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An analysis of the importance of industry-specific vertical policies for growing high technology industries in India

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India is one of the fastest growing countries of the world at present. Currently she is attempting to raise the share of her manufacturing sector to at least a quarter of her GDP by 2022 through variety of proactive industrial policies. This has led to a debate of sorts on the role of industrial policies when the economy is moving towards a free market economy where the discretionary role of government is reduced to a minimum. India's small manufacturing sector, although now sixth largest in the world, is slowly moving towards high and medium technology industries, both in terms of manufacturing value added and in terms of share of manufactured exports. India is now slowly becoming an important player in selected high and medium high technology sectors such as aerospace, pharmaceuticals, and automobiles while her attempts at developing a telecommunications equipment manufacturing industry has failed. The paper identifies the vertical policies that have been crucial for the development or lack of it of each of these four high tech industries. While these vertical policies are shown to be one of the necessary conditions for the growth of these high technology sectors, the sufficient conditions depend on the existence of firm strategies that can take advantage of these proactive vertical policies. The paper thus underscores the importance of specific vertical policies be it is the case of the offset policy in the case of the aerospace industry, the patent policy in the case of the pharmaceutical industry and so on.

Keywords*:* high technology industry, aerospace, pharmaceutical, automotive and telecommunications equipment, offset policy, R&D tax incentives, public technology procurement, India.

Introduction: India, currently (c2015) is one of the fastest growing countries in the world. But this growth is largely driven by its services sector. From around 2006 or so, the country has been striving to industrialize through the manufacturing route as growth driven by the manufacturing sector has a number of long lasting economic benefits. First of all, manufacturing sector has much more linkages with the other two sectors of the economy, namely the primary and tertiary sectors. Second, most of the innovations that are used in the primary and tertiary sectors emanate from the manufacturing sector. For these reasons and more, countries across the world including that of India are on a conscious drive to increase the size and technical content of its manufacturing sector. The manufacturing sector in turn consists of a number of disparate industries. One way

of grouping them is in terms of their respective employment content and another way is to group them according to their technology content. Although the manufacturing sector in most developing countries are supposed to be dominated by labour-intensive or low technology industries, the current emphasis is on increasing the share of high technology industries. This emphasis on high technology manufacturing is for three specific reasons at least. First, high technology industries have very high levels of productivity, both capital and labour. So, even if their share is small, their contribution to GDP of the country is expected to be much larger. Second, high technology industries have much better linkages with downstream and upstream industries as most high technology manufactured products are based on an assembly of components. So their multiplier effects on growth in the region where they are located is supposed to be much higher. Third, world trade in manufactured products is dominated by high technology products (Mani, 2004, Lall, (1998) and if a country wants to increase its share of exports, it must encourage the production of high technology manufactures. Given the capital-intensive nature of production, use of very often-proprietary technology, high failure rates etc., the role of the state in high technology production is very well accepted. Even in advanced countries such as the USA or Japan, where the market is perceived to be more efficient in the allocation of resources, high technology production has been supported through concerted state intervention. For instance, the role of the state in the SEMATECH project in the USA or the VLSI one in Japan is now very well accepted as the main reason for the supremacy of both the USA and Japan in semiconductor production. Having successfully achieved its original target, the programme is now moving towards the development of other high technology industries such as biomedicine, cyber security and alternative energy. The specific way in which the state intervenes in the development of high technology industries can vary in terms of its content. There are at least three ways in which the state intervenes. The first mode is a direct one in which the state establishes a state owned-enterprise (SOE) which then manufactures the high technology product. The second mode is for the state to establish a public R&D programme either exclusively or in partnership with the market, develop the high technology and then transfer it to production enterprises whether owned by the state or the private sector. The third mode is for the state to craft the eco system for high technology production by having explicit policies and instruments for this to be developed by both public and private sector enterprises. Most industrializing countries

such as India have actually used all the three modes. Modes 1 and 2 were very popular in the pre- liberalization phase while Mode 3 is the preferred one in the post-liberalisation phase characterised by a paring down of state intervention in economic activities.

In the context, the purpose of the study is to analyse the growth of high technology manufacturing industries in India. Our hypothesis is that whichever mode is employed, each high technology industry requires a specific policy that is crucial for its sustained growth. In short, one size rarely fits all. Let us consider two different high technology manufacturing industries, namely aerospace and pharmaceutical. For the aerospace industry the most important instrument for its promotion will be public technology procurement, which manifests itself in the form of an offset policy. Such a policy assures a certain amount of demand for the new product, which encourages the manufacturers to be venturesome. On the contrary, for the pharmaceutical industry, the most important policy is the one on patents, as patents are extremely important for chemical industries in general and pharma in particular[1]. However, a policy for financing R&D and policies on increasing the quantity and quality of science and engineering human resource is important for both the industries. We refer to the former set of specific policies as vertical policies (VP) and the latter set as horizontal policies (HP). The study proposes to verify the hypothesis of the crucial importance of VP by taking three successful cases and one unsuccessful case from India's manufacturing industry. The three successful cases are aerospace, pharmaceutical and automotive industries, and the one unsuccessful case is the telecommunications equipment industry.

Rest of the paper is structured into three sections. Section 11 maps out the growing importance of high technology products in India's commodity export basket. Section III identifies four high technology products that are important contributors to India's high technology exports, namely aerospace, pharmaceutical, and automotive and telecommunications equipments and identify the key policies that have contributed to the growth performance of these high technology sectors. Of these four,

[1]The importance of patents to pharmaceutical innovation has been reported in several cross-industry studies by economists. See for instance Levin ET a (1987), Cohen et al (1997), Mani and Nelson, 2013.

telecommunications is a failure in as much as that, India is very much dependent on imports for its requirement, while in the other three, India has a growing positive trade balance and innovative activity by domestic enterprises. The fourth and final section sums up the main findings of the paper and identifies the key policies that are responsible for the growth performance of each of these chosen four high technology industries.

II. Growing importance of high technology manufacturing:

India has now (c2015) emerged as the sixth largest manufacturer in the world defined in terms' of her share in world Manufacturing Value Added (MVA). See Figure 1. According to the latest estimates by the CSO, the share of the manufacturing sector in overall GDP works out to about 18 per cent (Central Statistical Organization, 2015). The government is pursuing a strategy for increasing both the share of manufacturing and an improvement of its technology content through a number of high profile strategies the most recent version of it is the "Make in India" strategy announced in 2014.

For quite some time, and precisely since the start of the current millennium, India has been trying to improve its small manufacturing sector both in terms of its size and in terms of its technological content. There are two visible manifestations of this "growing high technology manufacturing industry" strategy. First, a number of policy statements pertaining to specific high technology manufacturing sectors have been enunciated. Examples of this are the Aerospace manufacturing (contained in the civil aviation), Automotive, Biotechnology, Chemical, Electronics and telecommunications, Pharmaceutical, Semiconductor policies announced from time to time during the period. Second, is the growing importance of high technology products in both the gross value added and exports of the manufacturing sector. The quantitative dimensions of both these are presented in Tables 1 and 2 respectively.

Growing importance of high technology products in India's manufacturing value added

It is interesting to note that high technology manufactures account for about 40 per cent of gross value added of the manufacturing sector. Unfortunately, lack of availability of consistent disaggregated data for earlier periods are not available and so one cannot track how much of an improvement in the high technology intensity of domestic manufacturing has actually taken place. Further, our way of defining the high technology sector does fully correspond to the OECD definition[2] and so we do not foresee any overestimation of high tech output. This means that India's manufacturing sector has a high share of technology-intensive industries such as chemicals in general, pharmaceuticals, automotive and machinery and equipment in general.

Table 1: Share of high technology products in total manufactured products
(Values are in Rs in crores; Based on Gross Value Added in Constant 2011-12 price)

	2011–12	2012–13	2013–14
Electronic component, consumer electronics, magnetic and optical media	15652	14966	15957
Computer and peripheral equipment	3330	3822	4256
Communication equipment	3315	5273	5680
Optical and electronics products n.e.c	6567	7452	8166
Electrical equipment	48255	54278	59139
Machinery and equipment n.e.c	108555	119145	127476
Transport equipment	128665	147584	158346
Chemical and chemical products except pharmaceuticals, medicinal and botanical products	134782	121173	130846
Pharmaceutical; medicinal chemicals and botanical products	85099	87924	96923
Total high technology	534220	561617	606789
GVA unadjusted for FISIM	1358625	1400815	1490556
Share of high technology manufactures in total manfactured products (in per cent)	**39.32**	**40.09**	**40.71**

Source: Central Statistical Organization (2015)

However most of the high technology products are targeted at the domestic market and as we can see from the next section that India's high technology intensity (high tech exports measured as a percentage of manufactured exports) although doubled itself over time, is still less much less compared to other high technology promoting countries such as that of China.

[2] See the OECD definition at http://www.nsf.gov/statistics/seind93/chap6/doc/6s193.htm (Accessed on April 7, 2016)

Growing importance of high technology products in India's manufactured exports

As a late industrializing country, deficient in both disembodied technology and management and organizational skills, India's export basket was to a large extent dominated by labour-intensive manufacturers such a cotton textile, ready-made garments, gems and jewellery and leather and leather manufactures. However, India's export basket has slowly undergone a qualitative change with more high technology products taking a discernible position in it. In fact, the high technology product intensity has virtually doubled itself during 1988 through 2013 (Table 1). In value terms it has been growing at a rate of 17 per cent per annum during this period. The growing importance of high technology production is evident even in Indian patenting abroad as almost the entire patents granted to Indian inventors at the USPTO, during the same period, is in high technology areas such as pharmaceuticals and computer software.

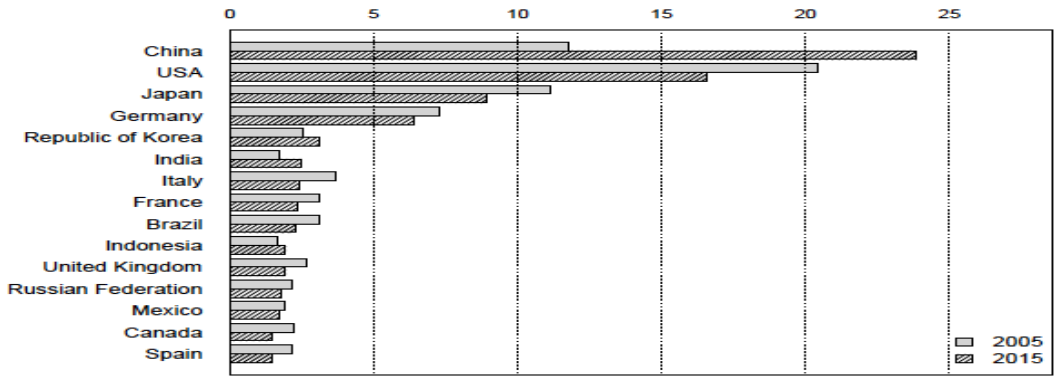

Figure 1: Share of India in World Manufacturing Value Added in constant 2010 prices

Source: UNIDO (2016)

Table 2: Growing high technology exports from India, 1988-2013

	Value (Millions of USD)	Intensity (%)
1988	402.15	4.07
1989	512.08	4.20
1990	497.83	3.94
1991	604.23	4.69
1992	615.24	4.05
1993	695.84	4.25
1994	959.20	4.78
1995	1351.22	5.80
1996	1662.49	6.87
1997	1685.90	6.54
1998	1414.83	5.62
1999	1679.11	5.74
2000	2062.49	6.26
2001	2286.51	6.97
2002	2353.67	6.24
2003	2710.12	5.95
2004	3355.93	6.00
2005	4139.24	5.80
2006	4876.30	6.07
2007	5997.79	6.40
2008	7738.41	6.78
2009	10728.45	9.09
2010	10086.63	7.18
2011	12870.673	6.87
2012	12434.267	6.63
2013	16693.424	8.07

Source: World Bank (2016)

High technology exports from India are driven by four items, namely automobiles, pharmaceuticals, electronics (read as telecommunications equipments) and aerospace (Figure 2). Of these four, exports of three of them have been increasing (although there is decline in aerospace exports in 2015 compared to 2014). Exports of electronic products have been steadily declining. However, India has a consistent positive trade balance in only three of them namely, aerospace, automobiles and pharmaceuticals, while it has a growing negative trade balance in telecommunications products. This is a bit counter intuitive as India had a long strategy of developing local technological capability in telecommunications equipment where considerable amount of state investments in manufacturing and R&D were done. Further, with a total subscriber strength of nearly 1 billion telephone subscribers and growing India has one of the

largest markets in the world for telecommunications equipments but it has virtually no serious manufacturer of telecom equipments, but only assemblers of equipments based on imported components. It was seen that gross value added to gross value of output ratio is very low in the case of this industry (Mani, 2012).

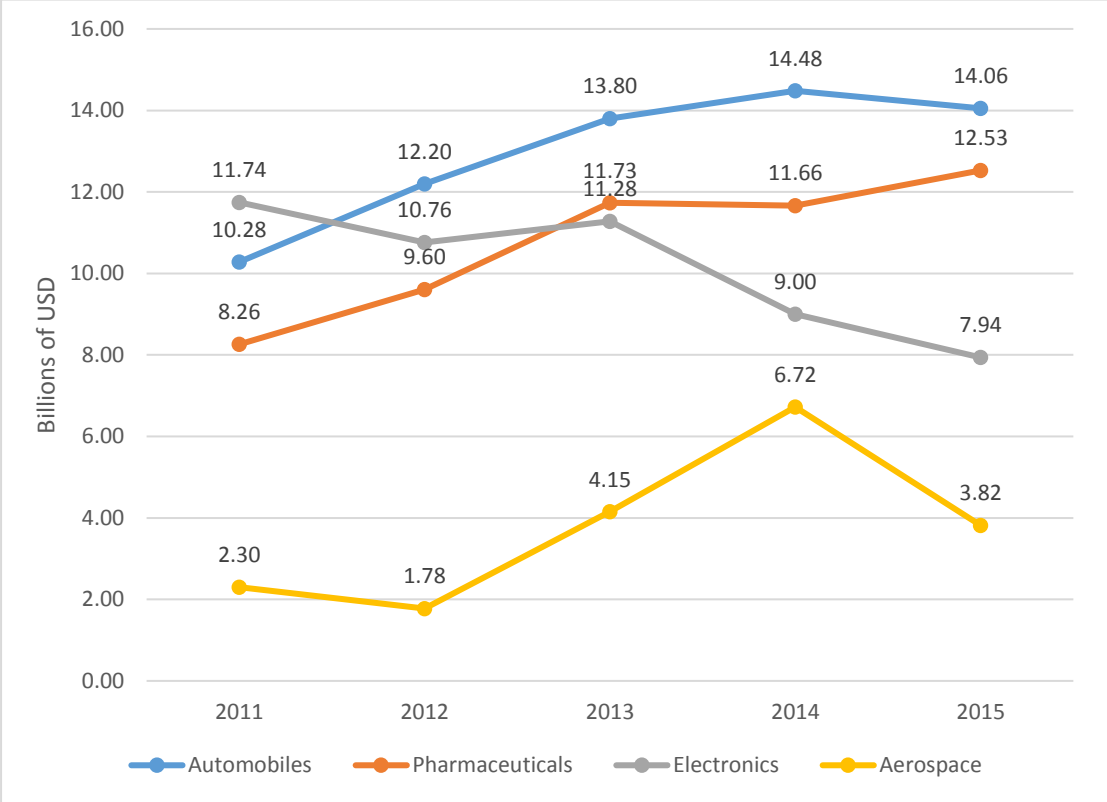

Figure 2: Exports of high technology products- disaggregated during 2011 through 2015
Source: ITC Trade Map-International Trade Statistics, http://www.trademap.org/tradestat/Product_SelCountry_TS.aspx?nvpm=1|699||||TOTAL|||2|1|1|2|2|1|1|1| (Accessed on March 29, 2016).

Of these four industries, only the success achieved in pharmaceutical industry has merited any detailed attention. Although there are some studies available on the automobile and telecommunications equipment industries, there are, practically, no studies on the aerospace industry in the country. While the role played by the policy on patents in explaining the growth of India's pharmaceutical industry has been debated, the role of public policies in shaping the growth trajectory of the other three high technology industries have hardly attracted any attention in the scholarly literature. In fact, in India, there has been an erroneous tendency to equate high technology with luxury consumption goods, which are hardly suited for bulk of the consumers with very

low purchasing power. But as recent events and discussions have showed rather conclusively that each of these four high technologies have made a perceptible difference to the living conditions of an average Indian citizen. For instance, having a successful and innovative generics drug industry has made many lifesaving drugs at affordable prices, having one of the cheapest telecommunications services and indeed equipments (although much of the latter is imported) has increased the affordability of telecommunication services and reduced the rural urban digital divide by a significant amount. Likewise having a successful aerospace industry has increased communications services and have increased the diffusion of tele medicine and education in unreachable physical locations, and having a domestic automobile industry has increased both the movement of passengers and goods across large tracts of the country. In other words, the growth of high technology industries has gone towards improving the quality of life of an Indian citizen. In the following section, we now analyse the role of public policies in explaining the growth performance of four chosen high technology industries although it has not resulted in successful outcomes in all the four cases.

III. The four high technology industries

We discuss the four cases separately beginning with the aerospace case.

(i) Aerospace industry: The aerospace industry in India consists of two distinct industries: aeronautical and astronautics. While the success of the astronautics is fairly well understood as India has demonstrated time and again her technological capability to design and manufacture and successfully launch both satellite launch vehicles and satellites, her forays in aeronautics is hardly recognised. Although India has one of the most profitable aerospace enterprises in the world, its technological activities are almost entirely in the defence space. However, what is most interesting is that India has started becoming an important exporter of aeronautical products since 2010. See Table 3. Currently (c2013) she accounts for over 2 per cent of the world exports and it is also significant to note that her level of exports is twice that of China's. India is increasingly getting inserted into the global value chain for aeronautical products. In fact most of the leading aircraft manufacturers like Airbus and Boeing have started

manufacturing and R&D operations in India although the scale of it may be low.

Table 3: Exports of aerospace products from India

	Exports (in millions of USD)	Share in world exports (%)	Ratio of India to China
2010	1534.6	1.1	1.22
2011	2302.3	0.9	1.42
2012	1775.5	0.6	1.14
2013	4151.3	1.3	2.15
2014	6721.2	2.1	2.54
2015	3815.8	na	1.10

Source: Computed from UN Comtrade

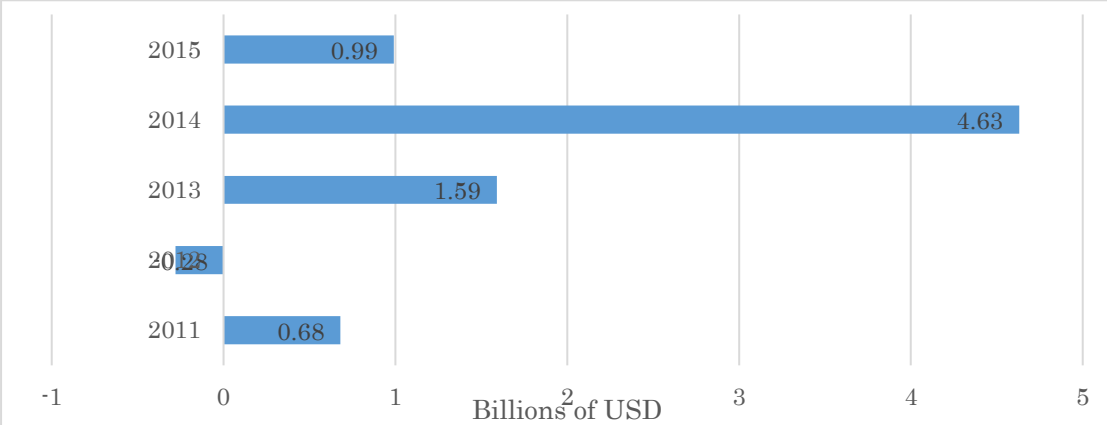

Figure 3: India's trade balance in Aerospace products (Billions of USD)
Source: Computed from ITC, Trade Map- International Trade Statistics, http://www.trademap.org/tradestat/Country_SelProduct_TS.aspx (Accessed on March 24, 2016)

Types of aerospace products exported

India's aerospace exports is largely composed of aircraft parts (Figure 4).However exports in 2015 is largely composed of aircraft to Sri Lanka. According to Engineering Export Promotion Council, Sri Lanka has been importing engineering items from India and the current increase in exports is due to various reasons including the free trade agreement with India and some big orders received in the recent past. However the traditional market for India's exports of aerospace products is to the UAE,

USA, UK, France and Germany in that order.

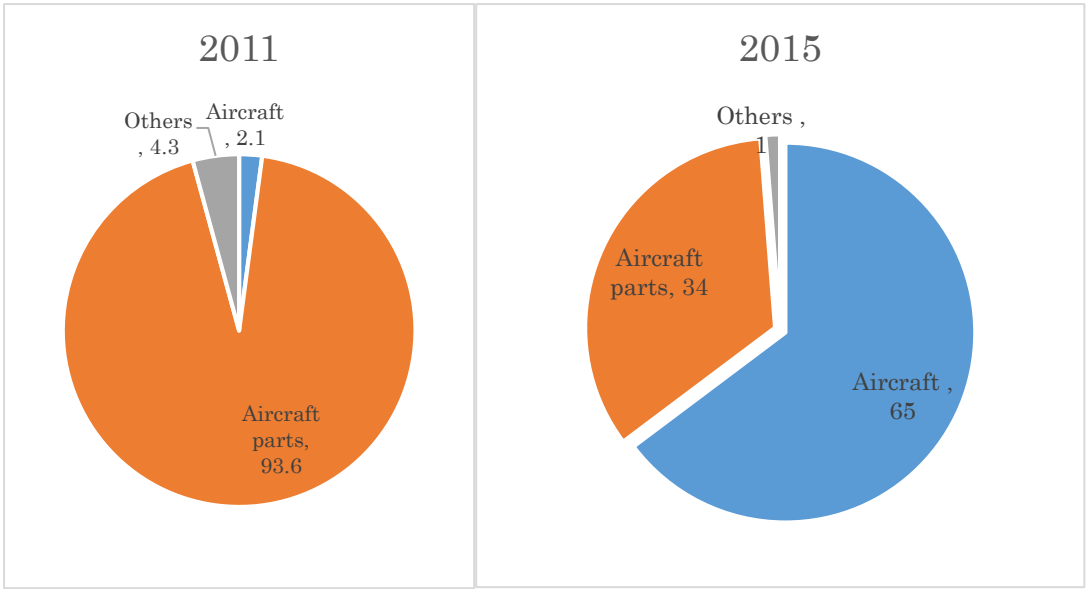

Figure 4: Distribution of aerospace products exported from India according to type
Source: Computed from ITC, Trade Map- International Trade Statistics, http://www.trademap.org/tradestat/Country_SelProduct_TS.aspx (Accessed on March 24, 2016)

Aerospace product manufacturing is taking place through firms located in five aerospace clusters of which, quantitatively speaking, the most important one is in Bangalore. This is because of one of the largest aerospace manufacturing firms in the country, the state-owned Hindustan Aeronautics Limited is located in Bangalore besides a number of sector specific research establishments such as the National Aerospace Laboratory are also located in the city. Mani (2013) had discussed the evolving sectoral system of innovation of this high technology industry in terms of its three building blocks namely the lead actors, the technology domain and demand. At the sub national the state governments of both Karnataka and Andhra Pradesh have very explicit policies for establishing aerospace manufacturing clusters in their respective states[3].

What can possibly explain this phenomenal growth in exports of aeronautical products from India?

[3] See for details, Government of Andhra Pradesh (2013) and PWC (2015)

Contribution of the offset policy

Our hypothesis is that this could possibly be traced to a vertical policy known as Offset Policy (OP)[4]. The OP of a country defines the mechanism for routing procurement funds paid to international contractors back into the spending country. OP can manifest itself in three ways, direct, semi direct and indirect.

Offset policy in India

The policy was introduced in India for the first time in 2005.Since then, the Defence Offset Guidelines have been revised in 2006, 2008, 2011, 2012, 2013, 2015 and 2016 based on difficulties faced in their implementation and feedback from stakeholders and the same have been made more comprehensive and user friendly to derive maximum advantage from offsets in defence contracts. See Figure 5.

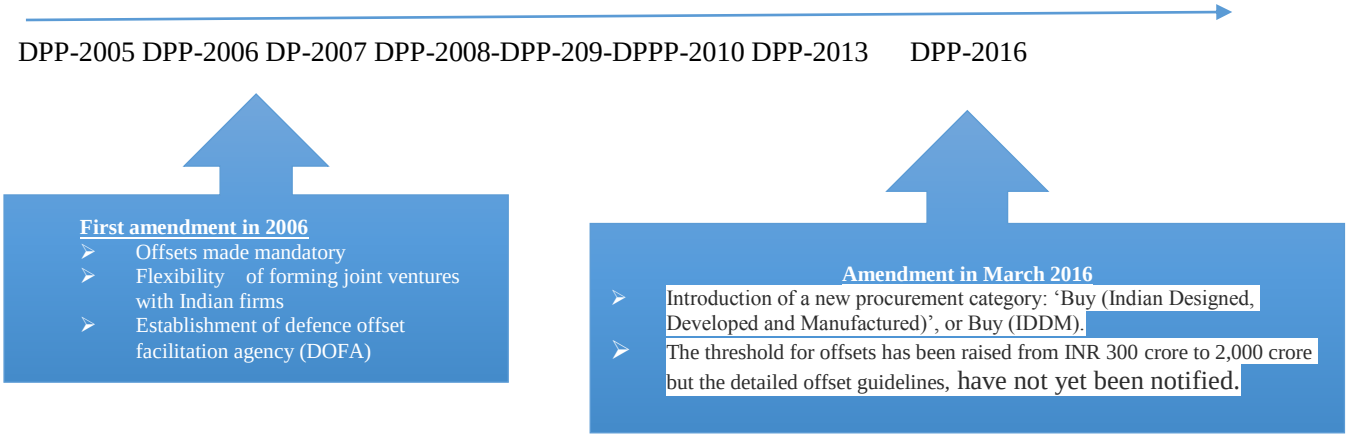

Figure 5: Major trends in India's offset policy
Source: Department of Defence Production, Government of India

[4]The key objective of the Defence Offset Policy is to leverage capital acquisitions to develop Indian defence industry by (i) fostering development of internationally competitive enterprises, (ii) augmenting capacity for Research, Design and Development related to defence products and services and (iii) encouraging development of synergistic sectors like civil aerospace, and internal security.

According to the OP when the value of either a defence or civilian contract exceeds the threshold of Rs 3 billion, 30 per cent of the value of the equipment imported will have to be co-produced or manufactured in India by the exporter. The OP then implies a direct and positive correlation between import and exports of the equipment or product covered by the policy. The Defence Acquisition Council (DAC), the apex decision-making body of the ministry, in January 2016 approved changes to its Defence Procurement Procedures (DPP) to introduce a new category for indigenously made products. The DAC has revised the defence offset clause, which will now be applied only to contracts of more than Rs.2, 000 crores instead of the current Rs.300 crores. The rationale for this change is to encourage more foreign companies to do business with India, but it has the greatest danger of negating the success achieved through the present policy in jump starting a domestic aerospace industry. However in order to minimise this negative effect, the government has introduced a new category under the new category for Indigenously Designed, Developed and Manufactured (IDDM) equipment, it will be mandatory for 40 per cent of the content to be sourced locally. According to industry sources[5], this category is expected to bring two benefits to the fledgling aerospace industry in India: (i) significant investments in R&D; and (ii) will ensure that the human resource in India is engaged in developing cutting-edge technologies in defence.

Routes through which offsets can increase domestic production and exports

The precise routes through which offsets can create an aerospace industry is mapped out in Figure 6. Hitherto (c2014) a total of 24 offset contracts have been concluded amounting to approximately USD 5 billion. These offset contracts are currently under implementation stage with the execution period of certain contracts extending till 2022, although the status of most of the contracts, at the moment, is not known in any detail. The Indian government announced some years ago its plans to implement a fully automated system to monitor, account for and audit offsets in real time, however, to date this system has not been realised. The Indian Offset Partners (IOP) through which the vendors are executing offset obligations are both from public and private sector. In those cases where foreign vendors are not

[5] See PwC-Assocham (2016)

adhering to implementation schedule of signed offset contracts, penalties at the rate of 5 per cent of the unfulfilled obligations are being levied as per the provisions of the offset guidelines. But as pointed out by successive Comptroller and Auditor Genera (CAG) reports that the actual offsets implemented is short of what was expected to be implemented.

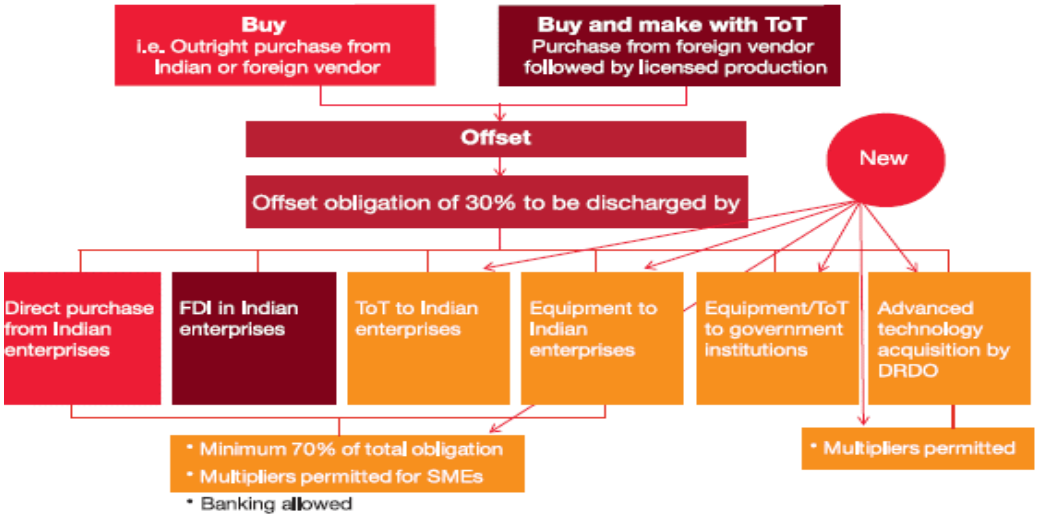

Figure 6: Routes through which an offset policy can create domestic aerospace industry
Source: PWC (un dated)

Offsets and aerospace exports

The offset policy can explain much of the aerospace exports till 2013 as most of the offsets are actually in the aerospace arena with foreign buyers such as Boeing, Airbus, Lockheed Martin and Dassault Aviation and the Indian beneficiaries of these offsets are aerospace companies such as Hindustan Aeronautics and private companies such as the Tata, Reliance group, Mahindra and the Larsen and Toubro. During the period, 2008 through 2010 for which data are available, a cumulative sum of USD 2.64 billion was the offset amount (Figure 7). The largest offsets is from Boeing. Of late Airbus has also become a very large contractor to Indian aerospace companies. (See Box 1).

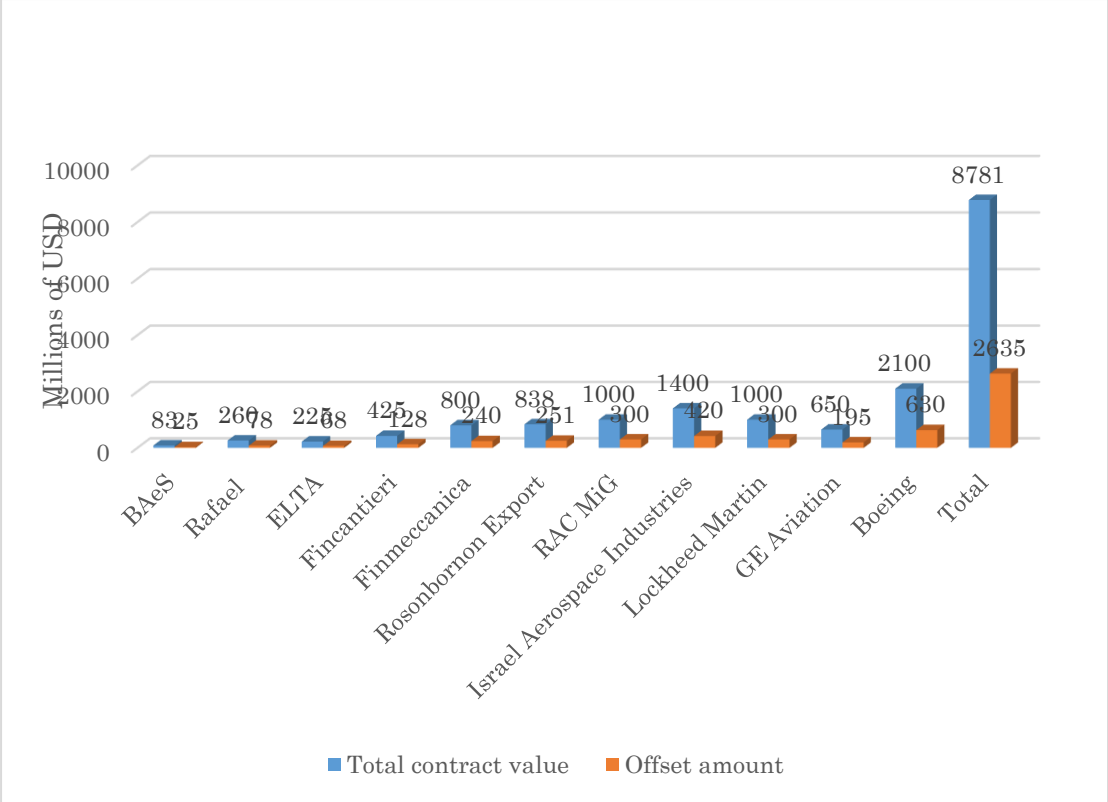

Figure 7: Offset amount vs Total contracted value in aerospace contracts in India, 2008-2010
Source: Lucintel (2012)

Apart from Airbus, Boeing too is concerned with sourcing components worth about USD 1 billion from India as part of an offset obligation linked to the purchase of USD 3 billion-helicopter deal.

With the ongoing acquisition spree of India's airline carriers such as Indigo, Go Air and Spice Jet, the amount of offsets that will be implemented is likely to increase manifold although raising the threshold for offsets to a much higher level is likely to dampen it as well. Success will now depend on IDDM policy. If the daily announcement of domestic manufacturing activity by foreign aerospace firms is anything to go by domestic manufacturing of aerospace components is bound to increase by a significant amount in the years to come.

Box 1: Airbus procurement from India ((c2015)

- In 2015, Airbus exceeded $500 million in annual procurement from India from over 45 suppliers.
- Hindustan Aeronautics Ltd makes half of the Airbus A320 family forward passenger doors produced worldwide, while Dynamatic Technologies Ltd makes flap-track beams for A320 on a global single-source basis and has been contracted to manufacture them for the A330 family.
- Mahindra Aerospace Ltd is in a contract to supply a million aero-components per year, while Aequs Pvt Ltd recently added to a pre-existing sheet metal, assembly and forging facility.
- Tata Advanced Materials Ltd provides composite parts for the wing for the A350 XWB and the A320, while another Tata unit TAL Manufacturing Solutions Ltd is supplying some parts for the A320.
- Infosys Ltd, Geometric Ltd and Tech Mahindra Ltd provide engineering and IT services for the Airbus.

Source: Sanjai (2016)

Other policies promoting aerospace exports.

Apart from the offset policy, which creates the condition for a number of SMEs to emerge in the country, three other factors also have led to the emergence and growth of the aerospace industry in India. The first factor is India's growing emphasis on space research and also her growing technological capability in designing and manufacturing satellites and satellite launch vehicles. This policy has spawned a large number of private sector aerospace component manufacturers in the private sector located mostly in the south India cities of Bangalore and Hyderabad. The second one is the increasing opening up of India's manufacturing sector and specifically the defence equipment-manufacturing sector that has resulted in increasing inflows of FDI to the sector. This policy has also resulted in a large number of joint ventures in aerospace manufacturing in the country. The third factor is the increasing technological sophistication of India's computer software industry. We now discuss each of these three factors in some detail below.

Growing emphasis on space research

Since the 1960s India has an active programme of space research. Approximately a third of India's total expenditure is on space research. Unlike many other space agencies across the world, the Indian Space Research Organisation (ISRO) assembles satellites and launch vehicles from parts supplied by ISROs eleven centres spread around the country. It has also a commercial branch, Antrix, which among other things exports satellite components. However, increasingly over time ISRO has been able to transfer the technology for manufacture of satellite components to a whole host of private sector space manufactureres. Acciording to various estimates (OECD, 2014), about 80 per cent of the parts of Polar Satellite Launch Vehicles (PSLVs) are now produced by the industry.

Table 4: Space budget as a per cent of GDP

	2013
Russia	0.25
USA	0.23
France	0.10
Japan	0.07
China	0.07
India	0.06

	2008
Russia	0.09
USA	0.29
France	0.09
Japan	0.06
China	0.11
India	0.06

Source: OECD (201 4)

India's satellite communication sector has experienced significant growth over the period 2009 through 2014 driven by explosive demand from Direct to Home (DTH) pay-tv platforms and growing telecommunication needs in the country. The satellite communications (satcom) value chain is strongly influenced by the ISRO that is present all along the satcom value chain including for satellite manufacturing, launch, satellite operations, regulations and partially services. On the manufacturing level, roughly half of the country's satellite manufacturing sector spending is dedicated to developing communications satellites. While ISRO dominates the satcom manufacturing landscape, outsourcing to foreign and national companies will continue to provide growth opportunities for a number of manufacturers. Dhruva Space, Xovian and Transpace are new private sector manufacturers that have come up during the period since 2010. However, much of India's exports of satellite manufactures and services are exported by ISROs commercial wing, Antrix Corporation. Exports by Antrix Corporation, however, has been fluctuating as most of the satellite components manufactured within the country are exclusively meant for ISRO's consumption (Figure 8). Antrix has also

been rendering a number of other technical services such as launching satellites built by foreign customers on ISROs Polar Satellite Launch Vehicles (PSLVs) and these are not included in the export data depicted in Figure 9. Hitherto (c 2015), 57 foreign satellites from 21 countries have been successfully launched by PSLV[6]. During 2013 through 2015, a total of 28 international customer satellites belonging to 9 countries were launched viz. Austria (2), Canada (5), Denmark (1), France (1), Germany (1), Indonesia (1), Singapore (7), UK (6), USA (4) and Antrix has earned Euro 80.3 million from these launches. Further, it has signed agreements with clients in seven countries for launching 25 satellites during 2016-17. These include twelve from the US, four from Germany, three from Canada, three from Algeria and one each from Indonesia, Japan and Malaysia,

This growing emphasis on space research and indeed manufacturing is also a factor explaining India's arrival on the world market for aerospace products.

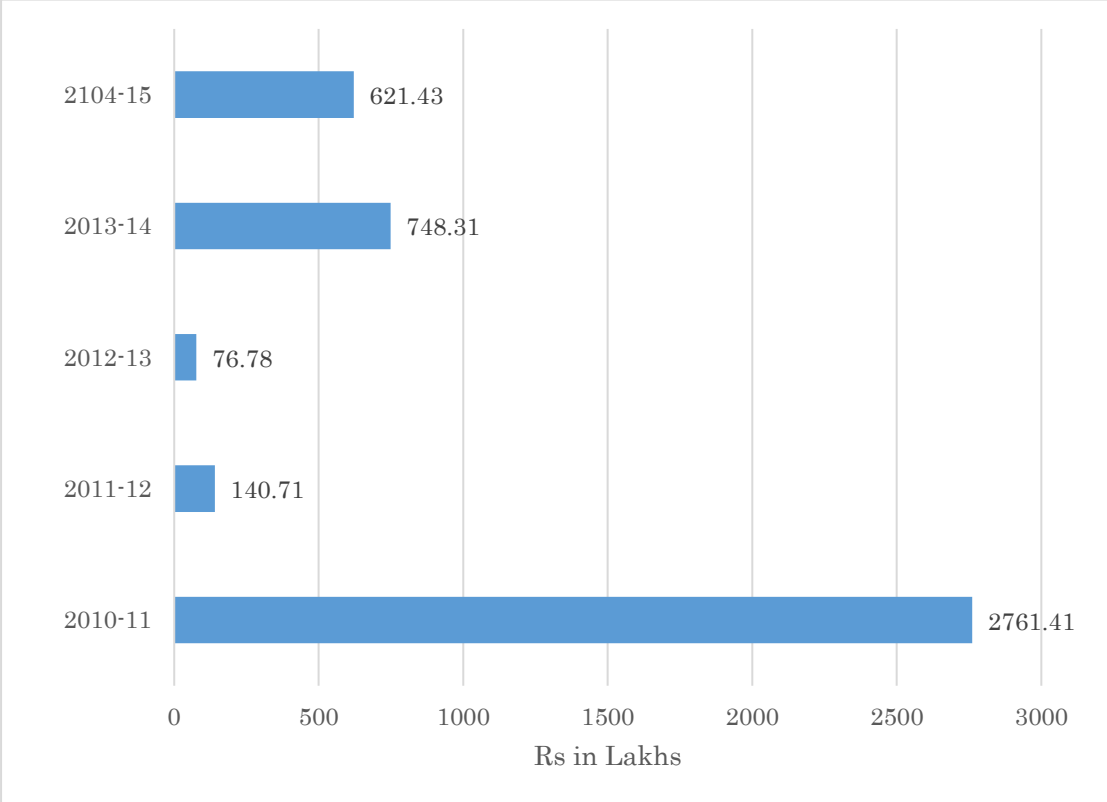

Figure 8: Exports of Antrix Corporation
Source: Annual Reports of Antrix Corporation (various issues)

[6] See answers to questions in India's upper house of the parliament, *Rajya Sabha*, http://164.100.47.4/newrsquestion/Search_minwise.aspx (Accessed on April 4, 2016)

Linkages with foreign buyers

Increasingly, India has managed to insert herself into the global value chain of international aeronautical manufacturing. This is very evident in two of the world's largest aircraft manufacturers establishing their operations in the country. Both have manufacturing and research collaborations with a number of Indian public and private sector aerospace manufacturers. For instance, Airbus has an agreement with Hindustan Aeronautics Limited (HAL) to manufacture forward passenger doors for the A320 aircraft. HAL now produces half of all A320 forward passenger doors. In addition, Airbus' list of Indian partners and suppliers has expanded to encompass engineering, IT services, technical publications, research and technology and manufacturing of aero-structures, detail parts and sub-assemblies. In March 2009, Boeing launched a research & technology centre for sustained collaboration with Indian R&D organizations, both government and private, universities and companies. Since 2007, Boeing has been working together with the Indian Institute of Science and Wipro and HCL, as part of the Aerospace Network Research Consortium. Boeing also has manufacturing contracts with Indian aeronautical companies such as HAL and Dynamatics for manufacturing aircraft parts and components and has now a joint venture with Tata Advanced Systems Limited (TASL). In fact, TASL has a number of other joint ventures with world's leading aerospace manufacturers. Mahindra Aerospace is another domestic manufacturer having manufacturing facilities for air frame parts and assemblies. The firm also has a number of foreign associations, primarily in Australia. Thus the Indian aerospace manufacturing industry is developing both its production and technological capability by being able to associate itself with some of the leading aircraft manufacturers abroad. This capability is now manifested in increasing exports of aerospace products from India.

Finally, there are two governmental initiatives, which will have potential implications for developing the civil aerospace industry in India. First, is the National Civil Aircraft Development project (NCAD) and second, is the most recent policy on civil aviation. Although the NCAD project was initiated in 2007 to design and full develop

a 90 seater Regional Transport Aircraft (RTA) nothing much is known about its actual progress. The draft National Civil Aviation Policy released in 2015 by the Ministry of Civil Aviation (MoCA) has also a number of provisions for increasing aircraft production in India. See Box 2.

Box 2: Aeronautical "Make in India"

a) MoCA will be nodal agency for developing commercial aero-related manufacturing and its eco-system in India. b) MoCA and MoD will work together to ensure that commercial aero-manufacturing is covered under defence offsets requirements. c) MoCA will encourage Indian carriers to consolidate their future demand for commercial aircraft. d) The government will negotiate with global OEMs to facilitate establishment of a complete aircraft assembly plant in India along with its ancillary industries. e) Area where aero-manufacturing takes place will be notified as SEZ. The government will provide fiscal and monetary incentives and fast-track clearances to global OEMs and their ancillary suppliers. f) In case the cost of made-in-India aircraft and components work out to be higher than those supplied from their original sources, the government will consider an incentive package to nullify the cost differential.

Source: Ministry of Civil Aviation, Government of India, http://www.civilaviation.gov.in/sites/default/files/Revised_Draft_NCAP%202015_30Oct2015_1.pdf (Accessed on April 4, 2016)

Increasing technological sophistication of India's computer software industry

India's computer software industry has become the world leader in rendering of computer and information services since 2005 (Mani, 2014). She has managed to maintain and improve her leadership position during the last 11 years or so and has also been going up the technology ladder in terms of rendering IT services to customers abroad. Aerospace design is one of those areas in which all the mainstream IT services providers and a few niche services providers have been showing their technological competences. This crucial capability is also going to give a fillip to India's aerospace industry. A proxy for this capability is the increasing exports of architectural, engineering and technical services (Figure 9).

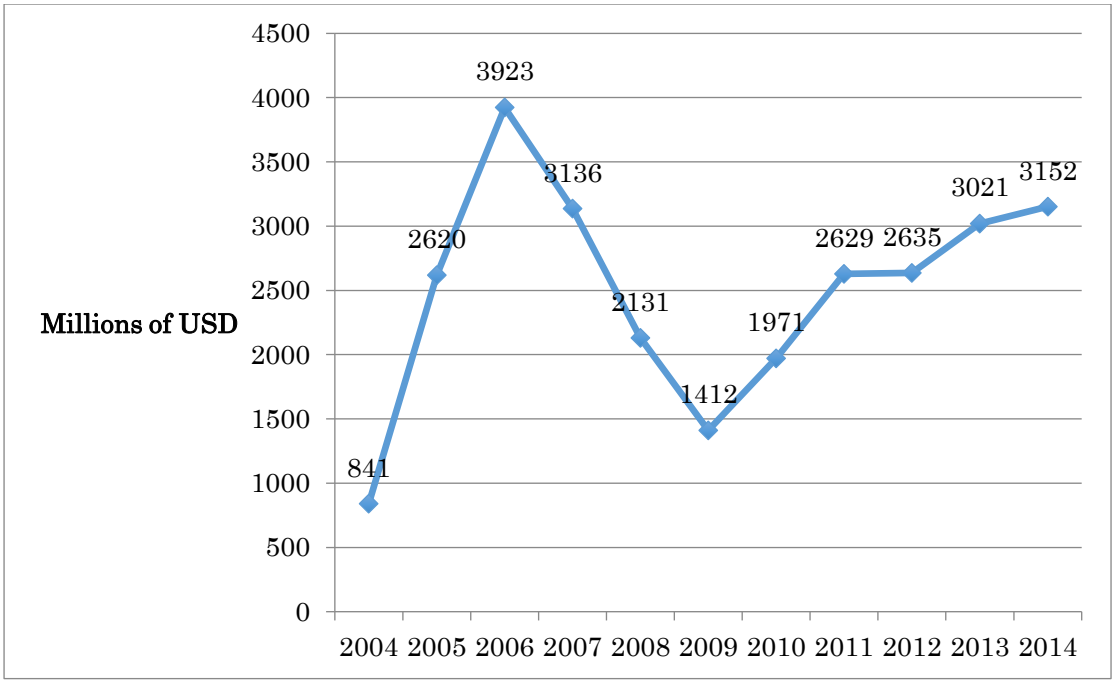

Figure 9: Exports of architectural, engineering and technical services from India
Source: Computed from UN Trade in Services Database

(ii) Pharmaceutical industry: The pharmaceutical industry is one of India's main high technology industries. The industry has three characteristics that are worth noting:

- India is an important player in the production and supply of generic drugs;
- India is virtually self-sufficient in most drugs
- The drug industry is very innovative.

In the following we discuss each of these three features in some more detail.

- **An important generic drugs manufacturer in the world**

India's pharmaceutical production falls into three broad categories: (i) generic drugs, accounting for 72 per cent, Over the Counter (OTC) medicines accounting for 19 per cent and patented drugs, the remaining 9 per cent. Generic drugs is the largest share and India alone accounts for 20 per cent of the global exports in terms of volume making the country the largest supplier of generic medicines in the world. This has earned the country, the sobriquet of 'pharmacy of the developing world'. The country

manufactures and sells over 60, 000 generic brands across 60 therapeutic categories. The number of Abbreviated New Drug Applications (ANDA)[7] approved by the USFDA can be taken as a good indicator of the innovation capability of generic drugs manufacturers. Going by this indicator, over 40 per cent of the ANDAs issued by the US FDA have gone to Indian pharmaceutical firms. Historically too this has been the case (Mani et al, 2013). See Table 5. The country has more than 100 manufacturing facilities approved by US FDA. The US FDA official figures indicate that 6300 active Drug Master Files (DMFs) with the regulatory body, of which 26% or 1,700 are from Indian companies.

- **India is self-sufficient in drugs**

India is self-sufficient in most drugs excepting for a small number of patented lifesaving drugs. Exports have been continuously rising and in 2014 stood at 11.56 billion of US dollars. As result of increases in exports trade balance too have been rising and remained positive all through the years. Pharmaceuticals is one of the few manufactured products where the trade balance has been consistently positive and that too rising over time. See Figure 10. This increase in exports is the result of India's considerable technological capability in the design, manufacture and sale of essentially generic drugs which are off patent. Chaudhuri (2005) has shown that this capability to a large extent is explained by the Indian Patents Act of 1970 which enabled the domestic firms to do reverse engineering. In short, the role of the state in enabling the domestic firms to acquire this important capability hardly needs to be re- emphasized.

[7]ANDAs were introduced in the Hatch-Waxman Act and are used by foreign generic drug makers to challenge a U.S patent before its expiry. If successful, the applicant gets a 6-month (180 day) exclusive right to sell its generic version. At the end that period, other generic drug companies can enter other versions of the molecule and generally the price of the generic version falls sharply.

Table 5: Number of ANDAs granted to Indian Pharmaceutical Firms in the USA

	Number of ANDAS approved	Share of the World (%)
2004	26	6.8
2005	49	14.2
2006	72	19.5
2007	98	24.6
2008	126	29.1
2009	126	31.3
2010	130	30.9
2011	154	34.8
2012	201	40.3
2013	158	42.7

Source: Based on USFDA data cited in CRISIL (2014), p. 7

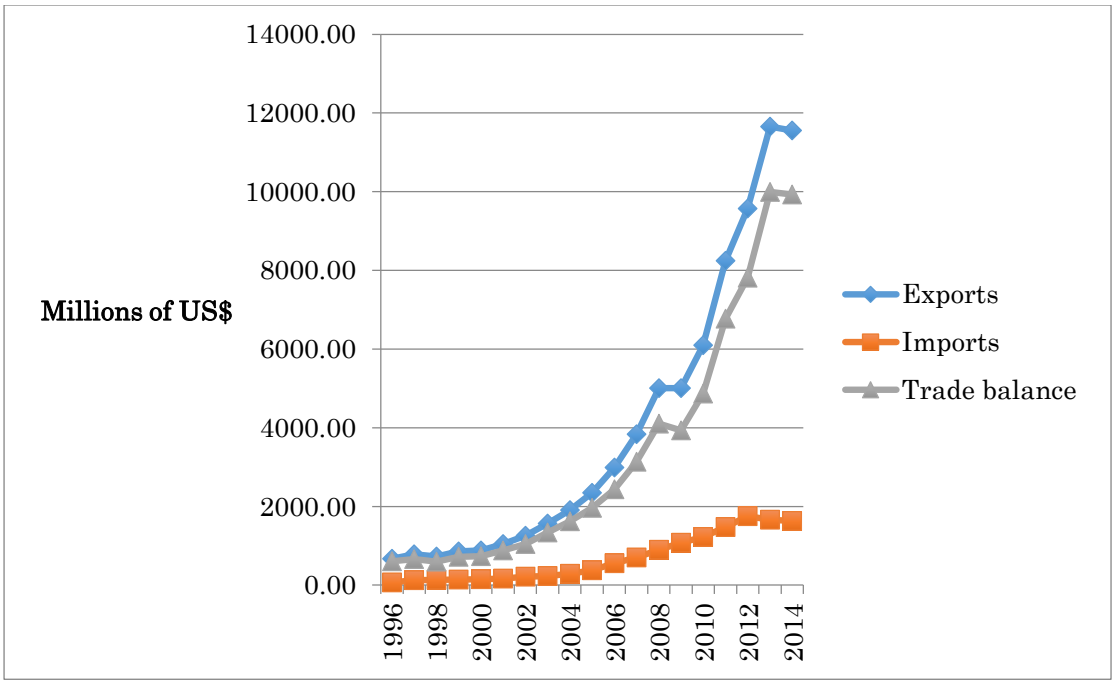

Figure 10: Trends in trade balance of India's pharmaceutical industry
Source: Computed from UN Comtrade

- **Pharmaceutical industry is very innovative**

The pharmaceutical industry is one of the leading innovative industries in India. In fact, the industry dominates both in terms of conventional measures of innovation such as in R&D expenditure incurred and in patents granted. In fact, the industry alone accounts for over 20 per cent of the business enterprise R&D (Mani, 2015). The number of patents granted to the industry, even after TRIPS compliance has

increased manifold (Figure 11). In short the main VP that was crucial for the growth and evolution of the pharmaceutical industry was the patents policy.

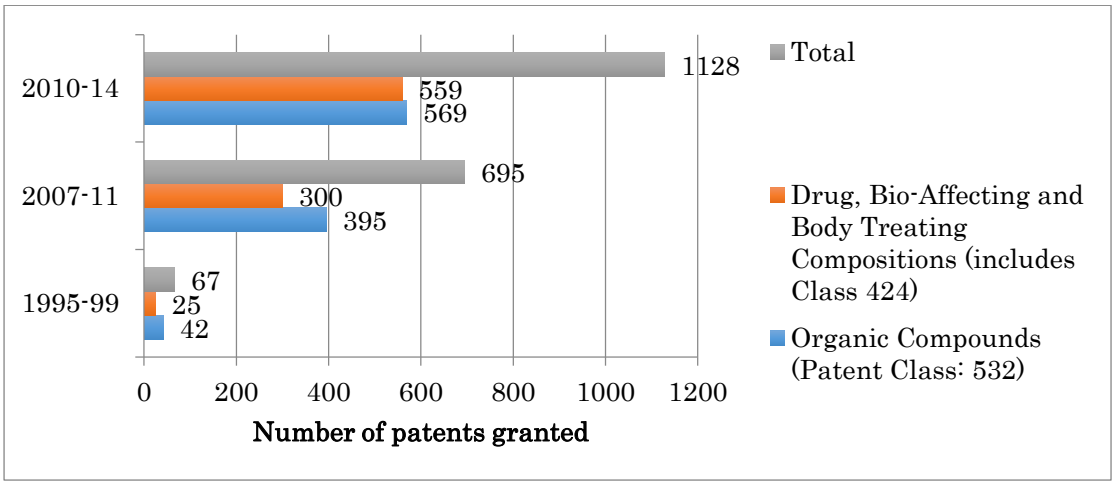

Figure 11: Trends in patents granted to Indian inventors in pharmaceutical technologies at the USPTO
Source: Computed from USPTO

Factors explaining the emergence and growth of India's pharmaceutical industry

The growth performance of this high technology industry has fairly well been documented (Chaudhuri, 2005). There is now enough consensus that the growth of a world class generics industry in India has been contributed to a great extent by the non-TRIPS compliant Indian Patents Act of 1970 which did not recognise product patents in pharmaceuticals, agrochemicals and food products. Only process patents in these three products were recognised by the prevailing intellectual property regime. Even in this case, the patent term was only seven years from the grant of the patent and the burden of proof for any possible infringement of the process patent lay with the patentee whose patent was infringed upon. Such an IPR regime enabled first of all a number of Indian pharma companies to emerge and once emerged grow very fast by developing own technological capability through reverse engineering and imitation. So the crucial one policy, which made the difference for India's generic drug industry, is the patent policy. Even though the policy has been made TRIPS compliant in 2005, the Indian drug industry continue to grow and innovate as evidenced by increases in the exports, positive trade balance, increase in direct employment, and increases in innovative activity (measured through increases in R&D expenditure, patents granted,

number of ANDAs secured etc.)[8]. This is because the industry has managed to develop fair amount of domestic technological capability, which enabled it to stand on its own feet when a product patent regime was re imposed in 2005. Exploiting variation in the timing of patent decisions, a recent paper by Duggan, Garthwaite and Goyal (2016) estimate that a molecule receiving a patent experienced an average price increase of just 3-6 per cent, with larger increases for more recently developed molecules and for those produced by monopoly firms when the patent system began. Their results also show little impact on quantities sold or on the number of pharmaceutical firms operating in the market. In other words, TRIPS compliance does not seem to have had any negative effects on the Indian pharmaceutical industry. Our argument is that this is essentially due to the build-up of domestic technological capability that happened during the non-TRIPS compliant. Further, in addition to this the policy of providing R&D tax incentives and research grants to this industry has also been another important policy that contributed the growth performance of the industry very favourably.

(iii) Automotive Industry: India's automotive industry is one of the successful cases of India's economic liberalisation strategy set into motion since 1991. The industry, which was dominated by a few domestic manufacturers, was hardly known for any innovations before 1991, but is now one of the fastest growing manufacturing industries (real GVA of the industry grew at 7 per cent in 2013-14) not just in India but globally as well. In 2015 India has emerged as the second fastest growing car market in the world next only to China. Sales of two wheelers is touching 20 million units during the year, a first, with all major two-wheeler manufacturers registering high double-digit growth and passenger vehicle sales have touched almost 2.6 million in 20`15. India by 2015 is the largest tractor manufacturer, second largest two-wheeler manufacturer, fifth largest heavy truck manufacturer, the sixth largest passenger vehicle manufacturer and the seventh largest commercial vehicle manufacturer in the world. Gross turnover of the industry has increased from just USD 30.5 billion in 2007 to USD 74 billion in 2015[9]. Exports of cars and auto parts together now make up for a large share of India's

[8]For a detailed analysis of this, see Mani and Nelson (2013).

[9]The source of this data is the website of Society for Indian Automobile Manufacturers (SIAM),

exports- even crossing the shares of her traditional exports such as gems and jewellery, readymade garments etc.

Table 6: Shares (in per cent) of various products exported at 4 digit level of disaggregation

	2011	2012	2013	2014	2015
Petroleum oils, not crude	18.11	18.22	19.93	19.16	11.36
Diamonds, not mounted or set	10.69	7.72	8.6	7.58	8.3
Medicament mixtures (not 3002, 3005, 3006), put in dosage	2.32	2.9	3.06	3.24	4.25
Articles of jewellery parts thereof	4.77	6.29	3.15	4.12	3.78
Rice	1.35	2.12	2.43	2.49	2.41
Cars (incl. station wagon)	1.2	1.46	1.65	1.82	2.04
Gold unwrought or in semi-manufactured forms	0.15	0.01	0.73	0.77	2.01
Meat of bovine animals, frozen	0.85	1.02	1.31	1.49	1.52
Parts & access of motor vehicles	0.91	1.21	1.16	1.26	1.47
Cotton yarn (not sewing thread) 85% or more cotton, not retail	0.91	1.09	1.42	1.29	1.42
Crustaceans	0.55	0.62	0.88	1.21	1.21
T-shirts, singlets and other vests, knitted or crocheted	0.69	0.72	0.77	0.86	1.08
Light vessel,dredger;floating dock; floating/submersible drill platform	1.57	0.8	0.39	1.05	1.06
Women's suits, jackets, dresses skirts etc. &shorts	0.84	0.78	0.73	0.81	1.02
Aircraft, (helicopter, aeroplanes) & spacecraft (satellites)	0.02	0.01	0.77	1.65	0.94

Source: Computed from ITC, Trade Map- International Trade Statistics, http://www.trademap.org/tradestat/Country_SelProduct_TS.aspx (Accessed on April 8, 2016)

The fact that India has emerged as one of the leading manufacturers of especially passenger cars is a fascinating story and our argument here is that this too can be related to industry specific policies which the government put in place beginning with the auto policy of 2002. A chronological evolution of these policies that were directed at the automotive industry is mapped out in Figure 12. The success of the industry could be explained by the liberalisation of the industry in general. Although this was a horizontal policy it affected the automotive industry much more than any other industry. Further, there were many vertical policies (VPs) for the first time like the Auto Policy of 2002, the Automotive Mission Plan of 2006-16, National Automotive Testing and R&D Infrastructure Project (NATRiP), the specific taxation proposals contained in various

http://www.siamindia.com/statistics.aspx?mpgid=8&pgidtrail=10 (Accessed on April 8, 2016)

union budgets. All these VPs aided the firms in the industry, both domestic and foreign to grow and improve both its domestic and export performances as well.

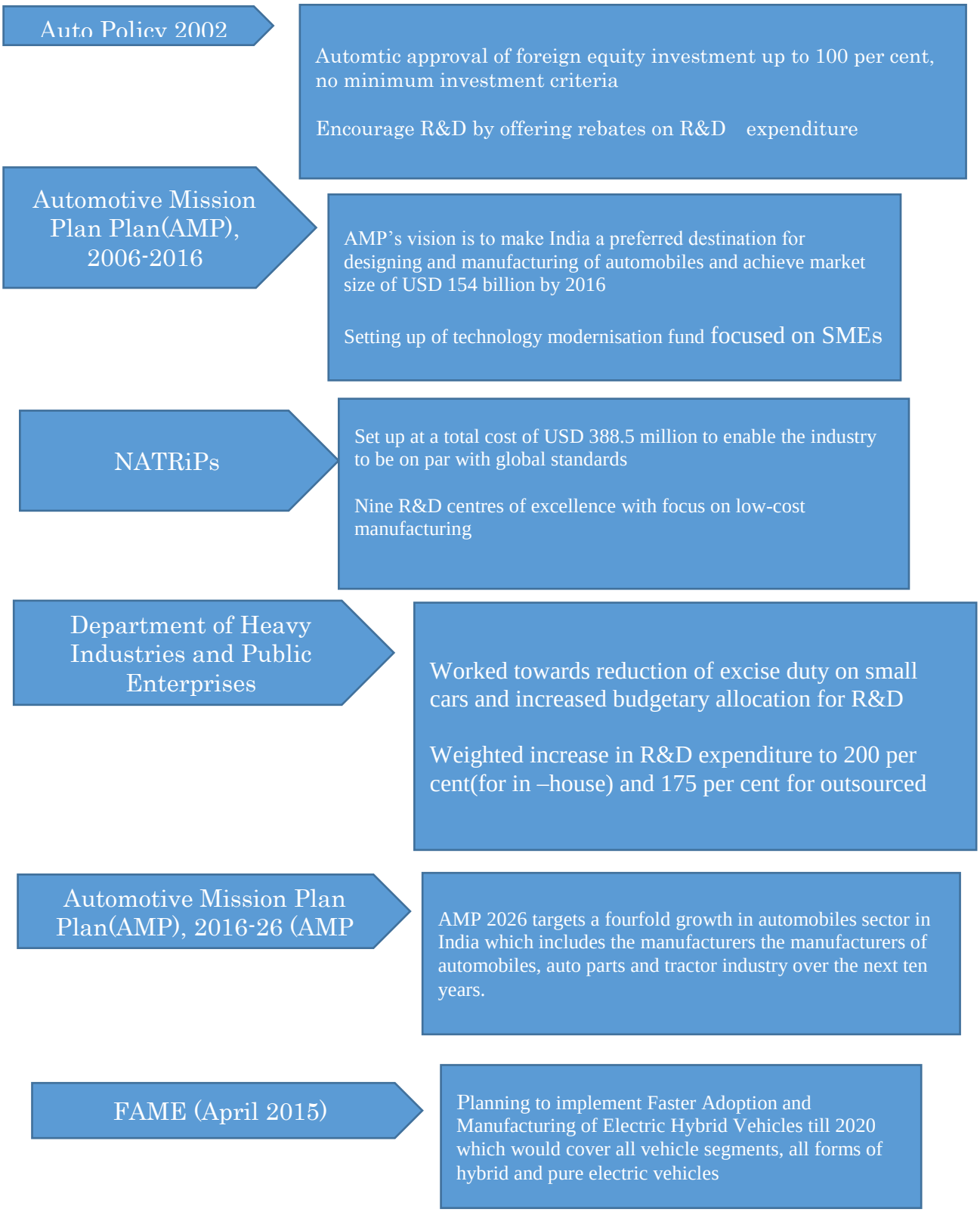

Figure 12: Specific policies that have supported the growth of the industry

Source: Adapted from India Brand Equity Fund (2016)

Along with growing exports, the industry has also become one of the strong R&D spenders in India's manufacturing sector: the industry accounts for about 8 per cent of business enterprise R&D in the country and is ranked number two in terms of its level of R&D spending.

(iv) Telecommunications equipment industry: There are two facets to the telecommunication industry growth story. **T**he first one is a positive story; India in 2016 is one of the world's largest markets for telecommunications equipments. The second one is a negative story of that large market being largely met through imports primarily from China as the country does not have any technological capability to manufacture mobile phones, which account for almost the entire share of the market. The total number of telecom subscribers which was just 5 million in 1991 now stands at over 1 billion and every month India is adding subscribers which are more than the total number of subscribers in a number of Western European countries. Figure 13 traces the trends in total number of subscribers and the monthly additions to it in India. Although India had pursued a policy of self-reliance in telecommunications technology, due to severe limitations in its actual implementation, the country has got into a situation of importing its telecom requirements from especially China. These large-scale imports have resulted in a growing negative trade balance in telecommunications equipments. Our argument here is that both the positive and negative sides of the story can be ascribed to government policies. We now propose to analyse the two sides of the telecommunications equipment coin by beginning with the positive side of the story.

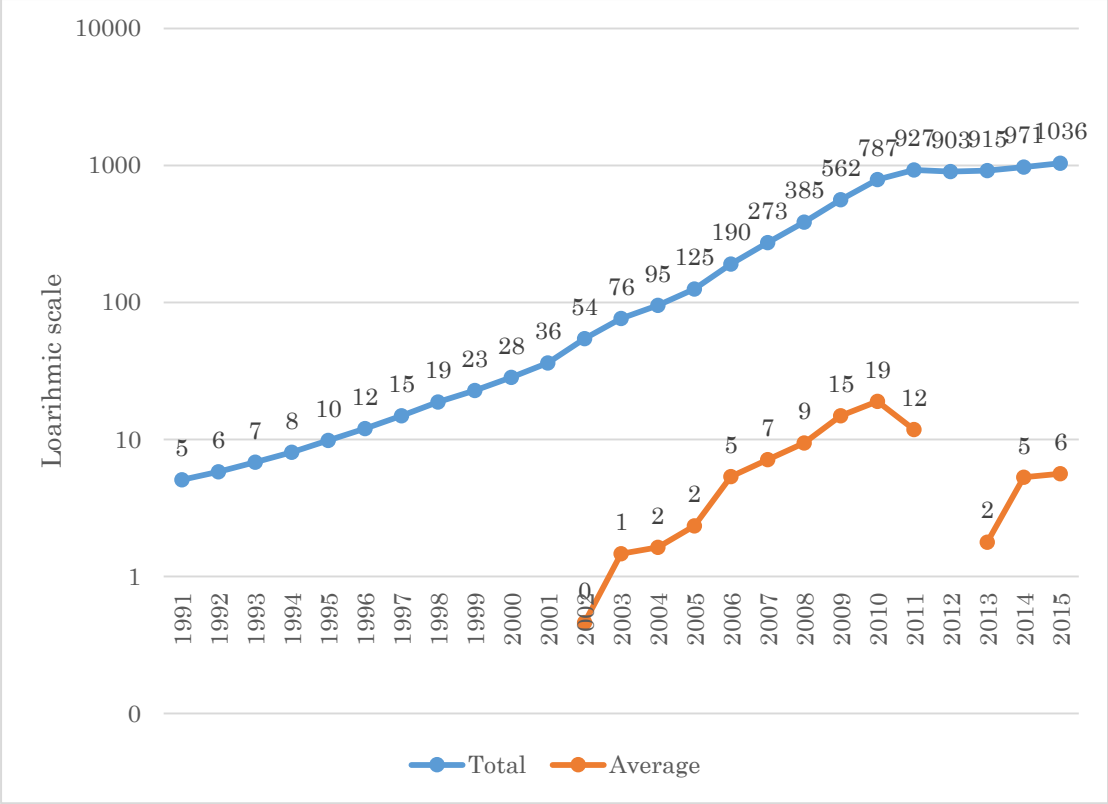

Figure 13 Emergence of India as a huge market for telecommunication equipments

Source: Compiled from monthly press releases of Telecom Regulatory Authority of India

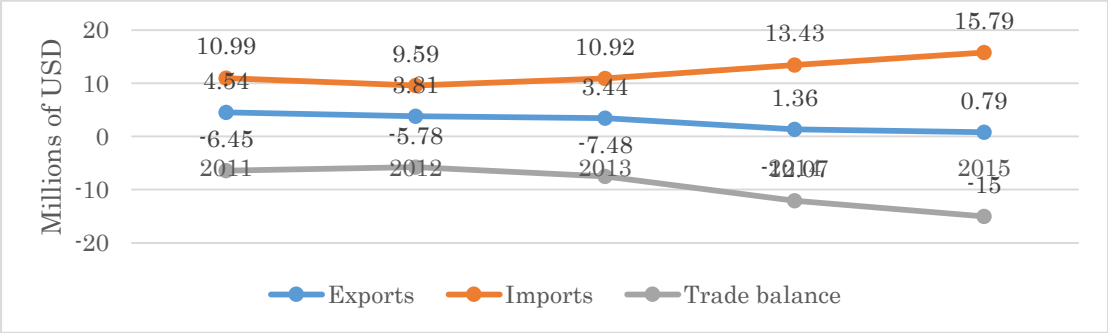

Figure 14: Exports, imports and trade balance in telecommunications equipments

Source: Compiled from ITC, Trade Map- International Trade Statistics, http://www.trademap.org/tradestat/Country_SelProduct_TS.aspx (Accessed on April 8, 2016)

How did the state create such a large market for telecom equipment?

Historically speaking right through independence in 1947, the government has sought to create a domestic manufacturing base in telecom equipment, although the size of this market was only a minute fraction of what it is now. Over the period from 1947 and up until now, one can identify three broad phases in the extent and nature of government intervention in the telecom equipment industry. The first phase covers the long period of 1947 through 1985, when state intervention took an extreme form of manufacturing being under the exclusive purview of state-owned undertakings but with imported technology. The second phase covers the period 1985 through 1991, when the manufacturing of some of the equipment were deregulated and opened up to private sector participation and the state establishing a public laboratory to generate state-of-the-art technologies domestically. The third phase is the period since 1991, when the market was opened up to private and indeed foreign participation. The main difference between the first two and the third phase is in the size of the market. During the first two phases the market for telecom equipment were extremely small as there was only one technology, namely fixed line and only one service provider, which too was owned, by the state. Mani (2005) had shown that during this period the main instrument for market creation was public technology procurement as the demand for these equipment emanated from just one state-owned provider. During the third phase there are two technologies, namely fixed and mobile and a large number of private sector service providers. Our argument here is that the state increased the size of the market by first promoting competition between service providers and then by regulating their market conducts through an independent regulatory agency. This increased competition coupled with regulation reduced telecom tariffs. In the previous section, we charted the phenomenal growth of the mobile services industry in India. Although mobile communications started to make their mark in the late 1990s, the growth picked up and accelerated over the last five years and to be very specific, since 2006 or so. This has led to demand for a variety of telecommunications equipment, most of which, especially the handsets, was not being domestically manufactured. As Mani (2005) has shown, this is because the domestic manufacturing industry and indeed the sectoral system of innovation that the state built up over time focused almost entirely on fixed line technology and indeed products. So the initial growth in the services segment

was met through imports of equipment leading to very high import dependence in the economy. However, with the domestic market becoming sizeable, with an average of 6 million subscribers per month (say in 2015), the monthly demand for telecom equipment in India is almost three or five times the annual demand for such equipment in countries such as Finland, South Korea and the United States of America (homes of some of the largest mobile handset manufacturers in the world). Such being the case, there has been a steady increase in the establishment of domestic manufacturing capacities in India by all leading MNCs in the telecommunications equipment industry. However most of the equipment were either imported or assembled locally with imported components. India has always been eager to create a domestic telecom manufacturing industry. Its history can be traced back to 1948, when the very first public- sector enterprise created turned out to be the leading telecom equipment manufacturer, ITI, set up in Bangalore.[1]This was followed by the establishment of a public laboratory in the name of C-DOT in 1985 to enhance the country's domestic technological capability in the area of equipment manufacturing. Mani (2005) had shown that the main public policy instrument used for domestic manufacturing was public technology procurement. However, with the deregulation and consequent privatization of the distribution of services, the ability of the state to practice this has been compromised. So during the 1990s, we find two discernible routes adopted by the state for encouraging the new desire of the government to make India a manufacturing hub. The first one is through the provision of a variety of fiscal incentives, including through the creation of Special Economic Zones (SEZs). The second is through opening up the sector to foreign direct investment (FDI) in telecom equipment manufacturing.

Mani (2012) showed that the way the telecom service providers were licensed ensured that there was intensive competition between them. The national market was divided into several circles or service areas and in each of the service areas a number of service providers were licensed. There are at present at least 10 service providers in most service areas, although four of them are very recent entrants and are too small in size to infuse any competitive

pressure on the market. We measure competition in terms of the Herfindahl Index (HI). The HI at the national level during the period 2003 through 2015 was within a narrow range of 0.14 to 0.16 with the HI in most years at 0.14. Most of the service providers have focused on specific regional markets, with the exception of the last four service providers. In fact there are only four service providers that have a presence in all the service areas. It is also interesting to see that the service areas where the state-owned BSNL has a monopoly position are also those with very low revenue potential. In other words, the private-sector providers have positioned themselves in the most revenue-earning markets. Also it is evident that it is in the circles with high revenue-earning potential that one sees an increase in the intensity of competition, such as the metropolitan areas of Delhi, Mumbai and Chennai.

One of the more direct effects of this competition is lower prices. Before the deregulation of the telecom services industry and indeed the entry of mobile service providers, the telecom consumers were periodically subjected to increases in the tariff. This has now been effectively checked. Although it is not easy to talk about the price of telecom services, basically it follows a two- part tariff both in the case of fixed and mobile services, first an activation charge followed by a charge for each type of call. For mobile communication consumers there is the additional cost of calls according to whether it is post- or pre-paid. Based on estimates made by TRAI we have obtained average revenue per user for GSM services during the period 2009-2013. See Figure 15. It shows a continuous reduction for every category of markets and by service providers (SPs). The implication of this continuous reduction is that with the price of mobile services falling so rapidly, this has given rise to an ever- increasing number of subscribers. Further, this reduction can also give an additional fillip to the growth of the information and communications technology (ICT) industry in the country. Although the above data refers only to tariffs for mobile telecommunications services, a similar trend may hold true even for fixed services. If one were to plot the price of telecom services and the number of subscribers, one can see an inverse relationship in the case of mobile services, although in the case of fixed services

such an inverse relationship is not visible. This is because of the relative advantages which mobile technology can bestow on its user.

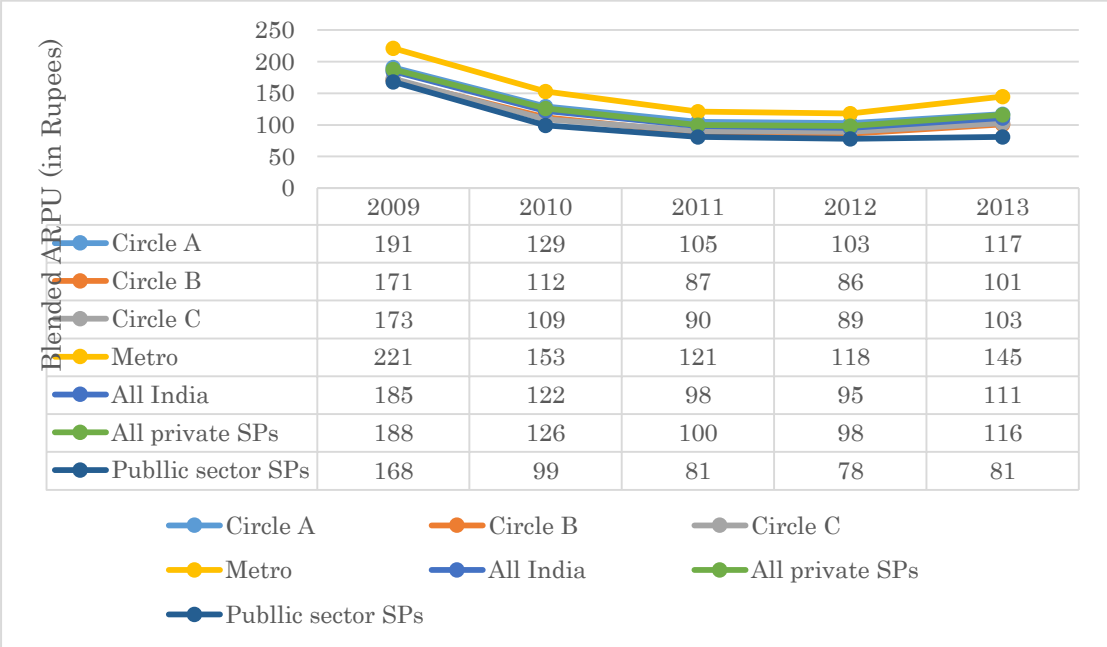

Figure 15: Average Revenue per User (ARPU) across markets and service provider

Note: Blended ARPU is average monthly ARPU of post-paid and prepaid subscribers

Source: Based on Open Government Data Platform India, https://data.gov.in/catalog/arpu-average-revenue-user (Accessed on April 8, 2016)

What went wrong with the policy on manufacturing of telecom equipment?

In the previous section, we charted the phenomenal growth of the mobile services industry in India. Although mobile communications started to make their mark in the late 1990s, the growth picked up and accelerated over the period since 2006 or so. This has led to demand for a variety of telecommunications equipment, most of which, especially the handsets, was not being domestically manufactured. As Mani (2005) has shown, this is because the domestic manufacturing industry and indeed the sectoral system of innovation that the state built up over time focused almost entirely on fixed line technology and

indeed products. So the initial growth in the services segment was met through imports of equipment leading to very high import dependence in the economy. However, with the domestic market becoming sizeable, with an average of 6 million subscribers per month (say in 2015), the monthly demand for telecom equipment in India is almost three or five times the annual demand for such equipment in countries such as Finland, South Korea and the United States of America (homes of some of the largest mobile handset manufacturers in the world). Such being the case, there has been a steady increase in the establishment of domestic manufacturing capacities in India by all leading MNCs in the telecommunications equipment industry. However most of the equipment were either imported or assembled locally with imported components. India has always been eager to create a domestic telecom manufacturing industry. Its history can be traced back to 1948, when the very first public- sector enterprise created turned out to be the leading telecom equipment manufacturer, ITI, set up in Bangalore.[1] This was followed by the establishment of a public laboratory in the name of C-DOT in 1985 to enhance the country's domestic technological capability in the area of equipment manufacturing. Mani (2012) had shown that the main public policy instrument used for domestic manufacturing was public technology procurement. However, with the deregulation and consequent privatization of the distribution of services, the ability of the state to practice this has been compromised. So during the 1990s, we find two discernible routes adopted by the state for encouraging the new desire of the government to make India a manufacturing hub. The first one is through the provision of a variety of fiscal incentives, including through the creation of Special Economic Zones (SEZs). The second is through opening up the sector to foreign direct investment (FDI) in telecom equipment manufacturing.

But these policies have failed to create a local manufacturing industry. So when the market for telecommunications equipment in India grew rapidly, these increased domestic demand were met through imports. Due to paucity of data, we measure the share of domestic output in total availability (total availability is Domestic output +Imports-Exports), only for the three years 2012-2014. See Figure 16. The self-sufficiency rate has been steadily falling and now stands

only at 20 per cent signifying the heavy dependence of the country on imports. Although the country has a few domestic manufacturers, all of them are basically assemblers of imported components. In fact some of the leading domestic handset manufacturers such as Samsung, Micromax, Xiaomi, Gionee, Lenovo and OnePlus have only set up assembly units in the country.

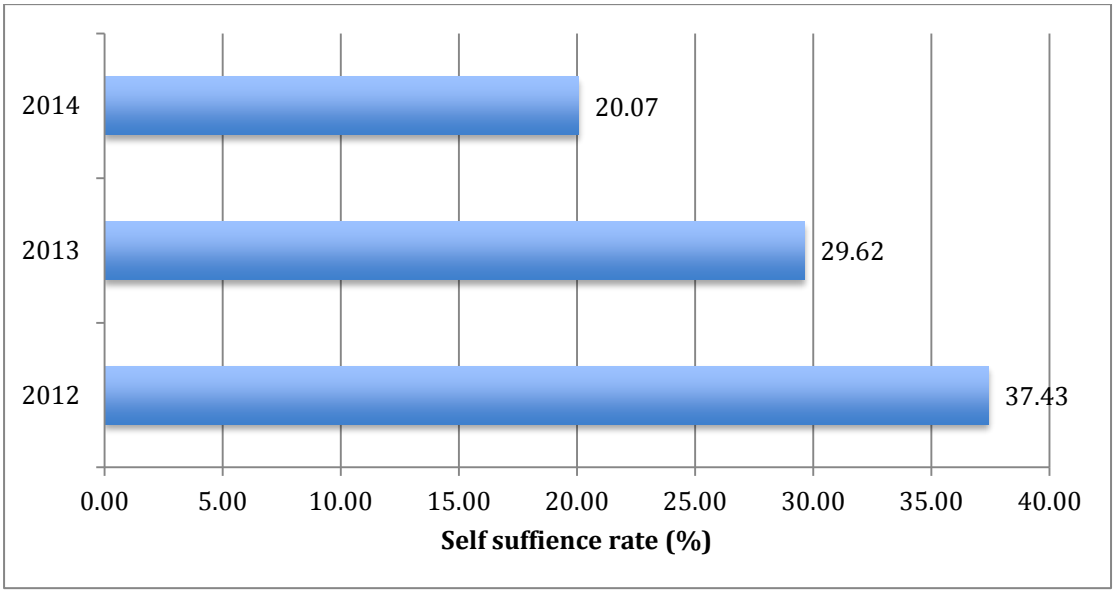

Figure 16: Self-sufficiency rate in telecommunications equipment industry
Source: Computed from CSO (2015) and ITC, Trade Map- International Trade Statistics

IV. Summing Up

The study is primarily concerned with the growth of the high technology sector in India and the role that specific policies have played in promoting the growth performance and especially the trade performance (growth in exports and sign of trade balance) of the industry. The argument in the paper is that each industry, given the nature of its technology and demand for it, requires a specific policy for nurturing its growth apart of general and horizontal policies like liberalization and easing the way business is done. The specific policies range from offset policy in the case of aerospace to public technology procurement in the case of telecommunications equipments. India has been, through these specific or VPs, successful in establishing and nurturing three of

the four high technology sectors considered. See Table 7. It is also interesting to note that government's intervention in the successful cases is, by and large, indirect. The policies have actually been implemented at the ground level by private sector enterprises although in the case of the aerospace industry there were public sector entities too in the form of HAL and ISRO.

Public policies for growing the telecommunications, although having the longest history has failed because the government had on the basis of, on hindsight, weighty non-technical considerations, implemented contradictory policies, which essentially nullified the positive effects of the specific VP.

Table 7: Summary of the four cases of high technology industry development in India

High technology industry	**Specific vertical policy that has been crucial**	**Export rank in the world for the most recent year**	**Qualitative assessment of domestic technological capability**	**Nature of government intervention**
Aerospace	Offset policy	6th rank, 2.1 per cent of the world in 2014	Fair amount for manufacturing aerospace components, and also for designing, manufacturing and launching satellites and satellite launchers	Indirect for component, Direct for satellites and satellite launch vehicles
Pharmaceutical	Patent policy	12 th , 2.4 per cent of the world in 2014	High technological capability for designing and manufacturing generic versions of known drugs	Indirect
Automobile	Automotive policy	22 nd, 1 per cent in 2014	High capability in designing and manufacturing latest models of fuel efficient cars, two-wheelers and a range of commercial vehicles	Indirect
Telecommunication equipment	Public technology procurement earlier, off late the National Telecom Policy	No rank at all	No capability at all in mobile phones-only assembling capability based on imported components	Was direct in the design and manufacture of fixed line telephones

Source: Own compilation

An important dimension of the growth performance story that is analysed in the present paper is the factor that while having sharply focused and implemented vertical policies are a necessary condition for a high technology industry to emerge and grow (best exemplified by the growth and continued success of Indian generics drug industry), the sufficiency condition is in terms of key actors like business enterprises with good corporate strategy and have themselves taken advantage of government policies and built up considerable internal technological capability. So the success depends on the existence of both the necessary and sufficient conditions although in the present study we focused only on the former, as this is very often not highlighted in the role of public policies for growing a sophisticated manufacturing sector. Finally, the study also emphasises the important role of government, which simply cannot be wished away.

References

Chaudhuri, Sudip (2005**),** *The WTO and India's Pharmaceuticals Industry, Patent protection, TRIPS and Developing countries***,** Delhi: Oxford University Press

CRISIL (2014), *Indian pharma well placed to weather spurt in FDA actions*, CRISIL Insight, http://www.crisil.com/Ratings/Brochureware/News/V5-Pharma%20Article%20EdV3.pdf (Accessed on June 8, 2015)

Cohen, Wes, et al (1997), "Appropriability Conditions and Why Firms Patent and Why They Do Not in the American Manufacturing Sector," Working Paper, Pittsburgh: Carnegie-Mellon University

Duggan, Mark, Craig Garthwaite and Aparajita Goyal. (2016), 'The Market Impacts of Pharmaceutical Product Patents in Developing Countries: Evidence from India.', *American Economic Review*, Vol. 106, No: 1, pp.99-135.

Government of Karnataka (2013), *Karnataka Aerospace Policy 2013-2023*, Bangalore: Department of Industries and Commerce, Government of Karnataka, http://gubbilabs.in/demo/investkarnataka/sites/default/files/Aerospace%20Policy_Final.pdf (Accessed on April 5, 2016)

Government of Andhra Pradesh (2015), *Aerospace and Defence Manufacturing Policy 2015-2020*, Department of Industries and Commerce, Government of Andhra Pradesh, https://www.apindustries.gov.in/APIndus/Data/GO/2015INDS_MS54.pdf (Accessed on April 5, 2016)

India Brand Equity Fund (2015), 'Automobiles, Presentation Slides', New Delhi: Indian Brand Equity Fund.

Levin Richard D, et al (1987), 'Appropriating the Returns from Industrial Research and Development', *Brookings Papers on Economic Activity*, pp. 783-820;

Lall, Sanjaya (1998), 'Exports of manufactures by developing countries: emerging patterns of trade and location'. *Oxford Review of Economic Policy* 14 (2), pp. 54-73

Lucintel (2011), *Aerospace offset market opportunity in India*, Presentation slides, Las Colinas: Lucintel.

Mani, Sunil (2004), 'Exports of high technology products from developing countries: Are the figures real or are they statistical artefacts?' in Sunil Mani and Henny Romijn (eds.), *Innovation, Learning and Technological Dynamism of Developing Countries*, Tokyo: United Nations University Press.

Mani, Sunil (2005), 'Innovation capability in India's Telecommunications equipment industry" in A.Saith and M. Vijayabaskar (Eds), *ICT's and Indian Economic Development*, New Delhi: Sage Publications, 2005, pp. 265-322.

Mani, Sunil (2012), 'The Mobile Communications Services Industry in India: Has it Led to India Becoming a Manufacturing Hub for Telecommunication Equipment?', *Pacific Affairs*, Vo.85, No: 3, pp. 511-530

Mani, Sunil (2013), 'Evolution of the sectoral system of innovation of India's aeronautical industry', *International Journal of Technology and Globalization*, Vol. 7, Nos: 1 and 2, pp. 92-117

Mani, Sunil and Richard Nelson (2013), *TRIPS compliance, national patent regimes and innovation*, Cheltenham, UK and Northampton, Mass: Edward Elgar.

PWC (un dated), *Decoding the Indian aerospace and defence sector, Domestic and foreign investments and offset obligations*,https://www.pwc.in/assets/pdfs/industries/aerospace-and-defence-services.pdf, (Accessed on March 30, 2016)

PWC (2015), 2015 *Aerospace Manufacturing Attractiveness Ranking*, https://www.pwc.com/us/en/industrial-products/publications/assets/aerospace-manufacturing-attractiveness-rankings-2015.pdf (Accessed on April 6, 2016)

PWC-Assocham (2016), *Make in India: Achieving self-reliance in defence production*, http://www.pwc.in/assets/pdfs/publications/2016/make-in-india-achieving-self-reliance-in-defence-production.pdf (Accessed on June 6, 2016)

Sanjai, P R (2016), 'Make in India at centre of our business strategy: Airbus", Mint, March 29, http://www.livemint.com/Companies/h5JDsmLG8kivRcD2PCG1uI/Make-in-India-at-centre-of-our-business-strategy-Airbus.html (Accessed on March 31, 2016)

UNIDO (2016), *International Yearbook of Industrial Statistics*, Cheltenham, UK: Edward Elgar.