



## **AEROSPACE CLUSTER OF BANGALORE: CAN THE SMES TAKE UP THE CHALLENGES?**

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### **Abstract**

As per estimates made by leading experts global civil aerospace industry is expected to touch revenue of US \$45 billion. The industry is witnessing emergence of developing countries such as India, Brazil and China as players pivoted to play major role in future. Small and Medium Scale Enterprises (SME) in India have the potential to garner a major share in Tier-3 and Tier-4 sectors of aerospace value chain. Overseas aircraft manufacturers such as Airbus and Boeing have recognized the competencies and skills India has in areas such as engineering, production, maintenance & service, etc. In this backdrop, this paper explores the global scenario of SMEs in some of the successful clusters. Some of the prominent clusters discussed in this paper include the clusters at California & Seattle, Toulouse, Hamburg and Chengdu. This would help us in drawing useful lessons for the Bangalore cluster, which is highlighted in the paper. An analysis is done to identify major challenges that influence the future growth prospects of aerospace industry in Bangalore namely Infrastructure, Finance, Technology and Manpower. A summary and discussion of the opportunities and challenges faced by the Bangalore aerospace cluster and draws conclusions, which have a bearing on policy measures.

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## **1. INTRODUCTION**

The Global civil aerospace industry is poised to touch revenue of US \$45 billion for the current fiscal, according to estimates made by leading industry analysts. The industry is witnessing the

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emergence of developing countries such as India, Brazil and China as emerging players pivoted to play major role in future and have been aspiring for their share in the pie (Mani, 2010). Aerospace industry portfolio consists of military & civilian aircrafts, premium business jets, military & civilian helicopters. The industry requires huge investments to operate and hence is limited to only a few. However competition among these players continues to remain strong. Even though aerospace industry is in existence for over six decades, India has not been able to make an impact globally as the manufacturer of either civilian or military aircrafts. However India is increasing required infrastructure to emerge as a strong contender in future, which includes R&D capabilities and manufacturing competencies. The Small and Medium Scale Enterprises (SMEs) in India have the potential to garner a major share in Tier-3 and Tier-4 sectors of aerospace value chain. Overseas aircraft manufacturers such as Airbus and Boeing have recognized the skills & competencies India has in areas such as engineering, production, maintenance & service, etc. The Bangalore aerospace cluster, comprising predominantly SMEs has become an important destination in the aerospace value chain (PwC, 2012).

The aerospace industry is divided into several tiers based on the value added as, at top comes Original Equipment Manufacturers (OEMs), then we have three tiers namely Tier-1, Tier-2 and Tier-3 consisting suppliers operating at different levels. OEMs consist of manufacturers of aircrafts such as Airbus, Boeing, HAL, Bombardier, Embraer, etc. Tier-1 suppliers consist of manufacturers of aero structures, avionics systems, engines, etc. Tier-2 suppliers comprise manufacturers of landing gear, actuator subsystems and sub-assembly, etc. Tier-3 suppliers are the companies which manufacture component and parts required for Tier-1 and Tier-2 suppliers. Traditionally OEMs define specific requirements onto what Tier-1 suppliers are required to produce. The airframe manufacturers would do the total aircraft design, and give their suppliers detailed specifications and drawings for the manufacture of sub structures and sub systems. Tier-1 suppliers have become large scale integrators by improving the complexity of the modules that they are manufacturing. New strategies adopted by the aerospace industry include greater dependence on tier suppliers by various methods including increased risk sharing by suppliers, selection of low cost regional suppliers, increased aero structures outsourcing and an increased transparency in their aircraft program plans and schedules. This has led to more focus on systems integration, reduction in internal production capability and significant reduction in direct dealings with Tier-2 and Tier-3 suppliers, thereby limiting the interactions of Tier-2 and Tier-3 suppliers with Tier-1 suppliers only.

The structure of aerospace industry is in form of clusters, similar to other clusters which are driven by strong OEMs driving the supply chain from the top. Some of the prominent clusters are the California and Seattle aerospace clusters in the USA, the Toulouse cluster in France, the Hamburg aviation cluster in Germany, the Chengdu cluster in China, the Bangalore aerospace cluster in India, to name a few. Clustering of firms in geographical proximity is believed to result in knowledge spill over for small firms. It is believed to provide the eco-system, which is conducive for quick dispersal of technological and market information. Moreover, the presence of large number of firms attracts suppliers of raw materials and services to set up shop. Toulouse aerospace cluster of France is one such classic example which has Airbus as the centralised OEM and a dense web of interaction is generated among host of other OEMs with public and private sector entities (Porter & Takeuchi, 2013). The major sub assembly components such as communication and control systems, navigation & electronic sub assemblies constitute in the cluster where as few sub-assemblies of engines, avionics and wings are imported into the cluster.

Bangalore in India is the hub of aerospace industry due to the government patronage extended to this city over the last five decades. The state-owned aerospace major, Hindustan Aeronautics Ltd (HAL) was established in the year 1964. HAL was initially established as Hindustan Aircraft Limited, a joint initiative of Seth Walchand Hirachand and the one-time princely State of Mysore in the year 1940. Government of India took over this company and renamed it as HAL. Bangalore also hosts the prestigious National Aerospace Laboratory (NAL), the Indian Space Research Organization (ISRO) and the Indian Institute of Science (IISc). These three organizations have created R & D infrastructures to drive forward the initiatives of HAL. India is hub for many Tier-2 and Tier-3

manufacturers in Automobile industry which have already began migration towards Aerospace industry with HAL, NAL being prime OEMs in the region. This has great significance because China and India are procuring the largest number of civilian aircrafts, and the respective clusters will contribute in the manufacturing of these aircrafts in time to come. Due to offset obligations, the need for airframe manufacturers will arise in future giving opportunities for Tier-2 and Tier-3 industries. It is important for these companies to increase their capability to realize, practice as well as absorb external knowledge to establish a long profitable enterprise.

In this backdrop, this paper explores the global scenario of SMEs in some of the successful clusters in section 2. This would help us in drawing useful lessons for the Bangalore cluster, which is highlighted in section 3. Section 4 presents the summary and discussion of the opportunities and challenges faced by the Bangalore aerospace cluster and draws conclusions, which have a bearing on policy measures.

## 2. GLOBAL SCENARIO OF AEROSPACE CLUSTERS

Aerospace industry, like many other industrial clusters around the world has been thriving in localized clusters. Clustering may not be a necessary part of the growth but, is believed to act as stimulator for overall development of the local industrial scenario. Specialisation of firms in complementary processes and capability building in technology is encouraged by clustering of companies (Prabhakara & Raghavendra, 2012). The success of any cluster is dependent on three factors: interdependency, orientation for export and wealth generation.

In recent times, several research studies on aerospace clusters such as Toulouse, Seattle, the North-West England, São Paulo and Chengdu, to name a few, have thrown more light on the impact of the aforementioned factors on the success of SMEs. There are many instances of knowledge flow regarding market and technological information, high level inter-company collaboration, etc., (Hickie, 2006). While France has pursued range of policies to enhance the knowledge and skill level of the sector, a similar approach is also seen in Seattle cluster in the USA where Boeing has been the harbinger of growth. An important factor for sustainability of these clusters is attributed to early design successes which continued attracting government support.

Aerospace cluster of Toulouse holds high stature in French exports (Porter & Takeuchi, 2013). It covers the geographical area of Midi-Pyrenees and Aquitaine and hosts a dozen of OEMs which includes Airbus along with around 1,500 companies in all tiers of supply chain and around 100,000 workers. The government of France provided the patronage for the cluster by establishment of Airbus project followed by development in world class educational and research institutions. The cluster can boast of productive and educated workforce, good infrastructure and a competent R&D. The performance of the SMEs in the cluster has been exceptional in the last ten years in terms of garnering 17% additional world export shares in aerospace component market.

Going forward, emerging aerospace clusters in Canada, Brazil, and China will increasingly threaten Toulouse's leadership (Porter & Takeuchi, 2013). Bombardier, Embraer, and COMAC respectively are competing in the narrow body aircraft market. Though their exports are currently limited, the expected growth of their domestic demand could fuel their sales, and push them to go upmarket into more profitable wide body aircraft, threatening the Airbus/Boeing worldwide duopoly. Another issue is the geographically dispersed supply chain across Western Europe. When Airbus was started as a consortium of aerospace manufacturers in 1970, it was inevitable to split the supply chain for the A300 between France, Germany, and the UK. This has resulted in the wide dispersal of supply chain. The industry has issues in terms of communication problems, incompatibility in meeting design specifications and inconsistency in pricing of sub-assemblies and components.

Boeing is one of the prime players in aerospace industry for over 7 decades. It is the largest aerospace company in the world and also largest manufacturer of civil & military aircrafts. The major commercial production plants of Boeing are located in Seattle and Long Beach in United States of

America (USA). The production plant at Seattle has strength of around 60,000 employees (Niosi & Zhegu, 2005). Boeing has efficiently internationalized its vendors across tiers. The vertical integration is also visible in Boeing with nearly 80% of its employees working in two of its locations. All companies manufacturing engines supply their engines to Boeing; they include Pratt & Whitney, General Electric, Rolls Royce, CFM International, BAE Systems and Honeywell. Most major components of Boeing's aircrafts are procured from other parts of USA and abroad, this compared with the official list of SMEs in Seattle and Long Beach.

Williams *et al.* (2002) have done a study in the United Kingdom to develop a framework to identify the variables influencing the supply chain of aerospace industry. Supply chains are conceptualized as having a structure of pyramid form with the chain broadening as it descends. The research identifies a set of capabilities within the supply chain and maps their roles in supply chain. OEMs, primarily take the position of handling the responsibilities of innovation, funding, assembly and production. Interestingly, SMEs, which are lower down in the pyramid operate in more than one supply chain, be in automobile sector, aerospace sector etc. The study also reveals that 70% of the final value of an aerospace product is outsourced to SMEs, highlighting the importance vendor's play in the cluster. Research also identifies the dearth of literature explaining the capabilities of aerospace sector.

The aerospace industry of Brazil has accomplished respectable international competitiveness and technological capacity in recent times. Embraer which forms the heart of cluster and is the world's fourth largest commercial aircraft manufacturer currently is competing with Bombardier for the elite third position. The turnover of the company was 7.55 US\$ Billion in 2008 and has been projected to increase its share throughout the world (Swiss Business Hub Brazil, 2009). The phenomenal achievement is that more than 90% of production were exported which represented nearly 3% of Brazilian exports. The aerospace industry in Brazil has lot of similarities with the Indian counterpart. Similar to India it was government backed as its key roles were national security, strategy and technological development. In 1969, the Brazilian government established Embraer, to be the torch bearer for a large aerospace industry. It was later privatized in December 1994.

The sector flourished due to massive public investment, proactive private ventures and has resulted today as a success story comprising civilian, defense and space related industry. Today the cluster consists of Embraer, CTA, INPE and ITA which play a major role developing new technologies, impart skill and generate revenue for the country. The Brazilian aerospace cluster has generated 5,000 direct jobs and has estimated 150 SMEs. More developing aerospace clusters are now competing with Brazilian aerospace mainly in China and Eastern part of Europe. The government of Brazil has initiated drives to promote the quality of cluster by involving private and public sectors, universities and research institutions to make Brazilian SMEs globally competitive.

Chinese aerospace industry has been making remarkable progress in recent times. Over the next 20 years the number of commercial and regional jets is expected to rise to 4,000 from the present number around 1,400 (Cliff *et al.*, 2011). This would mean a great and safe market for domestic manufacturers of China. The number still does not include cargo aircrafts and helicopters which will further boost the sector. The most important development coming from Chinese Aerospace Industry is the production of Comac ARJ21, which is a twin-engine civilian aircraft having a seating capacity of 158. It is developed with Major European and US suppliers like GE, Honeywell and Rockwell Collins. Its development was closely monitored by the Chinese government under its 10<sup>th</sup> five year plan by its controlled ACAC (Commercial Aircraft Company) consortium which became Commercial Aircraft Corporation of China (COMAC) from 2009. However the successful testing and delivery of ARJ21 may be just limited to Chinese market, at least for now. The major aerospace clusters are located in Chengdu, Shanghai and Guangdong. China has been aggressively pursuing a policy to collaborate with major aircraft manufacturers in the world to strengthen technological base for SMEs, especially in Tier-2 and Tier-3.

One of the general conclusions that could be drawn from these clusters is the significance of knowledge spillovers (Niosi, 2005). Knowledge spillovers happen in the form of exchange of

technological, marketing and financial knowledge due to closer supplier-vendor relationships over a period of time. Knowledge spillovers are provided by anchor firms attracting skilled labour and specialised suppliers. There is always provision for telecom and aerospace equipment manufacturers to improve their R&D expertise even though there might be deficit of learning process in a particular region, this is mainly because the sub assemblies can be developed in one or more locations, even in remote locations. The primary centripetal force has been the regional pool of skilled and semi-skilled labourers. On the other hand the longer manufacturing cycle time and persistent increase of R&D costs has been the major centrifugal force for the aircraft global decentralization, which is typical of the Toulouse cluster. Aerospace industry as compared to automobile industry does not have geographical disadvantage due to its location as aircrafts are produced in small numbers and impact of transportation cost is negligible in its final price. Offset agreements has been the prominent mechanism for technology transfer in aerospace industry. Governments in countries like India, Brazil, China and South Korea have been owners their respective national airlines, and have imposed conditions on aircraft producers relating to technology transfers and skill development in regional clusters.

### 3. THE BANGALORE AEROSPACE CLUSTER

Bangalore has emerged as an important cluster and the hub of Indian Aerospace industry. Three factors have contributed to the robust growth of Bangalore aerospace cluster in the last one decade (Mani, 2010). First is increase in market for aircrafts domestically due to rapid growth in air travel. Second, the successful launch of Saras and Hansa-3 has rejuvenated the confidence among Indian PSUs to finally get hold of an imprint in manufacture of civilian aircrafts, though out of schedule the performance of these aircrafts have been more than promising. Third and the most important one, is the growth of R&D companies in Bangalore and continuous outsourcing of projects to these companies. For example, Airbus has started Airbus Engineering Centre India (AECI), which is a 100% subsidiary owned by it. It has state-of-the-art research facility and focuses on the development of advanced capabilities in the areas of modeling and simulation, covering such areas as computational fluid dynamics (CFD), flight management systems, as well as digital visualisation and simulation – which are critical factors in the design and production of high-performance aircrafts.

Boeing has also opened its Bangalore Research and Technology centre in the year 2009. Incidentally it is only the third such advanced research centre Boeing has established outside USA. This centre coordinates with activities of Boeing in India with various other R&D organisations, government organisations and academic institutes. Bangalore is also home to large number of engineering colleges and reputed management schools. The graduates coming out of these institutions are much sought after by leading industries in India and abroad. Therefore, the cluster has the right kind of ecosystem to emerge successfully as a successful aerospace cluster.

A significant initiative has been implemented in 2008 which mandates overseas OEMs to outsource a minimum of 30% procurement to Indian companies. The different areas include infrastructure, component or services, technology sharing. One such example is Air India which due to agreement with Boeing has got 50% offset in its purchase to Indian companies. These policies would provide regional companies a prospect of gaining expertise in niche tech industry with its stringent requirements for safety, precision and quality control.

Many Joint Ventures (JVs) have been entered into with foreign firms in recent times. Sixteen joint ventures have been done recent times out of which ten have been done in last year alone in the aerospace cluster. These include Samtel Display Systems (SDS) tying up with companies such as HAL, DRDO, Thales Aerospace and Honeywell for design and manufacturing of parts for aerospace industry. Boeing is working with HAL for making subsystems which is valued around \$1 Billion for its fighter aircrafts and helicopters. Many other companies like Tata, BEL, L&T, Bharat Forge etc have either signed MoU with companies or invested in expanding their capabilities (Miranda *et al.*, 2010). Defence Offset Policy has dictated that MNCs must procure 30 to 50% of the components indigenously. This has nevertheless led to importing a bulk of the raw materials needed to make the

components at least temporarily. There is a big opportunity for SMEs to cater to the needs of OEMs and Tier-1 companies in India.

Bangalore has been the hub of India's IT companies for the last two decades. Although what started as outsourcing by companies from an economical perspective, the industry has undergone transformation in all the other sectors such as technology, innovation, entrepreneurship and marketing (Arora & Gambardella, 2006). India achieved success in IT sector by sustainable support from government and by huge pool of qualified engineers. But the IT industry is facing serious bottle-neck in infrastructure such as air connectivity, roads, electricity and water supply. These issues are common to all industry sectors in Bangalore, be it IT, aerospace or automobile. Therefore analyse is done on the major challenges, which are believed to influence the future growth and prospects of aerospace industry in Bangalore.

### 3.1. Infrastructure

Externalities exist in infrastructure and in India's manufacturing industry they are an important part of productivity growth (Hulten *et al.*, 2006). Physical infrastructure such as road, electricity, and port facility continues to affect more indirectly the growth of manufacture sector, however not much research has been carried out exclusively to study resulting in inadequacy of data. It is also observed that infrastructure gains more importance in developing countries like India when compared to developed economies with more mature and denser infrastructure systems. Gaps existing in Indian infrastructure posing threat to growth momentum (Lakshmanan, 2008), also private participation has failed to meet expectation in many projects. The basic requirements of PPP model in attributed to stable macroeconomic framework, sustainable project revenues, good corporate governance, effective labour laws and investor friendly policies. However many projects are facing hurdles coupled with severe power outages has made infrastructure a concern for many manufacturing industries.

### 3.2. Finance

In recent years, the government has been liberalizing FDI norms in key sectors including aerospace (Moser *et al.*, 2010). While the aerospace industry in India, traditionally dominated by the defence sector, is struggling with limited investment capability, FDI route appears to be the key factor for generating huge investments. There is a dire need to increase FDI limits and reduce bureaucratic hurdles, which is a dampener for FDIs interested to invest in India. While FDI option may be good for large domestic companies, government funding is critical to support SMEs. Direct and indirect tax incentives to SMEs can also go a long way in attracting the pool of entrepreneurs, to set up shops. Useful insights can be drawn from all the foreign clusters cited in the previous section. In all the clusters, without exception, government subsidies and funding saw through the success of SMEs in initial years. Nationalised banks in India have begun to move into venture funding, which has been accelerated by the clearance made by Governments for FDI in aerospace sector. Karnataka has set up venture capitals of their divisions to promote entrepreneurship and management skills, this is being done by many other state governments. Furthermore there has also been entry of international investors entering the sector in recent years.

### 3.3. Technology

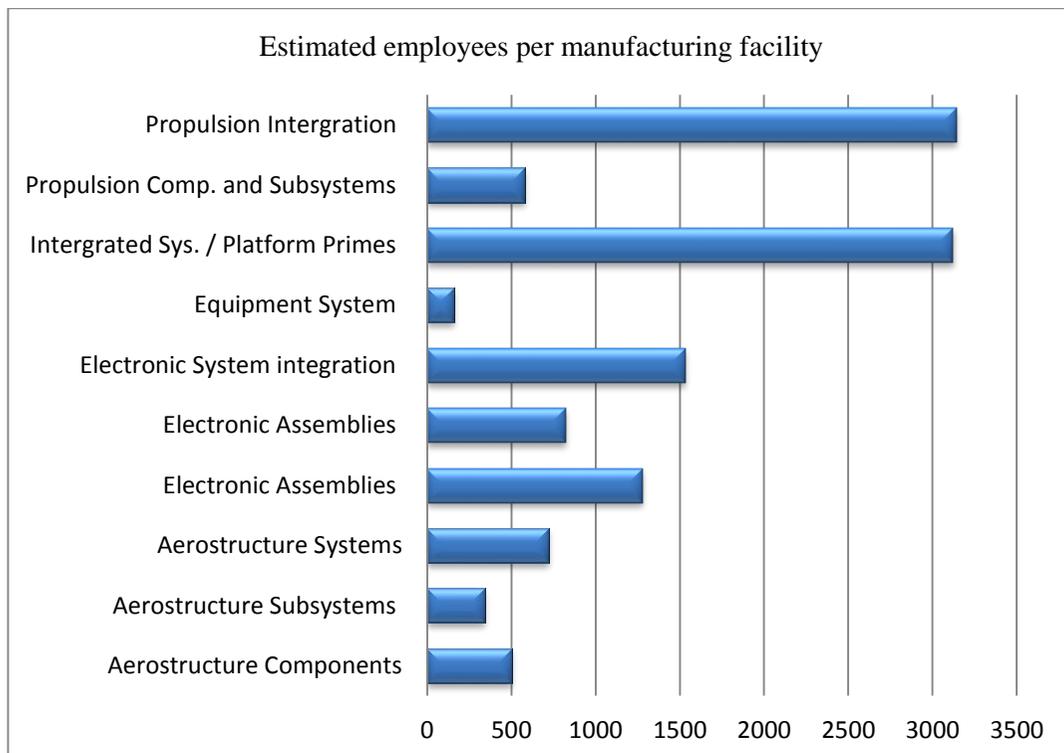
The core competency of any industrial cluster is its technical capability which comprises of manufacturing capability, information technology, R&D capability and quality standards. Bangalore presents highest concentration of IT and engineering service firms with software majors like Infosys, Wipro, TCS and HCL serving clients from all over the world in global aviation and aerospace industry. Global companies like Boeing, EADS, Bell Helicopters etc., have also set up their technology and engineering services support in India at Bangalore. With top technological innovations at its disposal, Bangalore is rapidly becoming an aviation simulation and R&D hub.

Indian government claims to encourage private investment in aerospace industry with focused target of in technology transfer, offset agreements, Indian Government encourages private investment in both the civil and defence aerospace sector with the goal of encouraging technology transfers and achieving indigenization. The offset policies of the government are believed to have facilitated this to

some extent. However India should recognize that it needs technological and managerial expertise from global original equipment manufacturers that will be crucial to the successful development of a commercial or defence aircraft. However, the strengthening of technological base of major companies will have a trickling down effect to SMEs, thanks to the favourable eco-system created by the industrial cluster.

### 3.4. Manpower

Aircraft manufacture calls for a great deal of differentiation in manufacturing operations. A typical aircraft has a large number of mechanical, electrical, electronic and electro-mechanical systems. Therefore, the employee skills show a high degree of differentiation cutting across all domains of engineering. The figure 1 below shows the estimated employees per manufacturing facility according to a study commissioned by PricewaterhouseCoopers' (PwC, 2012).



**Figure 1: Estimated employees per manufacturing facility**

Source: (PwC, 2012)

Bangalore has the potential to provide skilled manpower to aerospace industry. It already has a strong base of automotive, machine tools and electronic industry. However, the government and the industry bodies need to do more, in terms of setting up training institutes on the lines of Government Tool Room & Training Centre, which is doing good work. The presence of large number of industrial training institutes, polytechnic colleges and engineering colleges in and around Bangalore can provide the required manpower support.

## 4. CONCLUSIONS

The Bangalore aerospace cluster is on the threshold of whopping growth in its fortunes, provided the industry and government work together with a common vision. It enjoys unique advantages in terms of six decades of design & manufacturing experience, availability of quality manpower and good eco-system comprising SME pool, high quality research institutions, suppliers of raw materials, financial institutions of repute, to name a few. It has all the ingredients of a progressive industry cluster.

However, the challenges are many, and policy makers should take the centre stage to provide the required fillip to the industry.

Aerospace industry continues to face challenges due to increase in competition as well as high energy costs, volatile fuel prices and dynamically changing currency rates. OEMS are outsourcing sub assemblies such as structures, land gears & avionics and engines to reduce costs and are focusing on their core competencies of design, assembling and marketing aircraft (Niosi & Zhegu, 2005). This represents opportunity as well as threat for tier-2 and tier-3 manufacturers, who have to innovate, invest in change, adopt high level technologies and implement best practices to survive and progress in their respective clusters.

Each aerospace cluster around the world has its own growth experience, some of which have been highlighted in section 2 of this paper. It is interesting to see what lessons we can draw from these experiences. Industries around the world have been sustained by the patronage of respective governments, conducive policies, effective R&D support and constant interaction with academic institutions. Dynamics of aerospace clusters is unique and government policies have aided the growth of SMEs and it is the prime responsibility of the central and state governments to aid and nurture growths of SMEs. This has been observed in many clusters such as Toulous, Seattle and North-West England.

Thanks to the longer manufacturing cycle time for aircrafts, small batch size and the need to cut manufacturing costs, OEMs, especially in Europe have spread their supply chain across several countries. The implication for India is that unless creation of world class infrastructure and pooling of skilled manpower, the OEMs that are currently looking at India as the manufacturing destination, may start scanning the horizon for suppliers in our neighbourhood. Countries such as Indonesia, Malaysia, Taiwan and South Korea, are likely to snatch away sizable orders at the cost of Indian SMEs.

Chinese government has been aggressively promoting foreign participation in the development of the aerospace industry and transfers of foreign aerospace technology to China. China started as a manufacturing partner for foreign aircraft manufacturers. The visible signs of success for this policy are the extent to which U.S. and other foreign aerospace firms are dependent on supplies from China (Roger *et al.*, 2011). However, in the longer run, this route would not help indigenous aircraft manufacturers to design and develop new aircrafts. Unless we forge more R & D collaborations with global aircraft majors, we will not be able to leap frog on to the high technology band wagon. This will, in turn, seriously affect the fortunes of Indian SMEs since they will be always dancing to the tunes of global OEMs.

Bangalore aerospace cluster continues to evoke interest among all OEMs throughout the world as their manufacturing destination. It has the right mix of variables such as presence of quality focal firms like HAL, sizable population of SMEs, large pool of skilled manpower and the critical mass of indigenous research infrastructure. However the major concerns remain in terms of infrastructure bottle necks and slow pace of policy reforms to attract more FDI into this sector.

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## References

- Arora, A., & Gambardella, A. (2006). *From underdogs to tigers: The rise and growth of the software industry in Brazil, China, India, Ireland, and Israel*. Oxford University Press.
- Cliff, R., Ohlandt, C. J., & Yang, D. (2011). *Ready for takeoff: China's advancing aerospace industry*. Rand Corporation.
- Hickie, D. (2006). Knowledge and competitiveness in the aerospace industry: The cases of Toulouse, Seattle and North-West England. *European Planning Studies*, 14(5), 697-716.
- Hulten, C. R., Bennathan, E., & Srinivasan, S. (2006). Infrastructure, externalities, and economic development: A study of the Indian manufacturing industry. *The World Bank Economic Review*, 20(2), 291-308.
- Lakshmanan, L. (2008). Public-private partnership in Indian infrastructure development: Issues and options. *Reserve Bank of India Occasional Papers*, 29(1), 37-41.
- Mani, S. (2010). *The flight from defense to civilian space: Evolution of the sectorial system of innovation of India's aerospace industry*. Production and Science & Technology Linkages to Stimulate Innovation in ASEAN, Page 17.
- Miranda, N., & Finance, M. M. S. (2010). *India's aerospace industry*. MET League of Colleges: 25.
- Moser, R., Heiko, A. G., & Gnatsy, T. (2010). *The Indian aerospace industry 2019*. The BrainNet Supply Management Group AG, Germany.
- Niosi, J., & Zhegu, M. (2005). Aerospace Clusters: Local or Global Knowledge Spillovers?. *Industry and Innovation*, 12(1), 1-25
- Porter, E., Michael, & Takeuchi, H. (2013). *Aerospace cluster in the Toulouse region*. Working paper on Microeconomics of Competitiveness, Harvard Business School, USA.
- Prabhakara, S. S., & Raghavendra, N. V. (2012). Does clustering of enterprises foster technological learning? Insights from the Bangalore machine tool cluster in South India. *International Journal of Technological Learning, Innovation and Development, Inderscience*, 5(4), 408-426.
- PwC (2012). *Sectoral structure analysis aerospace review*. PricewaterhouseCoopers', on-line version, [www.pwc.com/aerospaceanddefence](http://www.pwc.com/aerospaceanddefence).
- Roger, C., Chad, J. R., & Ohlandt, D. Y. (2011). *Ready for Takeoff China's advancing aerospace industry*. RAND Corporation monograph series, USA.
- Swiss Business Hub Brazil (2009). *The Brazilian aerospace cluster*, São Paulo. June 2009.
- Williams, T., Maull, R., & Ellis, B. (2002). Demand chain management theory: Constraints and development from global aerospace supply webs. *Journal of Operations Management*, 20(6), 691-706.