hong Kong was especially well-known for its expertise in the past in repairing legacy aircraft like Lockheed L-1011 TriStar, which had relatively higher failure frequency due to its complexity in design. At that time, the most difficult MRO tasks, particularly the repairing of engines, were subcontracted to Hong Kong while Singapore was usually responsible for easier tasks. Until the 1990s, foreign aerospace enterprises, especially those from Singapore, came to Hong Kong to compete for local MRO talents. Unfortunately, Hong Kong now bears no favourable comparison with Singapore MRO industry, although Hong Kong is still one of the leading players in the global MRO market. For instance, in the field of airframe maintenance, which is the source of about 40% revenue of HEACO group, Singapore International Aerospace has already become the global champion. Taking another Singaporean MRO player, SIA Engineering Company Limited, into account, Singapore is actually double the size of HEACO in terms of maintenance man-hours sold.

---

60 Economic Survey of Singapore 2015.
61 Ibid.
62 Ibid.
63 吳邦謀 (2016) .《香港航空 125 年》 , 香港：中華書局(香港)有限公司。
64 Memories of HAECO Veterans, the website of Hong Kong Memories, http://www.hkmemory.org/haeco/en/home/.
65 吳邦謀 (2016) .《香港航空 125 年》 , 香港：中華書局(香港)有限公司。
66 Memories of HAECO Veterans, the website of Hong Kong Memories, http://www.hkmemory.org/haeco/en/home/.
5. Trajectory of Hong Kong’s MRO industry

5.1. If Hong Kong wishes to tap the potential of MRO segment as a means to transform domestic economy, it is surely important to find out the reasons of the relative stagnant of the Hong Kong’s MRO industry in recent years. We might get the answer by reviewing its development trajectory over the past decades. Compared with Singapore, technology knowledge learning was simply a commercial behaviour of a particular private-owned industry player. Hong Kong government has seldom participated to building up a sectoral system of innovation or a downstream manufacturing cluster. Once the knowledge acquiring was not boosted and monitored by the government, the industry player, which was in general risk-adverse, might stop the costly learning process and adopt a strategy focusing on short-run interests, blocking the path of long-term development of the domestic MRO segment and especially its spill-over beyond the corporate boundary.

5.2. “China factor” has exerted significant influence on the aviation development of Hong Kong from the demand side since the late 1940s. After the Second World War, there were two Hong Kong-based airlines in the British colony in southern China, namely Swire Group-controlled Cathay Pacific and Jardine Matheson-owned Hong Kong Airways. Each of them received MRO support from service provider founded by the same parent group, Pacific Air Maintenance & Supply Company (PAMAS) and Jardine Air Maintenance Company (JAMCo) respectively. Aviation service demand from the mainland of China was vital to the survival of MRO service providers in Hong Kong, particularly for the latter. It was because the colonial government divided the local aviation market into two and Hong Kong Airways were given the franchise for the routes to the north. These routes were filled with the rich escaping from the civil war in the mainland of China and facilitated by the absence of any regulation of in-migration of the Chinese as established under treaties in the 19th Century. However, after the establishment of People’s Republic of China in 1949, with the US sanctions against China and the obligation of the British government to follow suit, aviation connection between Hong Kong and the mainland was prohibited and it had hit a strong blow to Hong Kong’s aviation sector. Facing the shrinking demand, JAMCo was merged with PAMAS to form Hong Kong Aircraft Engineering Company Limited (HAECO) in 1950.

5.3. The military factor

5.3.1. Before providing rooms for expansion of HAECO business again in the 1980s, the favourable effect of “China factor” on the expansion of HAECO came from the supply of skilled labour. Besides employing those locally trained technicians from the Hong Kong Technical College (later became The Hong Kong Polytechnic University), the HAECO became since the 1950s a large melting pot of Chinese experts and talents coming to the south, absorbing those from China National Aviation Corporation, Central Air Transport Company and Air Force of the former Republic of
China. Although many of them were not capable of speaking English or even Cantonese, their expertise and knowledge simply made themselves qualified for the posts in departments of administration, planning and material supply. A majority of the remaining were galvanized iron artisans. As pointed out by the old staff of HAECO, the talents from China National Aviation Corporation accounted much for the advantage of HAECO on handling process related to the use of galvanized iron. The transplanted Chinese skilled labour formed the core factor for the early development of MRO industry in Hong Kong.

5.3.2. Similar to Singapore, the military demand for MRO processes has provided Hong Kong a foundation to build up the technological capabilities since the 1950s. Because of its special geographical position and geopolitical status of Hong Kong at that time, HAECO served the air force of various western countries of the US and UK alliance, rather than providing MRO support exclusively to the Royal Air Force of the Hong Kong’s suzerain. The breaking out of the first military action of the Cold War, Korean War, made the US a major client. The HAECO received many orders of repairing the US military transport aircrafts and fighters. The US direct military intervention in the Vietnam War in the 1960s further strengthened the role of Hong Kong as aircraft repairing centre in Asia. It was reported that the workload of the related repairing processes was large. Testing was conducted every Saturday and the US pilots would drive the aircrafts to leave Hong Kong on the next day.

5.4. However, the first opportunity for HAECO’s expansion was actually offered by the great development of civil aviation in Hong Kong starting from the mid-20th Century. First, Cathay Pacific rapidly expanded its network of routes and led to a significant growth in traffic volume, especially after the acquisition of Hong Kong Airways in 1959. Between 1962 and 1967, the annual growth rate of business was about 20% on average. The growing fleet of aircrafts if Cathay Pacific, which has also been under the ownership and management of the Swire Group, provided HAECO with stable MRO demand for the accumulation of technological capabilities. One of the notable examples was introduction of the Convair 880M, an American narrow-body jet aircraft, by Cathay Pacific. It pushed HAECO to acquire the necessary technology knowledge and become fully equipped to support the jet airliner by 1965. Second, the colonial government carried out projects to build a new runway to facilitate the landing and takeoff of large aircrafts and to upgrade the lighting and monitoring systems, with an objective to make Kai Tak Airport into an international airport. Kai Tak Airport eventually grew into one of the busiest international airports in the world, once ranked the third in terms of passenger traffic and ranked the first in terms of freight traffic. This offered HAECO access to various wide-body aircrafts and the only Hong Kong-based MRO provider gained opportunities to further broadened its technological capabilities. Two events symbolled the success of HAECO. First,

following the trebling of its turnover and workforce in the first decade after the merger, HAECO became publicly listed on the Hong Kong stock market in 1965. Second, to serve the strong MRO demand from aircrafts passing through Hong Kong, the construction of Asia’s largest aircraft maintenance hangar in Kai Tak Airport was kicked off by HAECO in 1968. This was proved to be a correct business decision as the amount of business from international airlines was increasing throughout the 1970s and 1980s.

5.5. The “China factor”

5.5.1. The China factor played an important role in shaping the development of Hong Kong’s aviation again in the late 1970s. The adoption of “open-door policy” and the implementation of economic reform made Hong Kong a window for the mainland to connect with the outside world. The subsequent economic expansion, liberalization and rapid growth in foreign trade and foreign direct investment have created huge demand for overseas air transport of China. Air traffic by and with China Mainland have increased exponentially. Given the lagging behind of MRO investment and facilities in China’s airports, many Chinese aircrafts have been sent to Hong Kong for repairing and maintenance and HAECO has been in the right location to capture these new MRO demands.

5.5.2. As in the past, “China factor” has not always positive and brought challenges to the MRO development of Hong Kong. The uncertainty about the future of Hong Kong generated significant “push effect” on out-migration of local MRO talents. Many of them moved to the other countries like the UK, the US and Australia before the return of Hong Kong to China, but HAECO as a private enterprise did manage to retain the valuable human resources. The company helped its employees to acquire residency in foreign countries. HAECO bought a repairing company in Australia and sent those who wanted to leave Hong Kong to work there. After they have got the passports, the company let them to choose whether to work in Hong Kong or Australia. At the same time, HEACO introduced foreign talents to Hong Kong through an intermediate. These measures secured the size of workforce to maintain efficient operation of the world-class company. HAECO was still a very well-known MRO provider around the world for its efficiency and high quality of service in the 1990s.

5.6. It is a pity that HAECO has not triggered the development of an advanced manufacturing sector in Hong Kong as part of the innovation and production/value chain for the much expanded MRO businesses. HAECO has indeed developed certain capabilities in parts manufacturing within the boundary of its group. However, there was no comprehensive integration between the MRO provider and local downstream manufacturing activities as existed in Singapore. One example was that the once robust electronics sector in Hong Kong was relocated to the north of the Shenzhen River, rather than upgraded to manufacture high value-added parts for the direct or indirect support of the local MRO industry and services. Hong Kong firms have been
mostly small and medium sized ones and they share the same problems of lacking vision and commitments for R&D investments for upgrading like their counterparts in other economies. The neighbouring Pearl River Delta region has also offered very attractive policy and market incentives for the continuous horizontal expansion of Hong Kong’s SMEs. Unlike their counterparts in Singapore and other late-comer industrial economies, manufacturing firms from Hong Kong have not faced the same extent of market competition pressure from adverse cost structure for upgrading. They have simply moved en bloc across into the Pearl River Delta region. The failure of the British colonial government and later the HKSAR government) to develop the local sectoral system of innovation including skilled manpower training has prevented the MRO industry to move up the industrial ladder. Nor it faces the pressure of competition to invest in local facilities. Without government’s direct involvement like the case of many other industrializing economies including not just Singapore, the monopolizing firm of HACEO has not the motivation and interest in invest in Hong Kong to capitalize on its first mover advantage in the greater China and even the booming Asia. Instead like SMEs firms in Hong Kong and multinational corporations from overseas, it simply expands horizontally in major airports in the China Mainland.

5.7. Until the construction of a new airport at Chak Lap Kok, the colonial government had not formulated any comprehensive planning to develop complementary and supporting manufacturing cluster for the local MRO sector. Nor did it think about setting up large-scale aviation industrial park in the vicinity of local airport. It was a strange scene for the Kai Tak Airport to be surrounded closely by residential buildings! The new international airport in operation in 1998 has not any spatial planning for large scale development of aerospace industry. There have been space allocated earmarked for the hangars of the large local MRO firms, but no planning or even conceptual planning for the development of aerospace industry cluster(s) at the new airport, or the disused old airport. With deindustrialization of the economy since the 1990s the Hong Kong government, whether colonial or SAR, has never a policy preference, not to mention industrial policy or actual planning, for continuing building up manufacturing industries for industrial upgrading. Even for the few science parks and cyber part, they are restricted for R & D and business activities and against any manufacturing.

5.8. It is natural for HAECO to behave like any other footloose local and non-local firms. It has been owned by the Swire Group, which as being part of the British colonial establishment before 1997 certainly would have political risk concerns about the transfer of sovereignty. From the very beginning, despite the fact it had served the military needs of MRO services, it is not state-owned and has never exhibited a commitment and obligation to develop the economy of Hong Kong by means of further grow the aerospace industry even for serving its own MRO businesses in Hong Kong. To tap the potential of the China Mainland’s market, HEACO set up joint venture at Xiamen of Fujian Province in 1993 and open more and more hangars
there, rather than increasing the number of hangars in Hong Kong. It could be argued that the limited space in the Hong Kong International Airport (HKIA) currently in use at Chap Lap Kok made it difficult to increase the number of hangars there. However, to the best of our knowledge, HAECO did not formally ask for the assistance of the Hong Kong SAR government on tackling the issues. It is also hesitating in taking up the earmarked space for hangars in the airport. Nowadays, the capacity of HAECO Xiamen is now one time more than Hong Kong in terms of the number of hangars, let alone other centres and facilities performing functions like parts manufacturing. All of the six hangars are double bay wide-body hangars and able to accommodate simultaneously 12 wide-body and 5 narrow-body aircrafts. The airframe service sold manhours of HAECO Xiamen has already surpassed HAECO Hong Kong, and the growth rate of profit was two times faster than that of Hong Kong. Xiamen-based expansion strategy may be an appropriate business decision for HAECO, but it simply prevents Hong Kong as a whole from further capturing the MRO demand from the mainland of China in the long-run and leveraging on it for expansion into other MRO aftermarket production and services. This is not favourable for the employment of local skilled labour and the accumulation of technological capabilities in Hong Kong. Unlike the Singapore state owned MRO firms, which are fully committed to the growth of the MRO and aerospace industry of the city-state, HAECO and its subsidiaries in Hong Kong behave more like foreign firms with little local commitment, apart from its own profitability. One might even say it has the 1997 syndrome like all other British firms that prospered during the colonial period in Hong Kong.

Table 7: Hangars at Hong Kong and Xiamen

<table>
<thead>
<tr>
<th></th>
<th>Hong Kong</th>
<th>Xiamen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of hangars</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Number of aircrafts</td>
<td>12 wide-body, 5 narrow-body aircrafts</td>
<td>7 wide-body, 2 narrow-body aircrafts, 2 Boeing 767 aircrafts</td>
</tr>
</tbody>
</table>

Source: HAECO.

Table 8: Review of operations of HAECO, 2015-2016 (in HK$m)

<table>
<thead>
<tr>
<th></th>
<th>2016</th>
<th>2015</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAECO Hong Kong</td>
<td>194</td>
<td>167</td>
<td>+16.2%</td>
</tr>
<tr>
<td>HAECO Americas</td>
<td>(238)</td>
<td>(158)</td>
<td>-50.6%</td>
</tr>
<tr>
<td>HAECO Xiamen</td>
<td>94</td>
<td>69</td>
<td>+36.2%</td>
</tr>
<tr>
<td>TEXL</td>
<td>196</td>
<td>149</td>
<td>+31.5%</td>
</tr>
<tr>
<td>Share of:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAESL and SAESL</td>
<td>218</td>
<td>194</td>
<td>+12.4%</td>
</tr>
<tr>
<td>Other subsidiaries and joint ventures</td>
<td>52</td>
<td>56</td>
<td>-7.1%</td>
</tr>
<tr>
<td>Adjusted Profit</td>
<td>516</td>
<td>477</td>
<td>+8.2%</td>
</tr>
</tbody>
</table>

5.9. HAECO has complained that the Hong Kong business of HAECO has suffered from the shortage of skilled labour. The stable growth of air transport in recent years boosted the demand for MRO talents, but the problem here is why the quantity supplied of talents could not meet the quantity demanded. Hong Kong has access not only to local skilled labour, but also talents from outside by means of various schemes of importation of recognized talents in shortage. It is observed that the wages offered by HAECO Hong Kong to its technicians are rather low, compared with other industries in Hong Kong. The starting salary of a maintenance trainee is about HK$13,000 to HK$15,000. Taking the remote location of HKIA (implying higher transportation costs in terms of time and money) and the demanding job nature into account, such a level of salary cannot be considered as competitive. The Chairman of HAECO Division of Staffs and Workers Union of Hong Kong Civil Airlines has given a set of interesting figures. In the era of Kai Tak, the airport had about 5,300 MRO workers serving in only one hangar. In the era of Chek Lap Kok, the number of workers increased slightly to 5,700, but serving three hangars. There reflected the difficulties of HEACO in expanding its workforce, even if we have isolated the impact of automation. One may wonder whether the relatively slower growth of HAECO’s own business has its origin from the corporate strategy rather than a formidable constraint imposed by labour shortage. In fact, there has been widespread shortage of skilled MTO labour in most late-comer economies, Singapore being no exception. It may create some pressure on corporate development, but never a large enough factor that may dislodge development and growth at a time of strong growing demand in Asia Pacific.

5.10. As the major MRO group in Hong Kong, the fortune of the group is somehow tied with the welfare and development of the local MRO. The Hong Kong government is somewhat obliged to support it for the functioning of the world leading airport. It is a pity only lately that the government through its supports to local university and Vocational Training Council starts to train more technicians and engineers for the MRO sector but at a scale much much smaller than the in-service training provided by HAECO. It would be inadequate to fill up the vacancies left by those existing staff leaving the MRO firm for better jobs of overseas MRO firms and of other local firms. Until now the government has not seen MRO or aerospace industry as the target for innovation and high tech industries to be promoted and for public supports.

5.11. As HEACO has adopted a “going-out” strategy horizontal expansion for years, the performance of the group will inevitably be affected by changes in the overseas business ecology. For instance, the proposed new airport at Xiang’an in Xiamen is likely to bring a big shock to the operation of HEACO’s largest subsidiary of airframe MRO in the city. If the new airport will commence operation in 2020 as the municipal government announced. HAECO will have to invest heavily for removing its local facilities to the new airport. In addition, the group is suffering from its bad performance in the US market. HAECO Americas, a recent corporate acquisition, recorded a loss of HK$523 million in 2016. Even excluding the impairment charge,
the loss was still amounting to HK$238 million, 50% larger than 2015 figure. The loss was so large that it cannot be covered by HAECO Hong Kong or HAECO Xiamen individually. If the financial condition of HAECO Americas continues to deteriorate, any budget-cutting measures by the group may affect the MRO operations in Hong Kong.

6. The outstanding achievements of Singapore and Hong Kong MRO industry

6.1. Both MRO industries in Singapore and Hong Kong have become regional hubs in Asia Pacific. The performance of their MRO firms has been leading in the world, especially in the more labour-intensive and outsourced airframe sub-sector. ST Aerospace and SIA Engineering and HAECO are among the top 10 airframe MROs in the world in terms of man-hours performed, with ST Aerospace for many years as the top with the largest man-hours done within one year. HAECO Group comes always in second and third, but with a large distance from ST Aerospace until when it acquired the Timco of the USA in 2014. ST Aerospace is 100% third party MRO, while SIA Engineering serves Singapore Airlines and HAECO has about 20% business from Cathay Pacific of the same Swire Group. One could say the Singaporean and Hong Kong MRO firms dominate the global scene. In terms of revenues HAECO is about the same as ST Aerospace, but they have been lagging behind major MRO firms from Europe like AFI KLM E&M and Lufthansa Technic. The disparity in financial performance may be a result of their over-reliance on labour intensive and thus less profitable airframe MRO business. SIA Engineering has even greater reliance on the business of line maintenance and has probably caused the decline of its airframe business. To overcome challenges in their core business, ST Aerospace has resorted to greater cooperation by means of joint ventures with OEMs (both engine and airframe as well as components) both locally and globally to upgrade their engine and more value added businesses. It has also taken up new businesses in cabin and interiors, including seat manufacturing. On the contrary, the strategy of HAECO is more for horizontal expansion by expanding beyond China to the US by acquiring Timco and has even lately abandoned line maintenance in the US to focus more on cabin and seat manufacturing and fittings. This seems to confirm the preoccupation of Hong Kong firms to avoid heavy and long term investment in technology upgrading and knowledge innovation, focusing instead on shorter-term market opportunities. Unfortunately the US investment of HAECO seems to turn out losses rather than profits for the whole group. HAECO also divests its stake in Singapore Aero Engine Services Private Limited (SAESL), a joint venture of SIA Engineering with Rolls Royce, in 2016. It was probably a result of the global rationalization of Rolls Royce, which has a joint venture in Hong Kong with HAECO, HASEL, but it helps Singapore to get rid of the legacy Hong Kong factor. In addition, it fits into Rolls Royce new business model of replacing the previous territorial division of labour between HASEL and SAESL with a new model of free competition for the service of

69 Leithen Francis, Singapore MROs expanding market segments, MRO-Network.com, 22 October 2015.
its engines. HASEL and SAESL have come into direct competition in China, the Asia Pacific region as well as globally. HASEL and HAECO are losing their comfortable captive market.

Table 9: Scale of top airframe MRO (in million man-hours)

<table>
<thead>
<tr>
<th>MROs</th>
<th>2008</th>
<th>2012</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST Aerospace</td>
<td>8.50 (1)</td>
<td>11.50 (1)</td>
<td>12.00 (1)</td>
</tr>
<tr>
<td>SIA Engineering</td>
<td>4.80 (10)</td>
<td>4.20 (4)</td>
<td>n/a</td>
</tr>
<tr>
<td>Haeco/Taeco/Staeco</td>
<td>5.36 (2)</td>
<td>7.40 (2)</td>
<td>11.70 (2)</td>
</tr>
<tr>
<td>Timco</td>
<td>3.70 (3)</td>
<td>3.20 (7)</td>
<td>Acquired by Haeco</td>
</tr>
<tr>
<td>Gameco</td>
<td>0.70 (15)</td>
<td>n/a</td>
<td>2.90 (6)</td>
</tr>
</tbody>
</table>

Source: Aviation Week.

6.2. It might take time for ST Aerospace to realize the potential gains (not just short term financial revenues but also longer term overall upgrading and integration). However in contrast to the lack luster performance of HAECO, ST Aerospace has a surprisingly high return in the first quarter of 2017, the best since 2011. Singapore is currently taking up 25% of MRO businesses in Asia Pacific and contributes 10% to the global industry. In 2014, the aerospace industry contributed an output of S$8.3 billion, and had a value-add (VA) of S$3.0 billion. Employment in the sector has grown in tandem at 4% over the same period. In 2014, the sector employed close to 20,000 workers with 90% of them being skilled jobs. It is not only because of the importance of the industry in terms of contributions to GDP and current employment that Singapore government supports the aerospace industry and its leading sector of MRO. The government has seen the further upgrading and development of the industry as a major driver for the overall economy of the city-sate. Singapore insists on manufacturing and its Committee on Future Economy has identified aerospace as key vertical under the advanced manufacturing cluster. As the Minister for Trade and Industry revealed in 2016, ‘The republic is cementing its position as the leading Asia-Pacific aerospace hub by enhancing capabilities and developing new growth clusters as it continues to support local aerospace companies’. This will be implemented by means of existing stronghold of MRO services, new market segments of aero-engine development, engineering and manufacturing as well as premium aftermarket services. It is probably due to the persistent investment and policy efforts of the

---

70 The new business model abolished the pre-existing geographic territory-based arrangements used by Rolls-Royce to direct MRO work to each of its three joint ventures in the region to be replaced with a competitive model where each will need to compete to secure their Trent TotalCare engine overhauls. Rolls-Royce believes that this competitive model will encourage greater capability and flexibility across the Trent Service Network. The joint ventures are also able to compete globally for MRO Services under "time and material" business terms. Rolls-Royce gets regulatory approval for Trent service network changes, Advance (UK), 30 June 2016.

71 Alex Derber, ST Aerospace Builds Momentum, MRO-Network.com, Apr. 18, 2017.

72 Rumi Hardasmalani, Singapore cements position as leading Asia-Pacific aerospace hub: Iswaran, Today Online, 15 February 2016. See also Minister Iswaran’s speech at A*STAR Aerospace technology leadership forum on 15 February at Pan Pacific Hotel.
Singapore government that MRO industry and the aerospace industry in the city state
could expand and upgrade attracting many world class OEMs in airframe, engine and
components to set up manufacturing factories and services station in Singapore along
with smaller local and overseas firms to build up a more extended local value chain
system for MRO and aerospace. It is the consolidation of the local industry and
services supported by strong and aggressive local system of knowledge, innovation
and human capital training that ST Aerospace and SIA Engineering could expand
their markets globally. A local industry turns global and in the process the local
industry is transformed into a globalized industry serving the local economy and
society. The Hong Kong MRO firms could still benefit from the proximity to the great
emerging market of China, but without an active role by the government, the story of
the MRO firms in Hong Kong is just the ups and downs of particular firms with little
spill-over impact on the local industry, economy and society. HAECO is a globalized
firm. It has not helped to develop a local MRO industry, not to mention aerospace
industry. Its globalization may transform it from a Hong Kong firm into a global firm
with its business focus shifting overseas.73

7. The new global model of MRO

7.1. Aerospace industry has entered a new era with liberalization of airline services first in
the USA in 1978 and in EU from 1987-1993. Liberalization or deregulation set off
competition within and outside national territorial systems and impact on the business
model of the airlines and other stakeholders in the aerospace industry’s value chain.
Significant changes have become visible in the global market in the 1990s as market
liberalization takes time to reinforce and echo across national boundaries
Liberalization removes institutional barriers and political interventions (including
resulting financial subsidies) and obliges firms to compete primarily on the basis of
costs and quality of services. As aerospace products and services are still highly
regulated by authorities and certified by OEMs, quality of products and services are
guaranteed so that competition centers mostly on cost reduction. The deregulation in
airline services is part of the broader process of global liberalization and integration.
The latter through enhanced FDI and trade has led to a spread of industrialization to
developing countries, ushered by China and the emergent market economies. With
economic growth of these late-comers increasing global integration, great air transport
demand for passengers and freight emerges, which gives rise to huge increases in

73 Hong Kong actually has another MRO firm with great potentials, the China Aircraft Services Ltd (CASL) that
was founded in 1995 It is a joint venture among China National Aviation Corporation (Group) Limited (40%),
Hutchison Whampoa (China) Limited (20%), United Airlines, Inc. (20%) and China Airlines Limited (20%),
providing aircraft line and base maintenance, cabin cleaning and ground support equipment as well as supply
and stores services at Hong Kong International Airport. It was reported that in June 1992 Zhu Rong-Ji, the then
Vice Premier of China (who later became the Premier) signed and approved the concept to proceed the
feasibility study of establishing China Aircraft Services Limited in Hong Kong. The decision seemed to be part
of the overall strategy to prepare the return of Hong Kong to Chinese sovereignty in 1997, probably for the
purpose of building up an alternative MRO set up to the Swire dominated local MRO and airline industry.
However, CASL moved slow and has now only one hangar with half of its engineers coming from the Mainland.
It is in no position to challenge HAECO and actually has to struggle for survival.
aerodynamics in service and proliferation of airlines. Air transport has spread to new emerging market economies and cities, and local airlines have also mushroomed to take advantage of the new demands. The geographical scope and scale for airline businesses including MRO rapidly expanded.

Figure 3: Global MRO evolution


7.2. With large number of aircrafts ordered and put into service at a time of oligopoly and even duopoly of suppliers, newer and fewer types of aircrafts have dominated the global fleet. The larger demand and larger resulting scale economy for the suppliers have also boosted their quicker adoption of new technologies and materials to further strengthen their oligopolistic market position and cut costs to enhance further profitability. The market forces have pushed changes in technologies, business organization and strategy of firms under the new competition, and economic restructuring. Some argue a new model of MRO has been emerging in recent years. The new model is characterized by outsourcing of MRO and the changing role of OEMs.

a) Maintenance work will be distributed among contract MROs and light manufacturers in complex supply chains, potentially under a variety of employment arrangements.

b) As greater amount will take place remotely from the hangar through the replacement, repair and remanufacturing of large component assemblies; equally some will be brought back on site and performed.

c) An increasingly large share of work will be controlled directly or through subcontracting by OEMs in the context of a distributed global industry.
d) Many of the traditional checks will have been replaced by sophisticated diagnostic 
equipment and self-monitoring capabilities built into the aircraft and the length of 
time between D checks is expected to increase significantly.  

7.3. In summary, the new model (with the new technologies yet to be widely adopted) is 
founded upon a growing distribution or geographical decentralization of MRO 
services along with the increasing global reach of OEMs and major MRO firms and 
the flourishing local development of airlines and MRO businesses in emerging 
economies and cities. The global reach of OEMs has inherently a tendency towards 
more oligopolistic controls over their respective markets and is itself a combination of 
territorial decentralization and concentration efforts, which is basically in line with the 
natural oligopolistic tendencies under a liberalized market regime.

7.4. However, the new model proceeds at different pace for each of the subsector of MRO.

7.4.1. Outsourcing and offshoring

7.4.1.1. The decision for outsourcing and offshoring is decided by airlines, which ultimately 
bear the airworthiness responsibility of the aircrafts served by MRO either in house or 
outsourced. The airlines have to define the core critical areas for its operation. In 
terms of MRO, line maintenance is on the spot and immediate in nature and is 
difficult to outsource, not to mention offshoring. Hence line maintenance is least 
outsourced than other MRO activities. The arrival of low cost carriers brings in a new 
need for cost reduction, and it is thus possible for them even to outsource line 
maintenance provided that there are available and quality certified facilities and 
services at particular airports. Economies of scale and scope play an important role 
here.  

7.4.1.2. Recently rapid economic expansion and air transport increase in Asia Pacific 
including China have also led the large jump in aircraft in service in the region, which 

---

74 The Future of Aircraft Maintenance in Australia. Business School, University of New South Wales, October 
2015, p. 197.

75 Outsourcing reasons for engine overhaul and component maintenance are mostly from economy of scale 
consideration whereas for airframe heavy maintenance it is basically economy of scope for the use of low labour 
cost platform. D.R.Vieria & P.L.Loures, Maintenance, repair and overhaul fundamentals and strategies: an 
21-29.
is projected to have largest fleet in the coming years, and in turn it would have led to the expansion of MRO facilities investment in the region. The development of MRO capabilities in the Asia Pacific region and China has been uneven. Both big markets like China and India are still deficient in MRO capabilities with importing 90% of MRO services in some sub-sectors, but other smaller economies like Singapore and Hong Kong and even Sri Lanka have surpluses. Because of cost advantages, Asia Pacific MRO sector has been attracting MRO orders from the US and West Europe along with MRO providers in Australia. In view of domination of Asia Pacific and China in future global fleet growth, there is in the process a geographical shift of MRO capabilities and industry to the East from both USA and Europe. Currently operators around the world are sending nearly 30% of wide-body heavy airframe maintenance needs to the region. However, with the further development of East Asian emergent market economies and China, labour cost parity may cause a reverse flow of MRO activities. Singapore and Hong Kong as the leading MRO providers in Asia Pacific and in the world have already faced a wage inflation and skill labour shortage.

Table 10: Local self-sufficiency in MRO sub sector services of major regions in 2014

<table>
<thead>
<tr>
<th>Sub-sector</th>
<th>Region</th>
<th>Net exporter</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Airframe (heavy maintenance visits &amp; modification)</td>
<td>Asia Pacific</td>
<td>Net exporter</td>
<td>93%</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>Net exporter</td>
<td>91%</td>
</tr>
<tr>
<td>Engine</td>
<td>Asia Pacific</td>
<td>Net importer</td>
<td>39%</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>Net importer</td>
<td>19%</td>
</tr>
<tr>
<td>Component</td>
<td>Asia Pacific</td>
<td>Net importer</td>
<td>21%</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>Net importer</td>
<td>70%</td>
</tr>
</tbody>
</table>


Table 11: Geographical distribution of MRO activities in the global system (% share of global total)

<table>
<thead>
<tr>
<th>Region</th>
<th>2014</th>
<th>2019</th>
<th>2024</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>31%</td>
<td>25%</td>
<td>22%</td>
</tr>
<tr>
<td>Western Europe</td>
<td>24%</td>
<td>22%</td>
<td>20%</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>18%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>China</td>
<td>7%</td>
<td>9%</td>
<td>12%</td>
</tr>
<tr>
<td>India</td>
<td>1%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>Asia Pacific plus China &amp; India</td>
<td>26%</td>
<td>31%</td>
<td>35%</td>
</tr>
</tbody>
</table>


7.4.1.3. Outsourcing and offshoring under a liberalized trade regime with more extensive industrialization would keep the global MRO industry shifting all the time in line with

---

76 *Global fleet and MRO market forecast summary, 2017-2027*, Oliver Wynman, 2016, p. 36.
the geographical shift in skill labour availability, comparative cost advantages, and investment.

Figure 4: Maintenance Outsourced vs. In-House in the USA, 1990-2011 (Percentage of U.S. Passenger Airlines’ Maintenance Expenses)

Source: Data provided to CRS by the Bureau of Transportation Statistics (BTS).

Figure 5: North American airlines’ engine and heavy maintenance outsourcing

Source: TeamSAI, Outsourcing trends in the USA, November 2009, quoted in Rachel Tang & Bart Elias, Offshoring of airline maintenance: implications for domestic jobs and aviation safety, CRS Report for Congress, US Congressional Research Service, 21 December 2012, p.4, Figure 3.
7.4.2. OEM involvement

7.4.2.1. With rising costs stemming from development of new technologies and materials and general development costs as well as the greater reliability of new generation aircrafts that now enjoy an average product life of 25 years or more recently, the large increasing in sales may not guarantee a ready improvement of profit margins. As maintenance constitutes over 10% of operation costs and approximately one sixth of the purchasing price of aircrafts, it would be an attractive area of business for OEMs (airframe and engine) for profit-boosting. The OEMs has a major advantage: each fleet type and engine type have a pre-determined maintenance programme set up by the OEMs. Engine OEMs have already used this advantage to entrench in the MRO market and aircraft OEMs like Airbus and Boeing have recently tried to enter into the MRO arenas. They are offering total MRO after-sale services for their new generation aircrafts. For example, Airbus offers Flight Hour and Total Support Package (FHS & TSP) services which provide flexible and tailor-made solutions. Boeing has planned to increase its service revenues from US$15 billion to $50 billion in the next 10 years, with a new “emphasis on generating life-cycle value” from its products. It currently

---

77 ‘The continuous demand for more efficient, light weight, reliable and long lasting equipment has led to gigantic development costs for the ever more sophisticated technology. At the same time, sale prices have come under pressure, amid tougher discount negotiations with operators and leasing companies as the industry and ultimately consumers became used to cheaper airfares. So the costs needed to be recuperated throughout the equipment’s lifecycle.’ Michael Gubisch, MRO companies need to form partnership networks, Flightglobal.com, 20 October 2011.

obtains about 10% of total Boeing Commercial Airplanes Revenue compared to about 50% for engine OEMs.  

7.4.2.2. The OEMs have many ways to enhance their competition and favourable relationships with MRO firms, especially third party independent firms, through withholding or restricting essential technical information. It has been argued that MRO is characterized by a balance of OEMs and independent service providers. There may be 6 scenarios for the industry:

a) OEMs dominate the supply of spare parts, but outsource the servicing of these parts to their network of suppliers or independent service suppliers;

b) Service suppliers dominate the MRO market and relegate OEMs and spare parts manufacturers to supplier status;

c) OEMs dominate the MRO market and shut service suppliers out completely;

d) Airlines dominate the MRO market;

e) MRO is characterized by a balance of OEMs and independent service providers;

f) MRO workloads become self-separating between independent service providers and OEMs.

7.4.2.3. Among the MRO service providers there is also the contest for businesses between airline-affiliated firms and independent providers. The latter would be squeezed between the airline-affiliated firms and OEMs, whose cooperation would be founded upon the bargaining power of the parent airlines if a large enough number of aircrafts and engines have been ordered from OEMs. Just like in all kinds of businesses and industries, for the MRO industry with the new model, the outcome of competition and

---

79 Alex Derber, Boeing Gets Serious About Services, MRO Network.com, 24 November 2016.
80 With the introduction of new aircraft and engine generations, manufacturers have increasingly restricted access to their intellectual property. The amount of information in aircraft maintenance manuals has continually decreased over the years, making it more difficult for independent MRO firms to repair parts without advice from the manufacturers. Michael Gubisch, 2011, op. cit.
82 'Despite the well-publicized outsourcing of heavy maintenance over several decades, on average around half of this category is still carried out in house, though airlines working solely on their own fleet account for only 28% of all work. Those airlines which have broadened their capability sufficiently to offer their services to other carriers are generally better placed to handle their own in-house maintenance because of the economies of scale they can achieve, and have managed to hold or capture another 22% of the market. Independent MROs and third-party services provided by other airlines or their specialized maintenance subsidiaries together account for just over 40%.’ ‘OEMs dominate the world market for engine maintenance, holding almost 65% of the market if their partner businesses are included, and expect to increase their involvement as new generations of engine come into service. They and their joint-venture partners together control a quarter of the world market for component maintenance. … OEMs take most of the more complex component work, and hold a 78% share of the supply chain.’ The Future of Aircraft Maintenance in Australia. Business School, University of New South Wales, October 2015.
cooperation in a rapidly changing ecosystem (technologies, business models and regulatory regime) would be indeterminate.

8. **Challenges to and responses from Hong Kong and Singapore in the coming decades**

8.1. **The opportunities of great expansion and inadequate supplies of MRO services**

8.1.1. The great expansion trends of global economy, trade, and tourism will most likely continue into the coming decades. The immediate consequence is the large increase in air transport and expansion of fleet of aircrafts. Demand of MRO will definitely grow as well. Most of the projections of fleet growth have been very optimistic.

![Figure 7: 2017-2027 global aircraft demand](https://example.com/figure7.png)


8.1.2. At present Asia Pacific has the second largest fleet in the world and most projections expect it to host the largest fleet by the mid 2020s. Given the huge demographical scale of China, India, Indonesia and Pakistan, if they could follow the example of China to complete industrialization and enter the stage of sustainable socio-economic development, the size of the fleet of aircrafts would increase even exponentially, surpassing the mature Western Europe and the USA. The percentage share of Asia Pacific and the larger Asia in the global fleet would be much larger even with that of developed economies combined together.
Figure 8: 10 Year Global Air Transport Fleet Growth projection


Figure 9: Global Market Share of Aircraft Operating Fleet by Region (2014-2034)

8.1.3. According to some estimates, Asia Pacific will become the second largest region for MRO services by 2024. North American market will lose its position to Western Europe over the period and move to the 3rd position by 2024 in terms of MRO spending. The greatest expansion in MRO demand is therefore in Asia pacific. In 2015 MRO spending in Asia Pacific amounted to US$ 12.34 billion compared with US$ 68 billion of the world in total.\textsuperscript{83} Asia Pacific has been a net exporter of MRO services mostly in airframe heavy maintenance due to local labour cost advantage. It relies on imports of services from out of the region. The expected large expansion in MRO demand has thus created investment in two major areas: for governments and firms within the region to invest in labour intensive airframe heavy maintenance (partly it is the demonstrative effect of the success of the Singaporean model); for OEM and global MRO firms to invest in more value added MRO segments like engine and components (the oligopolistic OEMs competition for global market share has extended to the fast growing regional market). For the latter the investment by OEMs has preferred firms and local production system that are capable of industrial upgrading to meet the high quality requirements for aerospace products they are specialized in. Singapore with its local innovation system and aggressive technology and infrastructural investment policies is probably the best partner with the OEMs, much better even than Chinese firms which are mostly government-owned and

\textsuperscript{83} \textit{Aviation Outlook: Growth Opportunities in Asia Abound}, Aerospace and Defense Practice, Frost & Sullivan, 1\textsuperscript{st} quarter 2016.
politically may be at odd with the governments of the OEMs. The cooperation between Singapore and OEMs might extend beyond the city-state to follow the globalization reach of the Singapore MRO firms. For the former, many governments in Asia have formulated plans to promote MRO industry as a means to develop local aerospace industry. These include governments of Malaysia, Indonesia, Thailand and even Taiwan. Being the third largest MRO market in Asia Pacific after China and Japan at US$1.5 billion annual revenues, Korean government has also focused on developing the local MRO capabilities in a bid to grow its aerospace industry.

8.2. The China factor

8.2.1. The China factor will play a most important factor in the development of regional and global MRO industry for the simple reason that China will see the largest delivery of new aircraft in the coming decade. In the next 10 years to 2027, it is estimated that the Chinese fleet will grow by over 3,700 aircraft, a net 136% increase. China will rank third in the world in operating aircraft numbers, behind regional leaders North America and Western Europe. Most importantly, the growth of the Chinese fleet is based on new deliveries, while North America and Western Europe, being the mature markets, will see a large retirement of aircraft despite the recent prolongation of the life of aircraft from 15 years to an average 25 years.

Figure 11: 2017-2027 Global fleet growth by region

Source: Oliver Wynman Global Fleet & MRO Market Forecasts

Source: Global fleet and MRO market forecast summary, 2017-2027, Oliver Wynman, 2016, p. 28.

---

84 Prashanth Parameswaran, Indonesia: ASEAN aerospace MRO leader? The Diplomat, 11 March 2017; Chris Pocock, The ‘other’ Air Asia seeks more third party MRO business, AinOnline, 6 March 2017; Firdaus Hashim, Thailand clears 15-year aviation action plan, Flightglobal Pro, 9 February 2017; and David Armstrong, MRO focus: Asia, MRO-Network.com, 1 February 2016.

85 Adrian Schofield, Korean government aims to boost MRO industry, MRO-Network.com, 9 March 2017.

8.2.2. TeamSAI projects the Chinese MRO market, which was in 2013 valued at US$3.6 billion will double in 10 years to US$7.8 billion in 2023, an 8.1% compounded average annual growth rate. This will nearly double the expected growth rate of 4.3% for the Asia-Pacific in the period.\(^{87}\) Another 10 years’ estimate by Frost & Sullivan puts the growth rate of China’s MRO market size at a slight higher rate of 9.0% to achieve an accumulated value of US$ 78.9 billion in 10 years to around 2025.\(^{88}\) TeamSAI suggests the growth would also be fueled by the tendency for West European and US carriers to send their wide-bodied aircraft to China for heavy maintenance, taking advantage of cost advantage.\(^{89}\) This is part of the reason for recent investment by foreign MRO firms to invest heavily in China, the outcome of which would also attract MRO demand from the domestic market, which has been lost by offshoring, and overseas, further expanding the Chinese MRO market size. This confirms the observation of China being net exporter of airframe maintenance service. For the 10 years period between 2015 and 2025, MRO spending in China is projected to increase by US 6 billion, smaller than Asia Pacific less China of US$ 7.9 billion, but higher than US$ 5.2 billion of the Middle East, US$ 3.2 billion for North America and by a large margin than US$ 1.2 billion of Western Europe.\(^{90}\)

8.2.3. By whatever standard the Chinese MRO market is the national market of the greatest opportunities in comparison to developing economies or mature developed economies. More importantly, except in airframe maintenance and localized line maintenance, China has long been a net importer of MRO services in other sub-sectors even before the scheduled large delivery of aircraft arriving in China. One may without doubt brand the Chinese MRO market as the most attractive and sizable one in the world in the coming one to two decades. As such it provides the market not only for indigenous Chinese MRO firms, whether joint venture or not, and for other active players in the aviation scene in Asia Pacific and the world as a whole. The proximity of Hong Kong to other Chinese airports and being part of China should spell good fortune for MRO firms like HAECO.

---

\(^{87}\) Colin Baker, op.cit.
\(^{88}\) *Aviation Outlook: Growth Opportunities in Asia Abound*, Aerospace and Defense Practice, Frost & Sullivan, 1st quarter 2016.
\(^{89}\) Colin Baker, op.cit.
Figure 12: 10 year MRO market forecast by regions

<table>
<thead>
<tr>
<th>Region</th>
<th>Market Size</th>
<th>CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>$209.9B</td>
<td>1.03%</td>
</tr>
<tr>
<td>Western Europe</td>
<td>$191.6B</td>
<td>4.02%</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>$167.2B</td>
<td>6.40%</td>
</tr>
<tr>
<td>China</td>
<td>$78.9B</td>
<td>9.00%</td>
</tr>
<tr>
<td>Middle East</td>
<td>$77.9B</td>
<td>7.71%</td>
</tr>
<tr>
<td>Latin America</td>
<td>$51.9B</td>
<td>5.82%</td>
</tr>
<tr>
<td>Eastern Europe</td>
<td>$41.6B</td>
<td>3.75%</td>
</tr>
<tr>
<td>Africa</td>
<td>$26.8B</td>
<td>1.45%</td>
</tr>
<tr>
<td>India</td>
<td>$17.0B</td>
<td>13.51%</td>
</tr>
</tbody>
</table>

*10 year consolidated market size


Figure 13: Difference in MRO spending, 2025 against 2015, by global regions (in US$ billion)

9. Conclusion

9.1. A brief comparison of the development trajectory of MRO industry in Singapore and Hong Kong in the context of industrial catch up shows the different success models of the two city-sates. In terms of scale, scope and potentials for further evolution, it seems the Singapore model that sees the MRO industry as a means to develop local aerospace industry and upgrade the local regional innovation and production system is more successful. Whilst both city states have the advantages being the first movers of MRO industry in Asia Pacific, with Hong Kong entering the industry and market even earlier than Singapore, The MRO firms have made less impact on the local economy in Hong Kong than Singapore. The main reason is probably the nature of ownership of the firms. In Singapore the firms are state-owned firms directed, motivated and supported by the government and the resources available to it. In return the MRO firms have to subscribe to the industrial and local development policy of the government in the broader and longer term interests of the Singapore economy and society. The major MRO firms in Hong Kong are privately owned and with the change of sovereignty in Hong Kong they are not perceived by themselves or by local society as local firms, and have been transforming themselves more as multinational corporations, despite the fact that they seem to have no country of affiliation (they are not British, even though owned by the Swire Group, which claims to be British). The government in Hong Kong has followed a lass es faire policy of the 19th Century with no idea of industrial, technology and even education policies. Being private firms the government has no obligation to support them for their profit-making activities. Firms like HAECO has thus become more and more footloose, especially in anticipation of the sovereignty change in 1997. A causal look at the subsidiaries and joint ventures of the major MRO in the two cities reveals a dissimilar pattern of corporate development: Hong Kong firms have less invested in Hong Kong and their globalization has mostly limited to the China Mainland, whereas the Singaporean firms have been more aggressive in their local investment and globalization. The Hong Kong firms seem to concentrate on their core competency, and hence showing strong path dependence in its corporate development. Singaporean firms serve the government’s broad and longer strategy and would not occupy themselves with short term profit maximization. It is difficult to conclude whether the Singaporean state-owned and state-managed MRO firms would always be outperforming the Hong Kong private MRO firm. In corporate world, firms’ fortune could turn bad unexpectedly. Profit and revenues wise, the East Asian MRO firms have been lagging behind the leading MRO firms from developed economies, especially from Western Europe, like Lufthansa Technik and AFI KLM E&M which have much more technology and skill intensive and have a mature large Western Europe as their captive market. However, judging from the expansion of the corporate businesses in Singapore and the impact on the development of local aerospace and related advanced manufacturing industries, the Singaporean firms have indeed turned out a much impressive record. Given the rapid technological changes brought by the arrival of new generation aircraft and fierce intra-industry and inter-regional competition, the more investment led and globalized
business model that is strongly rooted in the host economy of Singaporean MRO firms and industry is perhaps better equipped to overcoming the challenges and capitalize on the opportunities lying ahead. Hong Kong has not an aerospace industry or policy, HAECO’s close ownership and business relationship with Cathay Pacific may not be an asset for it, given difficulties the airline is facing recently. The Singaporean MRO firms and industry could be regarded as forming a Singaporean Incorporated and having embedded deeply in the local innovation system. It should have more resources and support to weather any coming storms much better than a single corporate entity that has no public resources and supports available to it.

9.2. Singapore has presented a viable and effective industrialization strategy for other late comers in forcing into the aerospace industry. Other countries have followed suit focusing on MRO as a short cut to lead local aerospace industrial development, and adopting a more coordinated government led programme to develop MRO into a comprehensive sub-sector. The emphasis these national efforts is industrial policy and planning plus government direct involvement. The following figures illustrate graphically the MRO and aerospace development strategy of Korea and Malaysia that have been installed in the last few years.

Figure 14: Korea government strategy of MRO development

Source: Yeun S Jeung, Korean Institute of Aviation Safety Technology, Commercial aircraft MRO industries and capacity in Korea, 8 March 2017, MRO East Asia 2017, Seoul, South Korea.
9.3. The aerospace industry should be regarded as belonging to the arena of post industrial catch up. However, the developed economies and their corporate champions, which have become multinational but rooted in the national or regional economies, still dominate the technology and business of the aerospace industry and market. Aerospace industry in general and MRO industry in particular are closely regulated and certified by standards set by the developed economies and their leading corporations. This has constituted a strong institutional barrier to late comers. The aerospace industry of the developed economies has not stopped upgrading and innovating and its position in the market has helped it to consolidate their technology leadership and thus continuous market controls by further raising the entry barriers. For instance, few developing economies could break the oligopolistic domination of leading aerospace corporations in the manufacturing of engines, airframes, and the key components as well as materials. Brazil has been able to develop its own Embraer in the global market. It has a very unique background and factors for the successful development of the Turboprop turned regional jet, which has made it successful while other economies like Japan and Indonesia failed. First, it started as a state-own firm with the Brazilian government and military behind and with experience of aircraft production. Second, it took up the opportunity of the deregulation of the US aerospace industry in 1978 and with technology and parts support (most importantly, engine from the Canadian firm, Pratt & Whitney) from firms of other developed economy at a time when the global industry had not been so oligopolistic in market competition.91 However, it has never been able to challenge the dominating aircraft and engine makers in the global market. Because of the small share of the regional jet market of Embraer, it has never developed an extensive MRO system to compete with the big

91 See the part on Brazil in Daniel Vertesy, 2011, op.cit., pp.131-176.
ones or to develop its own MRO industry into a nationally and globally competitive one. China is another good example of latecomer into the aerospace industry. It seems to be more ambitious and more successful than Brazil, as it has upgraded from the manufacturing of regional jets to large aircraft, the C919, which would have test flight in 2017, and a new Sino-Russian joint venture, C929, in the planning. It has also the resources, capabilities and innovation for building fighters and other military aircraft for domestic use and exports. At the same time it has the largest national market for aircraft and MRO in the coming years. Yet, China has not been able to build its MRO firms for military services into competitive ones for civilian MRO. There is still a long way for it to build the market for its large aircraft to set up separate MRO standards and regulations from the existing OEMs’ from the developed economies. Hence its MRO industry is still subject to the market regulation and pressures originated from the dominating OEMs. The results are: a) MRO industry in China is still underdeveloped and deficient in the more technology intensive subsectors; and b) the market has been dominated by foreign joint ventures. The Chinese industry just like other late comer economies are still in the process of industrial catch up, developing mostly by imitation and under the dominating market controls of major players from the developed economies. China like Brazil wishes and makes efforts to enter into the post industrial catch up stage. There is still yet a long way to go. Similarly Singapore is still in the catch up stage in the aerospace industry. MRO provides it a breakthrough key, but whether it is sufficient enough to establish sustainably the aerospace industry of Singapore (despite a higher output value than Brazil) remains to be seen, and with great doubts. The Hong Kong case has not implications for other late comers in the development of aerospace industry and the overall industrial catch up. It shows only a case for the evolution of business MRO at the firm level and probably also the lessons to be learnt for the absence of industrial policy and government supports not only for the industry alone but more significantly at the level of the local innovation system.

10. Policy Implications and Recommendations to the Hong Kong Government

Based on the findings of the comparison of Hong Kong and Singapore MRO industry and informed by the industrialization efforts and experiences of late-comer economies including China, the following policy recommendations are formulated for the reference of the SAR Government.

a) The SAR should develop a policy for the promotion of MRO industry in Hong Kong as a means to spearhead advanced producer service and related manufacturing for the restructuring of the local economy. Through the existing MRO firms, Hong Kong still has a leading role to play in China and globally. The strengthened MRO industry could also help to consolidate, if not defend, the international air transport hub of Hong Kong, which is also tied to the fortunes of the world financial centre, world trade centre and world services centre functions of the territory. With the complete deindustrialization, Hong Kong has only the
MRO services and the demand created for parts and components manufacturing as well as technical skilled labour for upgrading the local producer services. Viewed as part of the local innovation system, MRO services would create spin-off firms and services and train engineers and other professional staff for other related services and industries. The impact of the industry’s development on the larger economy could be large, given the example of the Singaporean MRO industry. The policy should be a policy for the sectoral innovation and production system of the MRO industry, in a broad value chain or supply chain perspective. The MRO policy could also be part of the innovation and technology policy of Hong Kong yet to be formulated by the government. It is realistic and workable. The only issue is how to coordinate the development of the industry in Hong Kong with the private assets and interests of existing MRO firms, in particular the dominating HAECO and the airline, Pacific Dragon. In line with normal procedure, there should be a consultancy research project to support and give substance to the MRO policy. One needs to emphasize that the MRO policy is for Hong Kong, not for HAECO and/or Pacific Dragon, or other MRO firms individually or collectively. It should be forward looking. The policy could be managed by the relevant policy Bureau of the government or by an independent commission set up specifically for the purpose.

b) For an easier task that could be achieved is to expand the education and training establishments for MRO and related professionals and technicians. Australia has recently faced a downturn in its MRO industry, partly because of the financial and operational problem of Qantas, the national carrier. A proposal from the academia is following the desire to establish Australian MRO as an independent sector to launch a major investment in rebuilding the skilled workforce before 2020. A major rationale behind is the need to develop an indigenous MRO industry with benefits to the local society and economy, not just for the profitability of the MRO firms. Additionally, with the projection of large increase in new generation aircraft in the coming years and decades, there will be a chronic shortage of skilled labour for the industry. A competitive advantage in the availability and quality of MRO professionals and technicians would easily be turned into competitive advantage for the local MRO industry. The concrete policy recommendation for the Australian government is to set up a National Aviation/Aerospace College with local branch network to cover beyond the special need of skilled labour in the MRO industry but in the local innovation system as whole (a cross-sectors, industry and maintenance integration one). To translate the Australian recommendation into Hong Kong, it is suggested that a territory-wide College of Aviation be established, building up on the momentum

---

92 Ian Hampson, Doug Fraser, Anne Junor, Michael Quinlan and Sarah Gregson, Aircraft maintenance in Australia: issues and prospects, presentation at the International Labour Process Conference, London, 7-9 April 2014.

93 The Future of Aircraft Maintenance in Australia, Business School, University of New South Wales, October 2015.
of government proposal lately, to incorporate or cooperate closely with the academy or training programmes of the local MRO firms. The enrolment of the college should be large, beyond the restricted projection of manpower needs by local firms\textsuperscript{94} and open to students and apprentices from China Mainland and overseas. There are many international and Chinese (e.g. the recent expanded academy of AMECO in Beijing) and overseas examples that Hong Kong could learn from. The College should also be linked with local universities and Vocational Training Council to provide complementary and supplementary programmes with those provided by the College. It should be constructed as part of the local innovation system, not stand alone institution serving only the immediate needs of particular industry. In other word, it is not a vocational training organization, but an education (in the broad and traditional sense) institution.

c) To take advantages of regional resources from the booming Pearl River Delta region across the boundary, Hong Kong should promote actively the integration of the regional market for MRO, by removing all regulatory barriers to facilitate a cross border system of innovation and business cooperation and integration. There have already been a large number of large MRO firms in the region, like GAMECO in Guangzhou, Lufthansa Technik, and ST Aerospace (Guangzhou) Aviation Services, all of which are aggressively expanding their facilities and investment in the region. Instead of competing against them, it might be better for Hong Kong to integrate them with the MRO establishments in Hong Kong guided and supported for example by the Guangdong-Hong Kong-Macau Big Bay Initiative announced in the government work report of the central government in this March. Hong Kong government should take the initiative to propose a regional cooperation mechanism for the development of MRO industry at the regional level.

\textsuperscript{94} It is argued that HAECO acquired one of the largest US MRO in 2014 with a view to accommodating some its demand within the USA, after experiencing a large 21\% drop in profits in the first half of 2013 due to problems in recruiting enough skilled labour. Ian Hampson, et.al., op.cit. As the firms have many ways of overcoming local labour shortage and suppressing local wage increase, their projections of manpower needs may not be useful.
Appendix: Subsidiaries and affiliated companies of HAECO, SIA Engineering and ST Aerospace.

**HAECO**

<table>
<thead>
<tr>
<th>Companies &amp; Affiliates</th>
<th>Location of Base</th>
<th>Year of Establishment</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAECO Hong Kong</td>
<td>Hong Kong</td>
<td>1950</td>
</tr>
<tr>
<td>HAECO America</td>
<td>The US</td>
<td>1990</td>
</tr>
<tr>
<td>Goodrich Asia-Pacific</td>
<td>Hong Kong</td>
<td>1993</td>
</tr>
<tr>
<td>HAECO Xiamen</td>
<td>Xiamen</td>
<td>1993</td>
</tr>
<tr>
<td>Goodrich TAECO</td>
<td>Xiamen</td>
<td>1994</td>
</tr>
<tr>
<td>Honeywell</td>
<td>Xiamen</td>
<td>1995</td>
</tr>
<tr>
<td>HAESL</td>
<td>Hong Kong</td>
<td>1996</td>
</tr>
<tr>
<td>STAECO</td>
<td>Jinan</td>
<td>1999</td>
</tr>
<tr>
<td>HAECO Landing Gear Services</td>
<td>Xiamen</td>
<td>2007</td>
</tr>
<tr>
<td>HAECO Line Services (Singapore)</td>
<td>Singapore</td>
<td>2007</td>
</tr>
<tr>
<td>Dunlop Taikoo</td>
<td>Jinjiang</td>
<td>2008</td>
</tr>
<tr>
<td>HAECO Spirit AeroSystems</td>
<td>Jinjiang</td>
<td>2008</td>
</tr>
<tr>
<td>SMECO</td>
<td>Chengdu</td>
<td>2008</td>
</tr>
<tr>
<td>TEXL</td>
<td>Xiamen</td>
<td>2008</td>
</tr>
<tr>
<td>HAECO Shanghai</td>
<td>Shanghai</td>
<td>2011</td>
</tr>
<tr>
<td>HAECO ITM</td>
<td>Hong Kong</td>
<td>2012</td>
</tr>
<tr>
<td>HAECO Component Overhaul (Xiamen)</td>
<td>Xiamen</td>
<td>2014</td>
</tr>
</tbody>
</table>

**SIA Engineering**

<table>
<thead>
<tr>
<th>Joint Ventures and Subsidiaries</th>
<th>Location of Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerospace Component Engineering Services</td>
<td>Singapore</td>
</tr>
<tr>
<td>Asian Surface Technologies</td>
<td>Singapore</td>
</tr>
<tr>
<td>Boeing Asia Pacific Aviation Services</td>
<td>Singapore</td>
</tr>
<tr>
<td>Component Aerospace Singapore</td>
<td>Singapore</td>
</tr>
<tr>
<td>Eagle Services Asia</td>
<td>Singapore</td>
</tr>
<tr>
<td>Fuel Accessory Service Technologies</td>
<td>Singapore</td>
</tr>
<tr>
<td>Goodrich Aerostructures Service Center - Asia</td>
<td>Singapore</td>
</tr>
<tr>
<td>Heavy Maintenance Singapore Services</td>
<td>Singapore</td>
</tr>
<tr>
<td>JAMCO Aero Design &amp; Engineering</td>
<td>Singapore</td>
</tr>
<tr>
<td>JAMCO Singapore</td>
<td>Singapore</td>
</tr>
<tr>
<td>Safran Landing Systems Services Singapore</td>
<td>Singapore</td>
</tr>
<tr>
<td>Panasonic Avionics Services Singapore</td>
<td>Singapore</td>
</tr>
<tr>
<td>Safran Electronics &amp; Defense Services Asia</td>
<td>Singapore</td>
</tr>
<tr>
<td>Singapore Aero Engine Services</td>
<td>Singapore</td>
</tr>
</tbody>
</table>
ST Aerospace

<table>
<thead>
<tr>
<th>Companies &amp; Affiliates</th>
<th>Location of Base/Origin</th>
<th>Year of Establishment/Acquisition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ST Aerospace Engineering</td>
<td>Singapore</td>
<td>1975</td>
</tr>
<tr>
<td>ST Aerospace Services Co</td>
<td>Singapore</td>
<td>1990</td>
</tr>
<tr>
<td>VT Mobile Aerospace Engineering</td>
<td>Mobile, Alabama</td>
<td>1991</td>
</tr>
<tr>
<td>VT San Antonio Aerospace</td>
<td>San Antonio</td>
<td>2002</td>
</tr>
<tr>
<td>AERIA Luxury Interiors</td>
<td>San Antonio</td>
<td>2011</td>
</tr>
<tr>
<td>Shanghai Technologies Aerospace Company</td>
<td>Shanghai</td>
<td>2004</td>
</tr>
<tr>
<td>ST Aerospace (Guangzhou) Aviation Services</td>
<td>Guangzhou</td>
<td>2011</td>
</tr>
<tr>
<td>Airbus Helicopters Southeast Asia</td>
<td>Singapore</td>
<td>1977</td>
</tr>
<tr>
<td>ST Aerospace Systems</td>
<td>Singapore</td>
<td>1969</td>
</tr>
<tr>
<td>ST Aerospace Solutions</td>
<td>Copenhagen</td>
<td>2006</td>
</tr>
<tr>
<td>ST Aerospace Supplies</td>
<td>Singapore</td>
<td>1982</td>
</tr>
<tr>
<td>ST Aerospace Rotables</td>
<td>Singapore</td>
<td>2012</td>
</tr>
<tr>
<td>ST Aerospace Airline Rotables</td>
<td>Stamsted, Essex</td>
<td>1990</td>
</tr>
<tr>
<td>ST Aerospace Guangzhou Aero-Technologies &amp; Engrg</td>
<td>Guangzhou</td>
<td>2007</td>
</tr>
<tr>
<td>Singapore Precision Repair And Overhaul</td>
<td>Singapore</td>
<td>1992</td>
</tr>
<tr>
<td>Composite Technology International</td>
<td>Singapore</td>
<td>1994</td>
</tr>
<tr>
<td>ST Aerospace Engines</td>
<td>Singapore</td>
<td>1977</td>
</tr>
<tr>
<td>ST Aerospace Technologies (Xiamen) Company</td>
<td>Xiamen</td>
<td>2008</td>
</tr>
<tr>
<td>Total Engine Asset Management</td>
<td>Singapore</td>
<td>2011</td>
</tr>
<tr>
<td>EcoServices</td>
<td>Wethersfield</td>
<td>2011</td>
</tr>
<tr>
<td>Name</td>
<td>Location</td>
<td>Year</td>
</tr>
<tr>
<td>---------------------------------------</td>
<td>---------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Turbine Overhaul Services</td>
<td>Singapore</td>
<td>1986</td>
</tr>
<tr>
<td>Turbine Coating Services</td>
<td>Singapore</td>
<td>2000</td>
</tr>
<tr>
<td>ST Aerospace Academy</td>
<td>Singapore</td>
<td>2007</td>
</tr>
<tr>
<td>Pacific Flight Services</td>
<td>Singapore</td>
<td>1990</td>
</tr>
<tr>
<td>ST Aerospace Technical Training Centre</td>
<td>Singapore</td>
<td>1985</td>
</tr>
<tr>
<td>Helicopter Flight Services</td>
<td>Singapore</td>
<td>1984</td>
</tr>
<tr>
<td>ST Aerospace Resources</td>
<td>Singapore</td>
<td>2013</td>
</tr>
<tr>
<td>Aviation Academy of America</td>
<td>Hondo, Texas</td>
<td>2009</td>
</tr>
<tr>
<td>Engineering &amp; Development Centre</td>
<td>Singapore</td>
<td>-</td>
</tr>
<tr>
<td>ST Aerospace International Structures</td>
<td>Singapore</td>
<td>1999</td>
</tr>
<tr>
<td>Precision Products Singapore</td>
<td>Singapore</td>
<td>2009</td>
</tr>
<tr>
<td>VT DRB Aviation Consultants</td>
<td>San Antonio</td>
<td>1997</td>
</tr>
<tr>
<td>VT Volant</td>
<td>Burlington, WA</td>
<td>1998</td>
</tr>
<tr>
<td>Elbe Flugzeugwerke</td>
<td>Dresden</td>
<td>2013</td>
</tr>
<tr>
<td>ST Aerospace Aircraft Seats</td>
<td>Singapore</td>
<td>2015</td>
</tr>
<tr>
<td>Objectives</td>
<td>Percentage Achieved (%)</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>-------------------------</td>
<td></td>
</tr>
<tr>
<td>To study and compare the development models of the aviation MRO industry in Hong Kong and Singapore.</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>To investigate the role of the Singapore Government and the contribution of its industry policies to foster the MRO sector and aerospace industry in Singapore.</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>To study the business strategies of Hong Kong MRO providers and their present challenges.</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Recommendations will be proposed to the HKSAR Government to formulate industry policy for the purpose of driving knowledge-oriented, institutional-sensitive industries in Hong Kong.</td>
<td>It should be handed to the HKSAR Government by the CPU</td>
<td></td>
</tr>
</tbody>
</table>