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India's information technology hardware segment is heavily dependent on imports of components and finished goods. After surveying Tamil Nadu's hardware electronics sector, this article argues that the stagnation of the electronics hardware sectors stems from a failure to create backward linkages, a liberal import regime and a foreign direct investment policy that has focused on employment generation instead of capability building. The study highlights the import-intensive nature of the industry, identifies skill gaps and infrastructural constraints faced especially by medium- and small-scale manufacturers.

Manufacturing has not only stagnated in India after 2000 but has also become import intensive. This is more so in technology intensive segments like electronics, which make up the second or third largest component of imports after petroleum products.[i] In India, the software and services segment dominates the information technology (IT) industry in both domestic and export markets, whereas the country's IT hardware segment has had a limited focus and is heavily dependent on imports of components and finished IT goods (OECD 2010).[ii] The domestic hardware electronics industry in India suffered a major drawback since liberalization, particularly since the implementation of World Trade Organization's (WTO) Information Technology Agreement (ITA-1)—the agreement meant zero custom duty for all the 217 tariff lines with effect from 2005. This article analyses the growth of the Indian electronics industry, particularly the hardware sector, and argues that manufacturing has stagnated because of the failure to create backward linkages, a liberal trade regime, and a foreign direct investment (FDI) policy that has focused more on employment generation vis-à-vis capability building. The article describes the case of Tamil Nadu, where a survey focusing on the constraints in manufacturing and employment growth in the electronics hardware sector was conducted in March and April 2014—in and around Chennai. Tamil Nadu is the largest state in

[1] The survey of electronics industry in Chennai was part of a larger study conducted by the Institute for Human Development and sponsored by the International Labour Organization. It is titled, "Promoting Employment and Skill Development in the Manufacturing Sector in India." The author is grateful to the ELCINA members and numerous CEOs of electronics manufacturing companies in Chennai who spent their valuable time and information on the subject. Madhuri Saripalle can be contacted at madhuri.saripalle@ifmr.ac.in.

India in terms of employment in industry and number of factories; it is third in terms of value addition. It also ranks highest in automobile and auto components manufacture, which stands

in contrast to electronics hardware in terms of policy initiatives. Section 1 analyses production structures of the electronics industry by segregating the growth in various segments. Section 2 evaluates the growth of electronics industry in Tamil Nadu; it identifies some of the major constraints based on a primary survey conducted in March–April 2014. Some of the major findings in the study highlight the import-intensive nature of the industry, lack of backward linkages, skill gaps and infrastructural constraints, faced especially by the medium- and small-scale sectors. Section 3 presents a summary and policy implications.

I. Production Structure

Diversity of applications and commonality of inputs make the electronics industry a complex enterprise. First, 70% of component requirement is based on semiconductor chips. The end users of the product are highly diverse, ranging from industries to consumers. Second, the nature of the end product varies from low value-added products like switches to high value-added products like televisions and cellular phones. India does not have semiconductor-chip fabrication facilities, and this makes the industry highly import-intensive. Imports of technology per se have been found to have a positive impact on the research and development (R&D) of high-tech firms (Sharma 2010; Saxena 2011). However, R&D in the Indian electronics industry is negligible and this, in turn, increases dependence on imports. The import-intensive nature of the industry makes the supply chain horizontal in structure, rather than vertical, given the absence of backward linkages with raw material suppliers and component manufacturers in India. Electronics is also strategically important because of the defense sector's dependence on it.

Table 2: Share in Value Added

Product classification	NIC	% share in value added
Electronic components	261	20
Computers and peripherals	262	17
Communication equipment	263	15
Consumer electronics	264	32
Measuring, testing and control equipment	265	9
Electro-medical equipment	266	4
Optical instruments	267	3
Irradiation, magnetic and optical media	268	0.4

Source: Annual Survey of Industries (ASI) 2011–12

Although India boasts of IT-led growth, the contribution of electronics to gross domestic product (GDP) is lopsided, with more weight given to designing vis-à-vis hardware manufacturing. What are the prospects of growth of the industry in India, given its strategic importance? To understand this, it is useful to look at the growth trajectory of electronics in countries like South Korea. The industry's hardware sector in India can be broadly divided into the following categories based on the National Industrial Classification (NIC) scheme: industrial components, communication equipment, consumer electronics, testing and measuring equipment including watches and clocks, optical instruments, and optical media. The main contribution to growth of industry is communication and broadcasting equipment followed by consumer electronics, components and computer peripherals (Table 1). However, in terms of value added, consumer electronics and electronic components rank highest followed by computers and communication equipment (Table 2). In contrast, in South Korea, communication equipment, electrical parts, computers, and electronic components (semiconductors) have the highest share in output as well as in respect of value added. Their share has expanded since 2000 whereas share of home appliances has decreased, reflecting a stage of maturity (Suh 2004). Tables 1 and 2 show that products which have a high share in total output do not have a high share in net value added. For example, the share of communication and broadcasting equipment in total output is 31% but share in net value added is only 15% of total net value added of this industry because not only is this segment raw-material intensive, but highly import-intensive too.

Table 1: Segment Share in Production

	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Consumer Electronics	27%	26%	26%	25%	24%	23%
Industrial Electronics	14%	13%	14%	13%	13%	12%
Computer Hardware	19%	14%	14%	12%	12%	14%
Communication & Broadcast Equipment	22%	27%	28%	27%	28%	31%
Strategic Electronics	7%	7%	6%	6%	6%	5%
Electronic Components	11%	12%	12%	17%	17%	15%
Software for Exports	78%	79%	78%	77%	78%	80%
Domestic Software	22%	21%	22%	23%	22%	20%

Source: Ministry of Communication and Information Technology, Government of India

1.1 Composition of Imports

Table 3 shows the top imports in the electronics industry. Communication and broadcast equipment which include telephones, radio broadcast and transmission equipment accounts for more than 50% of electronic

imports, automatic data-processing machines (including computers) account for 20% and the rest is accounted for by integrated circuits and micro assemblies. During 2001–14, India's import of electronic items rose from $1.6 bn to almost $22 bn dollars, out of which the import of mobile phones and their parts was almost $10 bn in 2012 (note that Table 3 is in $ million).

Table 3: Top electronics imports

			Value in USD million				Annual Growth %			CAGR 2001-14	in total imports
HS code	Product name	2000-01	2010-11	2011-12	2012-13	2013-14	2011-12	2012-13	2013-14	2001-2014	2013-14
8517	ELECTRICAL APPARATUS FOR LINE TELEPHNY/TELGRPHY/ CORDLESS HANDSET CARRIER-CURRENT LINE SYSTM; VIDEOPHONE (Line telephone sets, telephones for celllular network, fax machines, plcc machines, isdn terminals, modems, routers, x25 pads, set top boxes, populated or loaded PCBs, parts)	203.75	11,190.33	10,907.21	9,877.63	10,941.62	-3%	-9%	11%	40%	50%
8523	PREPARED /UNRECORDED MEDIA FOR SOUND RECORDING (Audio/video cassettes, CDs, magnetic tapes, smart cards, memory cards semiconductor media, etc)	29.48	1,691.84	2,269.05	1,196.40	1,238.20	34%	-47%	3%	47%	6%
8525	TRNSMISN APPARATS FOR RADIO,TELEPHNY ETC (Broadcast equipment, marine communication equpmt, cellular phones, cordless handset, satellite communication eqmt, transmission apparatus, TV/video/digital cameras,)	201.77	513.34	607.87	634.68	556.43	18%	4%	-12%	-1%	3%
8526	RADAR , RADIO NAVIGATIONAL AID APPARATUS AND RADIO REMOTE CONTROL APPARATUS	14.9	46.39	35.55	36.85	53.79	-23%	4%	46%	8%	0.2%
8527	RECEPTION APPARATUS FOR RADIO-BROADCASTING	6.98	81.45	124.81	147.83	167.31	53%	18%	13%	21%	1%
8528	RECEPTION APARATUS,WHETHER /NOT INCORPRTNG RADIOBRODCST RECIVRS/SOUND/VIDEO RCORDNG/ REPRODUCING APARATUS,VIDEO MONITORS	18.46	1,257.10	1,597.67	1,901.79	1,592.85	27%	19%	-16%	48%	7%
8529	PARTS SUITBL FOR USE SOLELY/PRNCPLLY WTH APPRTS OF HDGS NOS 8525 TO 8528	132.74	926.08	1,027.00	1,173.54	1,028.49	11%	14%	-12%	17%	5%
8542	ELCTRNC INTEGRTD CIRCUITS AND MICRO-ASSMBLS	307.6	1,334.95	1,964.15	2,012.03	1,747.22	47%	2%	-13%	17%	8%
8471	AUTOMATIC DATA PROCESSING MACHINES AND UNITS	711.87	2,691.95	3,941.20	4,237.52	4,370.21	46%	8%	3%	16%	20%
	Total Electronic imports	**1,627.55**	**19,733.43**	**22,474.51**	**21,218.27**	**21,696.12**	**14%**	**-6%**	**2%**	**23%**	
	Total Imports	**50536.45**	**3,69,769.13**	**4,89,319.49**	**4,90,736.65**	**4,50,199.79**					

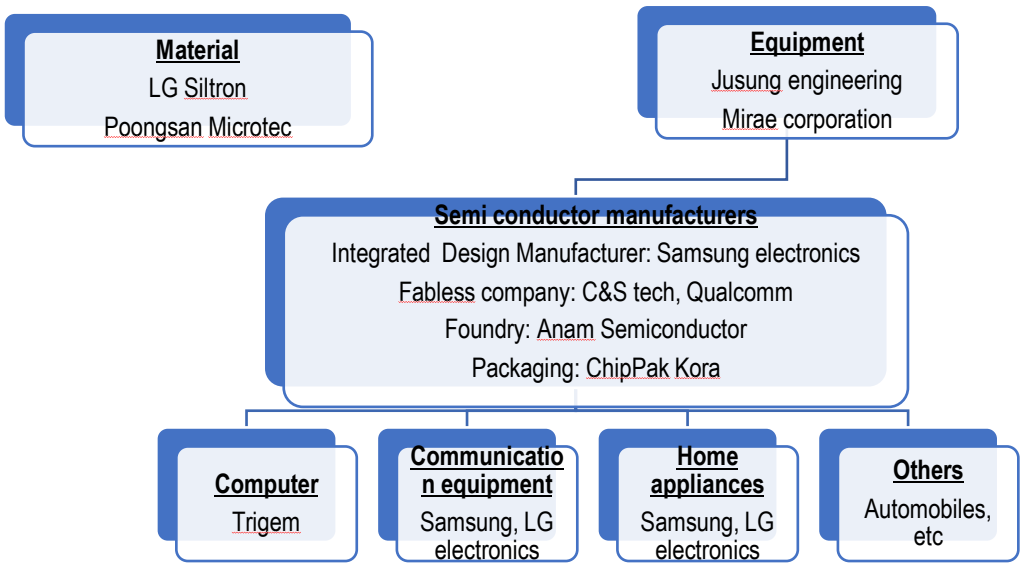
Source: EXIM data bank, Ministry of Commerce and Industry; http://commerce.nic.in/eidb/default.asp

1.2 Supply Chain

In advanced countries like South Korea, the electronics industry has developed vertically with backward and forward linkages. For example, South Korea's semiconductor and display industry is led by few conglomerates with capability to make large-scale investments and a small number of specialized raw material and equipment suppliers who have grown closely with the large manufacturers. Figure 1 shows the supply chain of semiconductor and display industry in Korea. Indian industry lacks such strong supply chain linkages. In the semiconductor industry in Korea, value addition to an integrated chip package broadly

consists of three stages: designing, fabrication of wafers, and finally assembly and shipment. In contrast, India does not have any semiconductor manufacturing firms, except for three government companies. However, there are approximately 125 semiconductor-chip designing companies that operate in the country—both foreign and domestic. The country has only one company specializing in the "Assembly Testing Mark Pack" (ATMP) or the post fabrication stage: the Chennai-based Southern Petrochemical Industries Corporation (SPIC) Electronics and Systems Limited (SPEL). Promoted by the SPIC, SPEL is a 100% export-oriented unit (EOU). It imports 95% of its final product requirements and does not have any subcontracting practices. Chip manufacturing companies based in Taiwan send silicon wafer to the company, which are attached to substrate, which goes through a process of bonding, simulation, final testing and delivery to global customers. The ATMP plant "receives 4- or 8-inch wafer discs containing thousands of circuit-bearing silicon dies. The wafer is cut into individual dies, which are then attached to a substrate with extremely thin gold wires. Plastic moulds are put on them to protect the circuit, after which they are tested for design, fabrication or assembly design defects" (Ramesh 2006).

Figure 1: South Korea Electronics Supply Chain



II. Structure in Tamil Nadu

Tamil Nadu contributes almost 42% of the production of computers and peripherals and 37% of testing and control equipment in the country (Table 4). The manufacture of electronic components—a crucial part of the production structure—takes third place in the state after production of computers and peripherals and testing and control equipment. The electronics industry in Chennai consists of 300 active firms spread across three industrial estates located in three areas: Guindy, Thiruvanmiyur and Perungudi. Apart from these, new firms are located in special economic zones (SEZ) in Sriperumbudur, Kanchipuram District. A

total of 35 units were surveyed belonging to different size-classes defined by the number of employees. Two broad classifications of size were used in the study. One based on employment and the other on sales. An important structure of the industry was the absence of any large conglomerates in this sector, other than Nokia and its suppliers, which on 31 October 2014 ceased operations. According to the employment classification, firms were divided into micro, small, medium and large enterprises. Micro units are also termed as directory manufacturing enterprises (DME) that employ six or more workers and are not registered under the Factories Act. In contrast small (employing less than 100 workers), medium (employing 100–499 workers) and large units (employing 500 or more workers) belong to the formal sector.

Table 4: Tamil Nadu's share in electronics output

Product	NIC	% share of TN
Electronic components	261	22%
Computers and peripherals	262	42%
Communication equipment	263	16%
Consumer electronics	264	0.2%
Measuring, testing and control equipment	265	37%
Electro-medical equipment	266	1%
Optical instruments	267	3%

Source: Annual Survey of Industries, Government of India, 2011-12

The size distribution by employment showed that nearly 23% were micro units, 46% were small-scale units, and 20% were medium-scale and 11% were large units. In terms of age, there were two groups of fi rms, those which witnessed the 1980s boom, and those which were a product of the post-2000s boom. The major drivers of the 1980s boom were telecom, defense and space research. This could not be sustained in the 1990s because of low domestic demand for hardware components, lack of infrastructure, changes in technology (telecom) and high cost of capital (Muniswamy 2007). Around a third (11 out of 35) of the units surveyed was involved in design and assembly of printed circuit boards. The rest included manufacturers of transformers and other electronic equipment like capacitors, connectors, integrated circuits, and light-emitting diode (LED) display boards. The sample also included two medical equipment manufacturers and two fi rms involved in process control and factory automation systems. Among the large firms, the sample included a mobile manufacturer, a manufacturer of radio-frequency identification (RFID) tags, and makers of magnetic assemblies and secure digital (SD) cards.

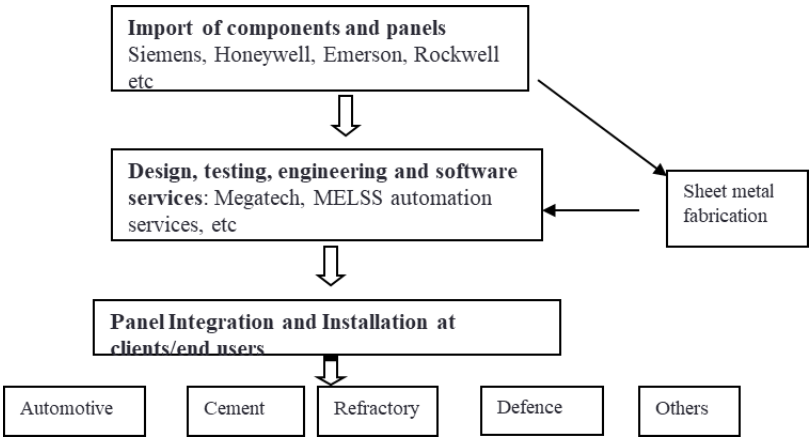
2.1 Supply Chain Linkages

The industry's intra-firm linkages can be inferred from their raw material sources and end users of their products. Forty two percent of the firms surveyed sourced raw material from other industry lines, which mostly included traders and imports. With regard to end-users, 11% of the firms sold only to traders, while

63% sold to other manufacturing enterprises, which include the final product or large-component manufacturers— also known as the original equipment manufacturers. Twenty three percent sold to both traders and manufacturers. Two major drawbacks inhibiting the growth of backward linkages in the industry are: (a) Lopsided duty structure: Unlike the automotive industry, where imported components attract high duties, import of electronic components attracts no duties. Hence, entrepreneurs prefer to import and trade even products like set top boxes, for which there is domestic capability. (b) Absence of a large firm which can support the growth of small industries. The FDI policy to allow multinational corporations (MNC) to set up large fi rms in India was a welcome step which could develop the electronics industrial ecosystem in Tamil Nadu. However, the industrial ecosystem that emerged was completely dependent on imports, as evident from the case of Nokia.

Nokia, one of the large firms we surveyed, is located in the industrial SEZ in Sriperumbudur District near Chennai. It used to employ close to 12,000 people a few years back but reduced its workforce to 7,000 regular workers and 1,000 contract labourers after a tax dispute. The number of models assembled in the manufacturing facility reduced from 15 phones per second to only five phones per second, as it shifted the manufacturing of high-end models to Hanoi, Vietnam. Although, Nokia's shutdown was a loss in terms of employment generated, it did not have any impact on other small and medium firms as 85% of Nokia's component requirements were imported and balance 15% supplied by tier I MNC suppliers located nearby—which also supplied imported components. The electronics industry in India is characterized by design, assembly, and testing services, and manufacturing is conspicuous by its absence. The examples of semiconductors and mobile phones corroborate this. Figure 2 shows the actors involved in industrial process design and automation, which is also import-dependent for component parts.

Figure 2: Industrial Process Automation



Source: Author's compilation, field survey

2.2 Import Dependence

One-third of firms surveyed had imported raw material costing up to 30% of total raw material costs and one-fifth had imported raw material costing up to 90% (Table 5). One of the firms surveyed imported 100% of its raw material from Taiwan and neighboring countries. Import dependence in the electronics firms surveyed increased with their size, indicating the absence of any backward linkages in this industry. However, timely import of raw materials was not perceived to be a major obstacle by the large firms, whereas, 45% of medium-sized firms found it a major obstacle.

It was observed that a majority of fi rms catered to the domestic market. Export markets were difficult to break through for many small- and medium-sized firms. In some of the component categories like connectors, manufacturers stated that it is a segmented market with every buyer having its patented designs and dedicated vendors. This indicates that some of the components may be highly oligopolistic with high costs of market entry.

Table 5: Raw material imports as % of total raw material costs

Percentage of imported raw material	Micro	Small	Medium	Large	Total
0%	67	33	8	0	29
1-10%	17	27	8	0	17
11-30%	0	13	17	0	11
31-50%	0	7	17	0	9
51-70%	0	7	8	0	6
71-90%	0	13	25	100	20
91-100%	17	0	17	0	9
Total	100	100	100	100	100

Source: Author Field Survey

2.3 Resource Constraints

Skilled labour was a major constraint in micro and small units. In Chennai, 80% of units face difficulty in hiring engineers and skilled workers. Among these, the micro and small units faced the most difficulty. The primary reason for this appeared to be a lack of quality, and secondly, competition from the software sector. One-fourth of the large units also faced difficulty in hiring unskilled workers. Forty-two percent of the units, primarily small and medium firms, found timely import of raw materials a major/ severe problem (Table 6). The large units did not report any problem with respect to import of raw materials. Local supplies were a moderate obstacle for one-third of small units and one-fourth of medium units. In general, the presence of traders was a threat to genuine suppliers of high-quality components. For example, a 25-micron printed

circuit board can be sold as 35 mm board by a trader and no one can make out the difference. In the process, traders increase their margins by Rs 200 per circuit board! Fifty-six percent of the firms reported power as a major/severe obstacle. This is also a reflection on the electricity crisis in Tamil Nadu. In the sample, 57%—47% small firms, 92% medium firms and 100% large fi rms—reported having a generator. Micro units reported minimal loss due to power problems because their work is mostly assembly oriented and they have flexible production schedules. Further, this question was not relevant to firms involved in factory automation systems and process control equipment because their work was mostly off-site. To large firms situated inside SEZs, power was not a constraint. Of the 35 firms surveyed, 17 responded to the question of production losses due to power. Of these firms, 41% reported 5%–10% power-related production losses, 29% reported 11%–20% losses, and the remaining 29% reported 21%–40% losses. Water did not seem to be a major constraint as almost all fi rms bought water. They did not have access to government-provided drinking water. Communication was a minor/moderate problem as all respondents reported the use of mobile phones over landlines. Cases where they faced obstacles were related to fax operation or landline-based internet services.

Table 6: Infrastructure constraints

	Water	Communi cation	Power	Timely import of raw materials	Skilled labor
No obstacle	51	49	6	30	18
Minor obstacle	31	37	24	24	30
Moderate obstacle	9	9	15	3	21
Major obstacle	9	6	44	21	27
Severe obstacle	0	0	12	21	3
Total	100	100	100	100	100

Source: Field Survey

III. Conclusions

The electronics industry in Tamil Nadu broadly consists of radio, television and communication equipment, office accounting and computing machinery, and electrical machinery, and apparatus not elsewhere classified (for example, transformers), all of which have a combined weight of 27 in the Index of Industrial Production. Based on the latest data available, while electrical machinery and apparatus grew at 20% over 2009, the other categories recorded a negative growth, which is a cause for concern. This article argues that due to the increasing import dependence, the electronics industry is unable to create backward linkages. However, import dependence is not the only major cause for absence of backward linkages. Large-scale investments in manufacturing facilities and removal of infrastructural constraints will go a long way towards the goal of Make in India.

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[i] The top three imports of India consisted of petroleum (37%), electronic goods (8%) and gold (7%) as on September 2014, but in recent months (like in March 2015) electronics goods have fallen to third position.

[ii] During 2004–05 to 2009–10, the average annual growth rate of computer software has been around 25% while that of the electronics hardware has been around 17%.