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India's Electronics Sector:

Policies, Practices and Lessons from China

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About the Author

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List of Abbreviations

ASIC	Application Specific Integrated Circuit
ASSP	Application Specific Standard Protocol
ATMP	Assembly Test Mark Parks (used by Semiconductor Industries)
BCG	Boston Consulting Group
BIRAC	Biotechnology Industry Research Assistance Council
CAGR	Compounded Annual Growth Rate
CAS	Conditional Access System
CMC	Computer Maintenance Company
CPU	Central Processing Unit
CRT	Cathode Ray Tube
CSIR	Council for Scientific and Industrial Research
DLRL	Defence Electronics and Research Laboratory
DRDO	Defence Research and Development Organisation
DSP	Digital Signal Processing
ECW	Electronic Counter Warfare
EDM	Electronic Design and Manufacturing
EDF	Electronic Development Fund
EIDF	Electronics Industry Development Fund
EMC	Enhanced Machine Controller (It's an earlier name for the LinuxCNC software used to control Computer Numerical Control (CNC) machines)
EMS	Electronic Manufacturing Services

ESDM	Electronic System Design and Manufacturing
ETP	Effluent Treatment Plant
FFE	Foreign Funded Enterprise
HTDZ	High Technology Development Zone
IC	Integrated Circuit
IGMDP	Integrated Guided Missile Development Programme
IISc	Indian Institute of Science
IIT	Indian Institute of Technology
ISRO	Indian Space Research Organisation
ITA-I	Information Technology Agreement-I
LCA	Light Combat Aircraft
LED	Light Emitting Diode
LRDE	Electronics and Radar Development Establishment
MCU	Micro Controller Unit
MEI	Ministry of Electronics Industry
MII	Ministry of Information Technology
M-SIPS	Modified-Special Incentive Package Scheme
NIC	National Informatics Centre
NIT	National Institute of Technology
NPE	National Policy on Electronics
PCB	Printed Circuit Board
PMA	Preferential Market Access
REC	Regional Engineering College

SERC	Supercomputer Education Research Centre
SOE	State Owned Enterprise
SSTC	State Science and Technology Commission
TIFR	Tata Institute for Fundamental Research
ToT	Transfer of Technology
TTEDM	Technology Transfer in Exchange for Domestic Market
UNDP	United Nations Development Programme
VCR	Video Cassette Recorder
VLSI	Very Large Scale Integration

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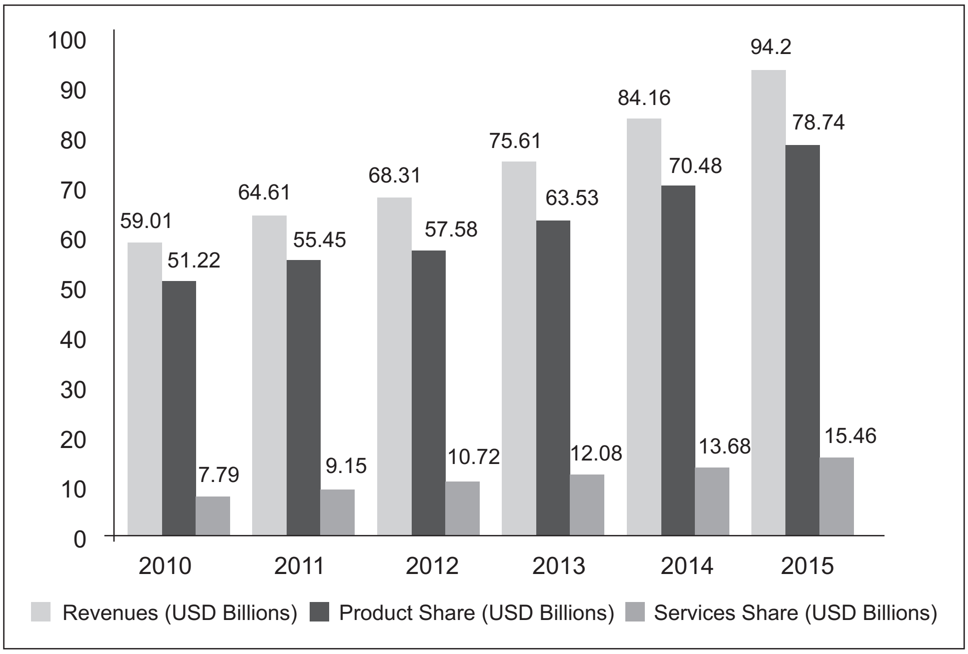
Introduction

By 2020 the demand for electronic goods in India is expected to breach the US$400 billion mark, with the import bill estimated to set the country back by US$300 billion. In fact, it is expected to trump the energy import bill. India is staring at an import nightmare of unprecedented proportions that can push the country into a spiral of high imports that would necessarily require higher external and internal borrowings. There are several South American economies that have gone down that route for us to learn our lessons and not implode. The National Policy on Electronics (NPE) 2012 is primarily aimed at ramping up India's Electronic Design and Manufacturing (ESDM) capability. It is by far the most comprehensive policy intervention in post-independent India to boost indigenous production of semiconductor components and chips. The policy comes on the back of a strong and sustained demand for consumer electronic goods that accounted for a hefty bill of US$125 billion last year.

However, just about 10 percent of India's consumption was produced internally; the rest was imported. In the last two decades China has become the second largest manufacturer of electronics goods in the world with its sales revenues crossing US$840 billion in 2013. This development must necessarily be seen in the context of China having overtaken the US in 2010 to become the world's dominant manufacturing economy. China beat its competitors in world manufacturing, notching up US$2.9 trillion in output in 2013. In contrast, the US generated US$2.43 trillion. The Indian sales revenues for the year 2012 stood at slightly above US $68 billion, less than even one-tenth the size of the Chinese juggernaut.

FIGURE 1: Indian ESDM Industry: Revenue Forecasts for 2010-2015



Source: IESA/Frost & Sullivan

What is interesting to note is that in 1995, less than two decades ago, the annual sales revenue of China's electronics manufacturing industry—which the Chinese government curiously insists on referring to as electronics information industry—was only worth about US$48 billion, which is less than India's billing of 2012.[1] Yet, in less than 20 years China has become a global powerhouse: its annual revenues from the electronic manufacturing sector have routinely grown three times faster every single year in the last decade than the national GDP growth rate. In fact, it has outstripped the growth in machinery, manufacturing and metallurgy industries. Interestingly, however, the value addition[2] of the sector has consistently hovered around the 23 percent mark compared to a rising national average across other sectors, which is now touching almost 33 percent. It is a stark indication of how difficult it is to research, develop and own technologies, and set up domestic semiconductor and chip manufacturing bases, as opposed to setting up assembly-based units. China has obviously done something right. At the very least it has created the right policy environment for an appropriate eco-system for electronics manufacturing to grow by leaps and bounds. Just as there are several humbling positive lessons to learn from its neighbour, there are also some pitfalls India has the opportunity to recognise and avoid. For instance, an analysis conducted in 2009 found that while iPhones, which are produced exclusively by Foxconn in China, contributed around US$2 billion, close to 0.8 percent of the country's bilateral trade with the United States of America, all that China got out of every US$ 600 iPhone was US$ 6.50. That is slightly over 1 percent of a single unit's value. China's phenomenal growth in the space of ESDM and semiconductors shows that India is on the verge of a similar paradigm shift, especially in the context of NPE 2012. It is estimated that the Indian ESDM industry will grow at a compounded annual growth rate (CAGR) of 9.9 percent to reach US$ 94.2 billion by 2015.[3]

The seriousness with which the Chinese are eyeing the Indian emergence can best be explained by an eccentric but true story. Charles Sterns,[4] an American businessman and Chief Executive Officer (CEO) of Coral Springs, a Florida-headquartered specialty medical supplies company, was held hostage by his Chinese workers last year after they discovered his company's plans to shift its entire production base to India, on the outskirts of Mumbai. He was, of course, eventually released. The story not only shows India's attractiveness for a host of companies, but also showcases the perception of India as a serious competitor on the global stage. The seriousness with which India is now approaching the task of developing its electronics manufacturing and wafer fabrication base can be seen from Table 1. India has been particularly working with Japan and Taiwan to set up electronics manufacturing zones. Since Taiwan is not directly recognised by India, it is directly negotiating with several state governments, notably Karnataka and Tamil Nadu. Forty seven Taiwanese companies are already setting up their plants and offices at a 300-acre cluster zone near the Bangalore International Airport.

Additionally, indicating the seriousness with which Taiwan is looking at Karnataka, the Taipei Computer Association, a grouping of 4,500 companies, has set up an office in Bangalore. Similarly, in January 2014, the first India-Japan Joint Working Group on IT and Electronics announced the setting up a Japanese Electronics Industrial Township in India. India has also extended a package of incentives to Japan in order to encourage investment in ESDM. The government has also given its go ahead for setting up of two Semiconductor Wafer Fabrications manufacturing facilities, with each plant requiring an investment of approximately Rs 25,000 crores. These plants will employ over 22,000 people, and indirectly provide benefits through ancillary jobs and employment to over 100,000 people. Initially each plant will produce 40,000 wafers per month of 300mm size, but in the second and third phases wafers of 90, 65 and 45, 28 and 22nm sizes will be produced. While these wafers will be sufficient to power devices like energy meters, inverters, auto electronics, instrumentation panels of bikes and low-end tablets like Aakash, India will still require technical and production capacity to fabricate wafers of 10-14nm size to power high-end electronics products.[5] It is this age-old challenge of developing indigenous research and development, fabrication expertise and capacity that the NPE 2012 seeks to overcome.

TABLE 1: M-SIPS Investments in India as on January 2014

Electronics Verticals	Application Amount (in Rs Crores)
Semiconductor Fabs	52,000
Telecom Products	8,409
LED Fabs	1,787
Automotive Electronics	831
Semiconductor ATMP	750
Handheld Devices	406
Consumer Electronics and Appliances	366
LED Products	223
Industrial	265
Strategic Electronics	203
EMC	103
Avionics	98
Medical Electronics	51
Total Proposed Investment	**65,492**

Source: DeitY

India and China: Shared Trajectories, Different Paths

India and China share a colonial legacy, though there were marked differences in their respective approaches towards achieving independence. The post-colonial political economy of development of both countries shows remarkable similarities, as also stark divergences. Both Asian giants, for various reasons ranging from lack of adequate capital base, deep distrust of private capital and enterprise to ideological orientations, invested a lot of faith and power in the apparatuses of the State to carry out the agenda of social and economic development. Indigenous development of a technological base was given a high priority in both countries, with India's first Prime Minister Jawaharlal Nehru allegorically referring to large-scale infrastructure and technology projects as 'temples of modern India'. India's approach towards development and infusion of critical technology and technology education was relatively robust in comparison to China, with the State displaying a rare scientific temper towards institutional and technical collaboration across disciplines and with countries. It resulted in active collaboration with the American and British computing worlds in the establishment of the Supercomputer Education Research Centre (SERC) in 1970, which interestingly started its life as a plain vanilla computer centre of the Indian Institute of Science (IISc) and was instrumental in the first official acquisition of computers from the Soviet Union during the 1950s. In contrast, the Chinese approach towards technology and global technical collaboration was more circumspect. Mao Zedong best exemplified the Chinese approach when he said: "We cannot adopt Western learning as the substance. We can only use Western technology."

The Indian approach towards science and technology, research and development and innovation can be divided into five phases. The first was between 1950 and 1970, arguably the golden period, and saw the Indian State adopt technologies from both the Western and Eastern bloc. The focus, however, was always on developing India's indigenous research and manufacturing base. The second was between 1970 and 1980, when Indian policy environment turned insular towards manufacturing and collaboration, but turned liberal enough for the foundation of software sector to be laid. The third phase between 1980 and 1990 was a period when the Indian policy makers tried to make up for lost ground in electronics manufacturing and computerisation. The fourth phase between 1992, the official start of liberalisation and structural adjustment programme, and 2005 was a period of the opening up of the economy, shoring up of India's export base and diversification of the country's manufacturing and sectoral capacity. The fifth phase from 2005 till present has seen an attempt to evolve a policy framework that seeks to increase the depth of research and manufacturing in a few select sectors like pharmaceuticals, biotechnology and electronics manufacturing.

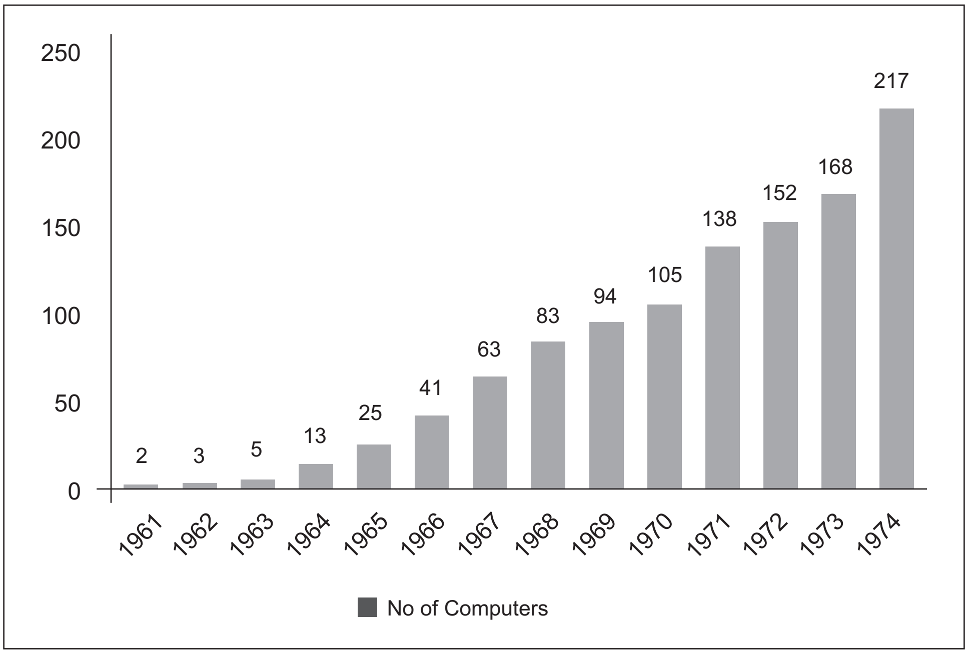
The differential approaches of China and India in the three decades of 1950-1980 gave India a strong base of technical innovation and technology educational facilities. It was, and still is, best showcased by the ecosystem of Indian Institute of Technologies (IITs) and Regional Engineering Colleges (RECs),–now called National Institute of Technologies (NITs), Council for Scientific and Industrial Research (CSIR) institutions, Indian Space Research Organisation (ISRO) and its numerous divisions, various arms of the Defence Research and Development Organisation (DRDO) and materials and fundamental research centres like Indian Institute of Science and Tata Institute for Fundamental Research (TIFR). India's relatively open and agnostic approach towards science and technology helped the country channelise a substantial amount of its resources in the first two five-year plans to build up institutions devoted to fundamental research, higher education and research and development. In fact, a 22-member committee of scholars and entrepreneurs under the chairmanship of Nalini Ranjan Sarkar was set up immediately after independence to help establish world class institutions of higher science education. Even though the renowned IIT is seen as a product of this commission, the Indian policy makers and politicians had showed an open-minded approach to science and technology even before independence. British Nobel laureate Professor A.V. Hill had, in August 1944, submitted a report titled

'Scientific Research in India' to the British Government of India 'on the organisation of scientific and industrial research as part of the country's post-war reconstruction plan'.[6] Prof Hill had visited Aligarh, Bangalore, Bombay, Calcutta, Kanpur, Delhi, Hyderabad, Jamshedpur, Kirkee, Madras, Mysore and Poona for his 40-page report. In one part of the report Prof. Hill writes, "…the future of Indian industrial and agricultural development must depend upon the supply of first-class technical brains, trained in an atmosphere both of original research and of practical experience. ...one or two technical institutes of the highest possible standing should be founded or developed from the existing ones (e.g., at Bangalore, where the Indian Institute of Science comes most closely of existing institutions to what is wanted)…"[7] Though there is no documentary corroboration, it is said that Jawaharlal Nehru had read the Hill report and requested the N.R. Sarkar committee to keep it as an intellectual foundation for their efforts. In taking forward and building upon the Hill report—a colonial legacy—to create a post-colonial configuration of a new modern India, the nation's policy makers displayed an open and global approach towards creating a self-sustaining technological base.

This was much before globalisation became a buzzword. By the late 1950s the government had acquired computers, the EVS EM, from the Soviet Union to use in large companies and research laboratories. The very first computer, an analogue one, was installed in the Indian Statistical Institute in Kolkata in 1950. Another one, installed four years later, was India's first digital computer—HEC 2M—and was developed by A.D. Booth at London's Birbeek College. This early exposure to computerisation goes against the popular, though untrue, perception that India's experimentation with computerisation began only in the late

1980s during Rajiv Gandhi's tenure as prime minister. In fact, by 1974 there were 217 computers–from only two in 1962–in operation in various government departments, including the Planning Commission, research institutions and high-technology missions. In today's context, where India has over 60 million personal computers and over 50 million smartphones, it might not appear to be a large number. But during that time and age where economic and technological demarcations between the developed and developing worlds were prominently outlined, India was a remarkable exception.

FIGURE 2: Number of Computers in India from 1962 to 1974



Source: NIC

By early 1960s, like most State-sponsored industrialisation strategies across the world, the country's defence sector started garnering a major chunk of research funds. They were funnelled into the emerging semiconductor and electronics technologies, especially in the field of radars and electronic counter warfare (ECW). Two institutions that benefitted the most from the infusion of funds were the Electronics and Radar Development Establishment (LRDE), established in 1962 and best known for Rohini, Revathi and Indra series of Pulse Doppler and multimode radars, and Defence Electronics and Research Laboratory (DLRL), established in 1961 and best remembered for providing all electronic systems and sub-systems for the Integrated Guided Missile Development Programme (IGMDP). Such a focussed approach created 'islands of excellence' in terms of fabrication, semiconductor componentisation, Very Large Scale Integration (VLSI) design, embedded software and board/hardware design. It led to the development of a tethered and closed eco-system where diversity and capability did not percolate down to create civilian or commercial interfaces.

The high point in the development of niche electronic design and manufacturing capabilities within the State-owned high-technology research and development institutions is the eco-system of advanced materials, semiconductor design and components and integration capabilities associated with the Light Combat Aircraft (LCA) and the Arjun Mark I and Mark II projects. Simultaneously, it also renders obvious the inability of these institutions to transfer the technologies to the civilian domain, as also the public and private industrial infrastructure's inadequate capacity to absorb such high-end technologies. When the first Electronics Commission was set up in the early 1970s under the legendary science and technology policy leader Professor M.G.K. Menon, the focus of the Indian policy makers was still on electronic design, manufacturing and semiconductor technology. The Commission, which also received support of the United Nations

Development Programme (UNDP), formulated a strategy for establishing regional computer centres. The idea behind setting up such centres was to create hubs of manpower development and diffuse informatics and technology into the local economic processes. One of the crucial decisions of the Commission was to channelise the country's resources and energies into creating intellectual capital and knowledge base, rather than large-scale hardware production base. The decision of the committee, in a way, refocused the Indian approach towards software services. Almost every single institution from the National Informatics Centre (NIC), set up in 1975, the iconic Computer Maintenance Company (CMC), established the following year, to Tata Infotech, Patni Computer Systems and Wipro, can trace their roots to that single decision of the MGK Menon Commission. The educational system also reoriented its approach towards the knowledge components of information technology, focussing more on training students on developing logic systems, understanding languages, configuring databases and offshore software projects. In retrospect, however, that single decision can also be held largely accountable for India missing the microchip revolution of the 1980s: a revolution that propelled Hong Kong, Singapore, Taiwan and South Korea, and later on China, to leadership positions in the world.

The Chinese Moves

The overall Chinese approach towards science and technology and innovation can be divided into five phases. The first phase between 1950 and 1978 was one of self-innovation and spade work. The second between 1979 and 1985 was a period of importing and learning through incremental improvements. The third phase between 1986 and 1996 represented a decade of opening up the market for technology assimilation. The fourth, between 1997 and 2005, was transitional in nature and was oriented towards experimentation in innovation. The fifth phase from 2006 and continuing is focussed on independent innovation.[8] It was during the early 1970s that China started taking the initial steps toward opening up its economy, a process that culminated in 1978 as the Four Modernisations programme[9] focussing on revamping the fields of agriculture, industry, national defence and science and technology.

The Chinese leadership understood that science and technology modernisation was critical, as the success of the other three modernisations depended on it. But they were faced by four seemingly impossible challenges of outdated university curriculum, lack of advanced scientific equipment, negligible information technology base and inadequate management know-how. As an aside, it is interesting to note that India was substantially ahead of China on all four fronts at that time. In a startling similarity with India, the Chinese government also received assistance from the United Nations Development Programme (UNDP) that ranged from financial assistance for overseas on-the-job training, academic programmes and setting up of information processing centres at key government units.[10] The post-1979 Chinese focus on developing an export-driven industrialisation and growth model also extended to the electronics manufacturing and semiconductor components sector. However, the Boston Consulting Group (BCG), as late as 1994 (Table 2), conducted a study on the competitiveness, readiness and human resources capability of the Chinese electronic industry in the private sector and found several capabilities to be either weak, negligible or completely absent. This specific context only amplifies the enormity of the achievement of the Chinese electronics industry, both public and private, in the last 20 years.

TABLE 2: China's Private Sector Capability in Electronics Manufacturing in 1994

Industry	R&D	Design	Manufacturing	Marketing/Sales
Computers/ Peripherals	Negligible	Weak	Moderate	Negligible
Consumer Electronics	Negligible	Weak	Moderate	Weak
Telecommunications	Negligible	Weak	Weak	Negligible
Parts/Components	Negligible	Negligible	Moderate	Negligible

Source: Boston Consulting Group (BCG)

The relationship that the Chinese public sector enterprises and the emerging private sector units established with the West for foreign investment, technologies and management practices is quite well documented.[11] But what is not that well known is the unique relationship that China and Japan established in the 1980s and 1990s (Table 3) that led to China acquiring control over critical technologies related to fabrication, electronic design and production. Japan, in fact, can be described as having provided the Chinese a high performance engine for their electronic manufacturing growth story.

TABLE 3: Technologies transferred by Japan to China in 1980s and 1990s

Parts/Components	Consumer Electronics	Information	Telecom
Signal generators, Optical fibres and cables, Capacitors, LEDs, Digital control systems, PCBs, Image intensifier tubes, Spectrophotometers, Spectrometers, Ceramic IC packaging, Chip mounting equipment, Hybrid ceramic IC fitters, PCB mounting/testing equipment, Transformers, Motors, Bipolar IC production, Measuring instruments, panel meters, Production single loop controllers	CRTs, VCR processing, VCRs, Digital recording, Video cameras	Hitac supercomputer, Barcode equipment, Software development	Microwave radios, Radars, Fibre optic cables, Ultrasonic diagnostics, Switchboards

Source: Boston Consulting Group (BCG)

China's Millennium Push

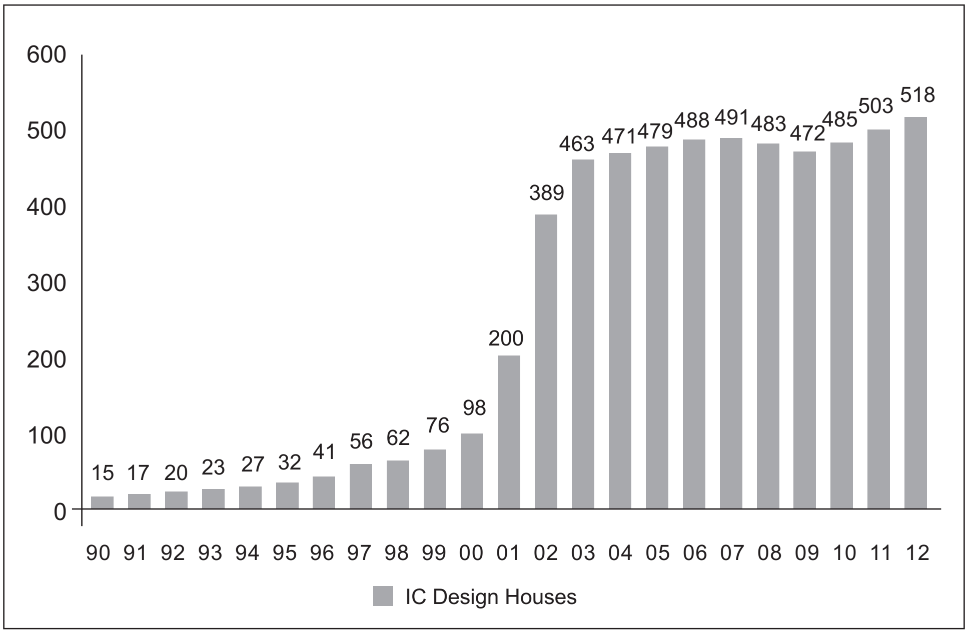
China's phenomenal growth in the electronics sector could not have been possible without deep-rooted institutional reforms and policy interventions. The decades of the 1980s and 1990s saw several important decisions oriented towards supporting electronics manufacturing. In 1982, a Ministry of Electronics Industry (MEI) and State Science and Technology Commission (SSTC), were established, responsible for research and development policy for high technology and reporting directly to the State Council, the administrative arm of the National People's Congress. Under the MEI, the Electronic Technology Information Research Institute, China Computer & Microelectronics Information Research Institute, China National Electronics Import Export Corporation, the Chengdu Electronics Research Institute and the Great Wall Computing Corporation – all behemoths today – were set up, each with a specific budget and an agenda to develop expertise in sub-systems, electronic design and fabrication and VLSI. In 1997, a separate division was carved out of MEI and a new Ministry of Information Technology (MII) was established.

The importance accorded to the development of electronics industry in the Chinese policy discourse can be understood by its explicit positioning as a critical sector for three major programmes: National Programme of Key Science and Technology Development; National Advanced Research Programme (863 Programme), which focuses on high-technology areas; and the National Basic Research Development Programme (973 Programme), which targets original innovation in select fields. Besides these programmes, the Chinese government set up the Electronics Industry Development Fund (EIDF) in 1986. The fund supported R&D and production of four key electronic products: integrated circuits, computers, software and programme-controlled switching devices.

An important policy decision taken by the Chinese government in the late 1980s transformed the landscape of electronics manufacturing in the country. The transformation did not always yield positive results. The policy, referred to as the Technology Transfer in Exchange for Domestic Market (TTEDM) strategy, focussed on five specific conditions of technology transfer. These were: establishment of joint ventures; review of such ventures by the central government; restrictions on fully-owned foreign enterprises in conjunction with the stipulation of at least 50 percent local equity in joint ventures; restrictions on labour-intensive joint ventures, unless there is an export guarantee of 100 percent of the products, with a preferential treatment to joint ventures exporting 70 percent of products. While this interlinked framework brought in massive foreign investment in the next two decades, making China a global electronic manufacturing powerhouse, it also created an ecosystem where Foreign Funded Enterprises (FFEs) developed a clear advantage over State Owned Enterprises (SOEs) in terms of output, sales value, fixed assets, added value and exports.

In 2005, the year China became the largest manufacturer of electronic goods, the FFEs owned over 80 percent of the fixed assets and chalked up output, sales and exports figures six to 11 times those of SOEs. In the last nine years, the figures have changed little, with the FFEs still owning over 70 percent of the fixed assets, and their output, sales value, added value and exports outstripping SOEs by at least four times. In 1979, when the economy was being opened up, the lack of telecommunications infrastructure and equipment became a bottleneck for any effective implementation of the multifaceted reforms policy at the ground level. It was this very bottleneck that was the trigger for the Chinese focus on electronics manufacturing sector. To bridge this massive telecommunications deficit, the Chinese government decided to directly import programme control switching devices, and then later on license produce them domestically, from all the major telecommunication countries and companies. It led to a nationwide telecommunications network that was often referred to, derisively so, in the Chinese policy circles as 'seven countries with eight systems'.[12]

FIGURE 3: Growth of Chinese IC Design Houses



Source: PwC

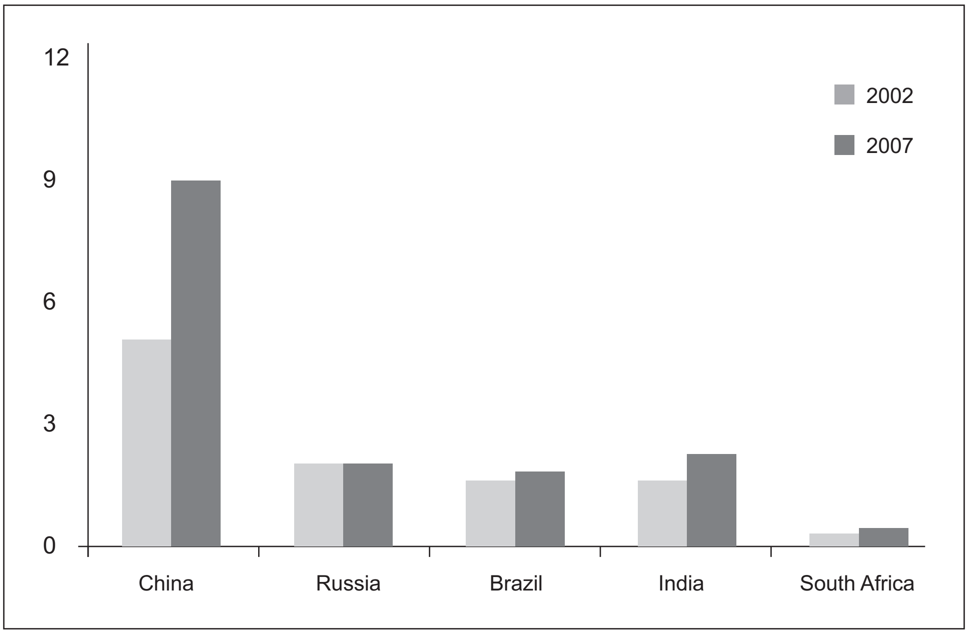
By the late 1990s, the Chinese government made the development of indigenous telecommunications equipment a national priority, and the results are there for all to see. Huawei and ZTE are but two prominent examples of this single-minded Chinese focus in the post-2000 period.

The focus of this national mission was on three specific points. The first was on establishing specific technical standards. A prime example is when the government, in 1985, enacted a series of regulations that mandated that programme controlled switching systems should be compatible with the V5.1 access network, a standard that foreign firms were not compliant with. This led to the development of the indigenous HJD04 programme controlled switches in 1991, which was the first large-capacity switching device designed and produced by China.

Its research and development was funded by the 863 Programme. One can actually trace the emergence of the global giant Julong to this particular chip. Similarly, one can directly trace the growth of Datang to SP30 chip, ZTE to ZXJ10, Huawei to C&C08C and Jin Peng to ETM601 chips. In creating an ecosystem of indigenous chip design and fabrication facilities, the Chinese government displayed foresight that is yielding visible results today. The government backed up its new technical standards by banning the import of large capacity programme controlled switching systems. Most of these imports were financed by loans from foreign governments. This intertwined policy approach slowly ended the domination of foreign firms by end of the 1990s. By 2002, over 85 percent of the switching devices market was occupied by domestic manufacturers.

Second, during this same period the Chinese government also implemented a series of steps, collectively called Market Access Regulations, which directly and indirectly promoted the domestic electronics manufacturers.

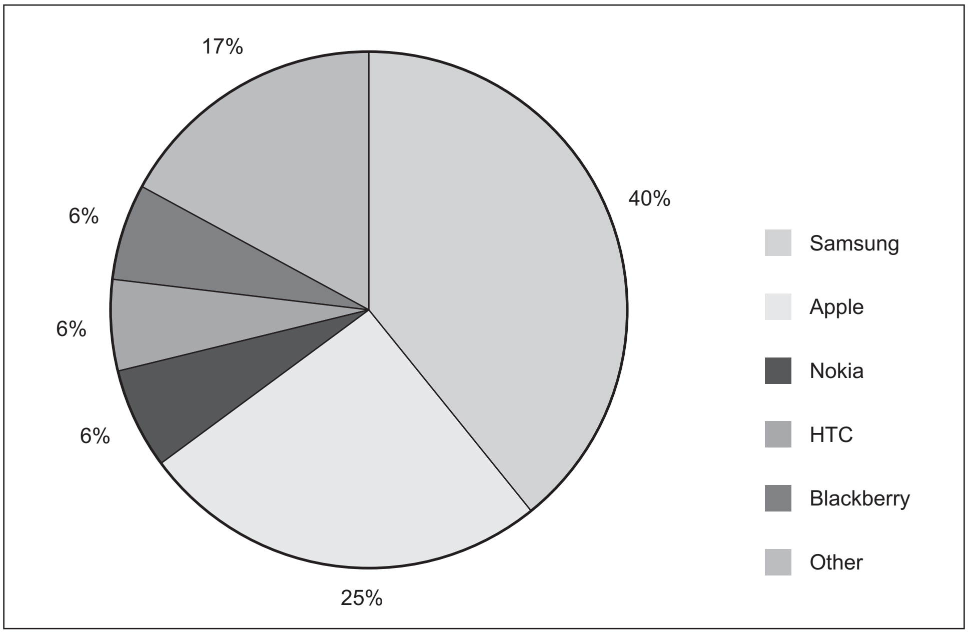
FIGURE 4: Expenditure on Innovation as Percentage of Total Expenditure



Source: UNESCO Science Report

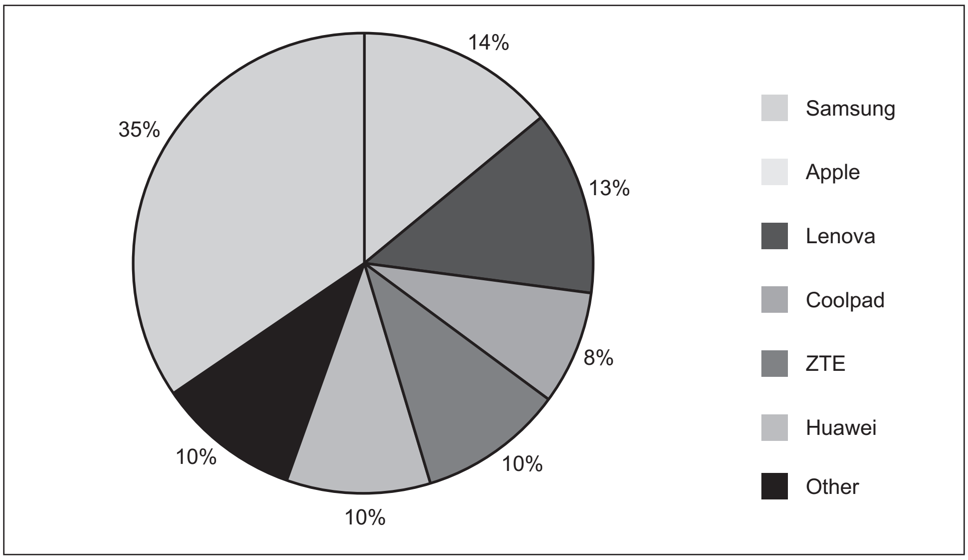
It was specifically oriented to boost domestic manufacturers of mobile telecommunications equipment and give them distinctly advantageous market conditions. The policies were designed to allow China 'leapfrog' old technologies, and included strict restrictions on foreign firms and joint ventures that ranged from a high degree of regulation in the manufacture of mobile handsets (for instance there is a government guidance plan), import quota on components to the requirement of a production licence, and a network license to sell mobile handsets in the market. The Chinese government also started building an advanced SDH telecommunications network, which provided domestic manufacturers of telecommunications a ready customer. The best indicator of the success of the Market Access Regulations can be seen from the fact that in 1998, not a single mobile handset sold in China was indigenous. In 2013, exactly 15 years later, close to 80 percent of the smartphone market is occupied by domestic manufacturers like Huawei and ZTE, and lesser-known brands like Gionee and Coolpad (Figure 6). In contrast, the global smartphone manufacturers Apple, Samsung and Nokia occupy over 50 percent of the world market (Figure 5), and up to 70 percent of the Indian market. This Chinese context not only provides a deep and informative backdrop to the current global debate on India's recently unveiled Preferential Market Access (PMA) policy, with the US calling it an 'unfair trade practice', but also supplies Indian policy and decision makers with markers and paths to take the right set of decisions for the future growth of India.

FIGURE 5: The Global Smartphone Market



Source: IDC, Apple Daily

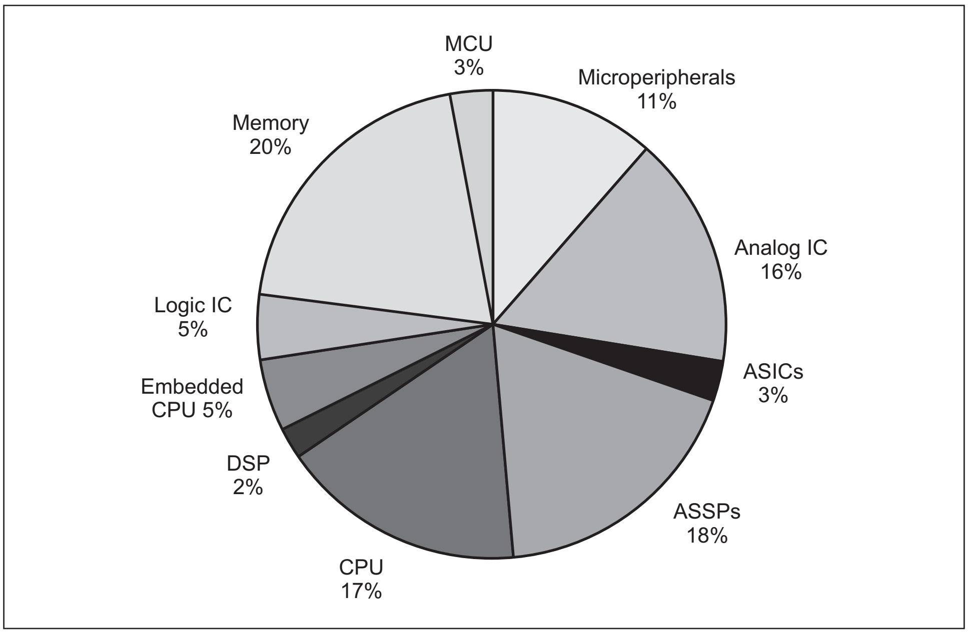
FIGURE 6: The Chinese Smartphone Market



Source: Canalys, Commercial Times

Third, the Chinese government realised during the middle of the 1990s that an organic domestic electronics manufacturing base cannot be established in the country unless a certain mastery over integrated circuits (ICs) is first established. The first attempts at developing domestic expertise in design, fabrication and mass production of ICs can be traced to Projects 908 and 909 that led to the establishment of the Huajing Electronic Group in Wuxi and Huahong Electronic Group in Shanghai. Both are today world leaders and their foundries manufacture ICs for some of the world's leading consumer electronics companies. The turning point, arguably, can be pegged to a single set of policy interventions brought about by the Chinese government in 2000 under an integrated policy document 'Policies for Encouraging the Development of Software and Integrated Circuit Industry'. The policies included tax concessions, government subsidies, soft loans and special government investments and funds. For instance, the valued-added tax on IC products ranged between 3 and 6 percent, as against the global average of 17 percent. The government also provided 1.5 to 3 percent interest subsidy on bank loans up to three years, in addition to follow-up investment of up to 15 percent of the total approved project cost. Additionally, the provincial governments competed with each other, and with the central government, to provide additional incentives like comprehensive and long-term leases on land for setting up IC foundries. The success of the specialised focus on ICs can be gauged from the fact that in 2000, there were less than 100 design houses; by 2004, there were 400 such houses, a 100 percent increase every year, and in next two years 100 more were added. With over 500 IC design studios (Figure 3), China today hosts more IC studios than even the iconic Silicon Valley and Hsinchu Science Park (Taiwan). By 2004, Chinese ICs accounted for over 18 percent of the global market, third behind US and Japan. In recent years it has declined but it is still a substantial 12 percent of the world market.[13]

FIGURE 7: Electronics Components Market in China



Source: Gartner

The Chinese government also took upon itself to generate demand for its products through policy initiatives that led to the implementation of nation-wide technology projects. The most far-reaching project was the Golden Project for IT, which began in 1993. It consisted of three components: Golden Bridge that developed information and data communication network across 500 cities and 12,000 enterprises; Golden Customs that created a digital bridge to track quotas, permits, foreign currency transactions, export and import statistics; and Golden Card that created electronic payment gateways for savings, withdrawals, credits and debits through digital cards. The foundation for the Golden Projects was laid by the High Technology Development Zone (HTDZ) policy adopted in 1988, especially the Torch Programme, that integrated research institutions with startup incubator facilities which helped commercialise China's research and development achievements.

China is an electronic manufacturing colossus today because of an integrated and inter-linked ecosystem of policies dealing with high technology, research, academic institutions, incubators, entrepreneurship and national electronic projects. It has coupled those policies with specific regulations providing protection and enhancement of domestic capabilities and industries. Equally, China is also a cheap destination for labour-intensive electronics industries, with its own set of problems, and has a poor record in increasing its value addition on the global stage because of the same set of policies that made it a giant in the first place.

The India Story

India tried to play catch up in its own way during the 1980s. With some justification, one can argue that Indira Gandhi, belatedly, and later Rajiv

Gandhi, recognised the importance of developing an ecosystem for electronics and telecommunications as future drivers of India's growth. However, India's information technology and business outsourcing sectors have come to occupy the prime position in the India growth story due to two main reasons. The first was the relative 'institutional distance' maintained by the Indian State in the initial stages of the inception of the sector. The second was a pragmatic policy framework and environment created during the late 1990s and the early part of 2000s that allowed industry bodies like Nasscom, private sector players and specific departments of the Government of India and state governments to work in tandem. The pragmatism has further percolated and deepened, allowing the sector to generate over US$100 billion in revenues in 2013 and contribute close to 8 percent of the country's GDP. It is pertinent to note that the contribution of this sector to GDP in 1998 was just 1.2 percent.

The seeds of India's phenomenal Information Technology sector, and ironically China and Southeast Asia's emergence as global centres for electronics manufacturing, can be traced to two specific tipping points that occurred in India. The first, as mentioned earlier, were the recommendations of the Prof. M.G.K. Menon Commission that reoriented the focus of India. The second were decisions taken by the Indira Gandhi regime, during its first tenure from 1966 to 1977, to regulate the flow of foreign capital, control foreign equity and impose restrictions on import of technology and equipment. It was during this period that several lucrative proposals from companies like Sony, Fairchild Semiconductors and Texas Instruments to set up export-led manufacturing units in India were rejected. All these companies then went to Southeast Asian countries—Hong Kong, Taiwan, Singapore, Malaysia, and of course, China. India, in a way, deliberately missed the hardware boom, practically having been given the first opportunity.

Ironically, it was Indira Gandhi who, in her second tenure, in a decisive manner set up the policy framework of relative 'institutional distance' that resulted in India's Information Technology revolution. She took four radical steps. First, she broke the mould of a statist model of development, and literally handpicked Dr. N. Seshagiri, then just a middle ranking official in the Department of Electronics, and gave him an open hand to prepare a market-friendly and liberalised computer policy. It helped, no doubt, that Indira Gandhi herself headed the DoE, and often with an iron hand. Second, she took the advice of Prabhakar S. Deodhar, a technocrat-turned-entrepreneur and her son Rajiv Gandhi's friend, to open up and delicense the consumer electronics manufacturing sector.

Of course, she also courted controversy later on when she appointed Deodhar as the chairman of a DoE-owned corporation. Third, she brought in an absolute outsider, a Non-Resident Indian (NRI) entrepreneur to give her a blueprint and implementation plan for introducing Made-in-India telephone exchanges. That person was Satyanarayan Gangaram Pitroda, and his blueprint led to the highly successful technology development programme under the Centre for Development of Telematics. A corollary to this blueprint was the Software Export Promotion Policy announced in January 1982. It is interesting to note that while India decided to take the path of an indigenous, and highly successful, development of fixed line telecommunications infrastructure, China took the path of foreign capital and technology infusion resulting in the controversial 'seven countries, eight systems'. Conversely, in the later part of the 1990s and for the first two decades of the new millennium, India moved towards a path of foreign technology infusion, while China went the home-grown way. Fourth, Indira Gandhi, just a few months before her assassination, introduced privately-owned duty-free technology parks, an out-of-the box idea for that time. It was first suggested to her by a young NRI entrepreneur Sharad Madhav Marathe, whom she had met during her trip to the United States of America in 1982. Marathe derived his idea from the Research Triangle Park in North Carolina. Interestingly, Seshagri had proposed a similar idea, though independently, in his report that he wrote for the United Nations Centre for Transnational Corporations.

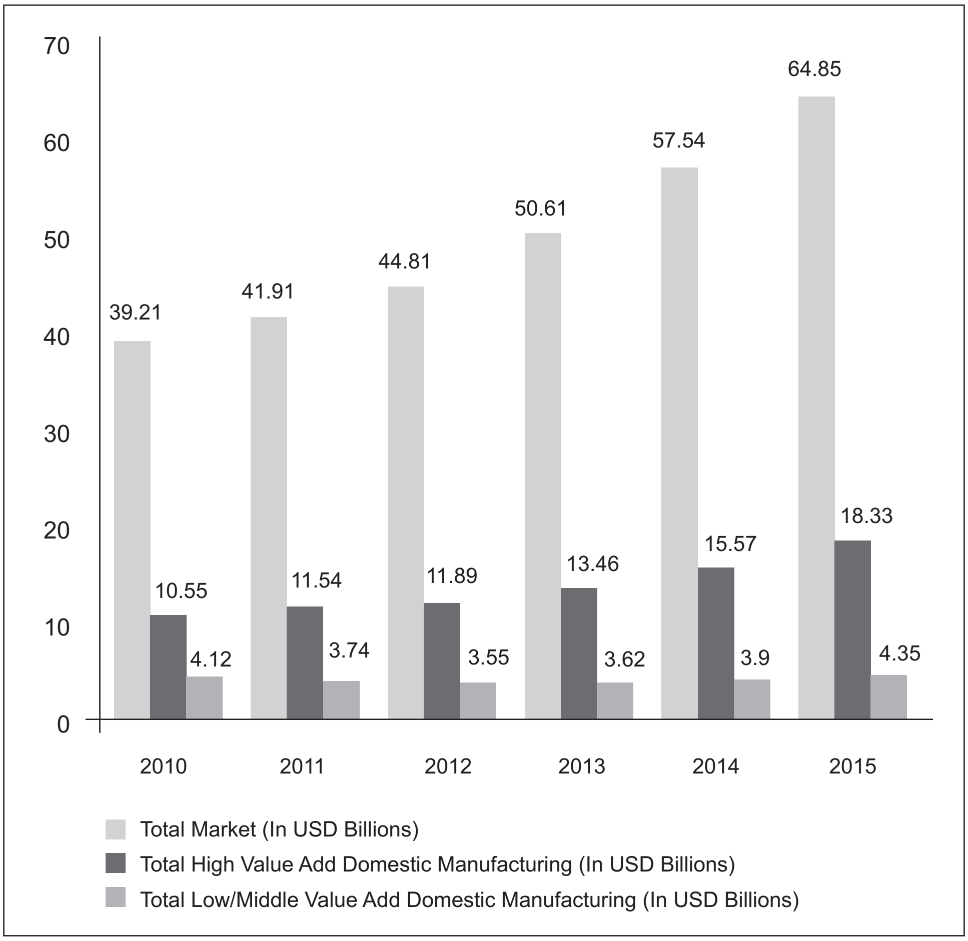
These four steps coagulated into a coherent Import-Export policy for 1985-88, which was approved by the Cabinet Committee on Economic Affairs on 6 September 1984, where 'software exports through satellite based data links with overseas computers' was permitted. In that day and age, and context, it was an astounding proposition: even revolutionary considering that satellite communication itself was in its infancy. This policy was further refined and morphed into the New Computer Policy. Since Rajiv Gandhi carried forward its implementation, he is often mistakenly seen as the architect of India's Information Technology revolution. The New Computer Policy, in one sweep, brought an export-driven software model that bypassed India's traditional constraints of hard infrastructure: lack of roads, ports, dedicated freight corridors and airports. In a twist of fate, Texas Instruments whose proposal to set up a semiconductor manufacturing unit in India was rejected by the Indira Gandhi government in 1975, set up one of the first export units in Bangalore exactly a decade later in 1985. The Rajiv Gandhi government fine-tuned this ecosystem of policies continuously for the next couple of years, and by the 1990s, even the niche and boutique software firms were exporting their services. By the late 1990s, the Indian software story was well and truly global. The Software Technology Parks scheme can be considered, with some justification, as the most successful ground-level implementation of a radical policy. Its success can be gauged from the fact that the software industry still wants its continuation.

India's Current Successes and Future Drivers

The incredible success of the Information Technology ecosystem, coupled with the liberalisation process of 1992 that made access to imported electronic goods and gadgets easier, diffused the focus required for setting up a robust electronic manufacturing base. It is not that efforts were not made, but that they were not within a consolidated policy framework. One notable effort was the setting up of semiconductor manufacturing plants in Mohali. The growth of the electronic manufacturing sector, however, remained stymied due to a variety of factors, ranging from a flawed tax structure that made imported gadgets cheaper than domestically produced or assembled ones and a weak R&D culture to economies of scale fostered by a globalised economy and a weak system of vocational and technical training.

While the three decades between 1990 and 2010 saw a massive growth in software services sector, with a major push coming from exports, the growth in the hardware sector was primarily fuelled by imports. The worldwide electronics industry is one of the fastest growing in the world, with an estimated billing of US$1.75 trillion. Ironically, the Indian market has contributed over US$100 billion to that bill, with over 90 percent as imports. As indicated earlier, the Indian import bill will be over US$300 billion in 2020. The ESDM sector in India comprises of four divisions: electronic products, electronic components, semiconductor design services and Electronic Manufacturing Services (EMS). Over 70 percent of the revenues of the Indian ESDM sector are generated by electronic products (Figure 8).

FIGURE 8: Revenue Forecast of Indian Electronics Market 2010-2015



Source: IESA & Frost-Sullivan

Faced with an ever-expanding electronics export bill and a near dumping-like situation in the lower end of electronic goods and gadgets, the United Progressive Alliance (UPA) government, especially its second edition, realised the need for a strong electronics manufacturing sector.

The NPE 2012 is in reality a culmination of the efforts of several task forces, reports and committees before it. The four prominent ones are the 2009 task force of industry and government experts headed by the HCL Chairman and CEO Ajai Chaudhry to provide suggestions for the growth of IT, ITeS and electronic manufacturing industry, the reports by Sam Pitroda and V. Krishnamurthy, who was the chairman of the National Manufacturing Competitiveness Council, and the research-based compilation by Frost and Sullivan. The key recommendations made by all the four reports were similar.

They included the establishment of a National Electronic Mission, set up in 2011 but still a work in progress and a policy for establishing new clusters and promote existing ones. 50 new clusters are being set up, 35 Brownfield projects on land that has already been used for commercial and industrial activity earlier, and 15 Greenfield ones are being set up set up by large brands like GMR (in Hosur), ELCEA (in Bhiwadi), APISE (in Hyderabad) and MPSESDC (in Jabalpur). It is interesting to note the similarities between the current cluster development policy, the Chinese High Technology Development Zone policy of 1988 and India's own highly successful policy of Software Technology Parks. The Ajai Chowdhry report also recommended the government to come up with specifications for products and services suited to the Indian environment. The mostly indigenous effort of digitisation of Indian television through the Conditional Access System (CAS), Aakash projects and the setting up of the Biotechnology Industry Research Assistance Council (BIRAC) are examples of this recommendation being implemented at the ground level.

Till now, standards for 15 categories of products and services have been mandated by the government. As per recommendations, a Rs10,000-crore R&D fund and an Electronic Development Fund (EDF), set up in conjunction with Venture Capitalists (VCs) for value addition, which is similar to the Chinese Electronics Industry Development Fund of 1986, have been set up. Of course, several crucial recommendations with reference to rationalisation of tax structure, especially on the inverted duty structure and zero imports duty on electronics, are still pending or are caught up in procedural difficulties. The issue of zero duty, for instance, is linked to the Information Technology Agreement-I (ITA-I) of World Trade Organisation that came into effect in 1997 by which large electronic components and products are bound with zero tariffs making trade unrestricted across international borders. The inverted tax structure, on the other hand, is India's own doing. This structure applies taxes like excise duty, value added tax, goods and services tax and central sales tax evenly to both domestic and imported electronic products, making Indian products uncompetitive.

Even the domestically assembled ones are costlier than fully integrated kits imported from China, Taiwan, South Korea, Malaysia, Indonesia and Philippines. It is within this context that the NPE 2012 needs to be positioned. It needs to be seen as continuation of the series of efforts and steps taken by the Indian State during the last decade.

Three Challenges and Six Interventions

The NPE 2012[14] seeks to address three interconnected challenges through six sets of policy interventions that are broad enough to create multiple ecosystems, but narrow enough to mould the specific nature and form of each one of them. Supporting these intervention are sets of rules and regulations that range from procurement norms to value additions. The first challenge of creating a self-sustaining manufacturing base for electronic products and goods has always been India's Achilles heel. It is also a particularly trenchant challenge considering that even today the actual value addition in domestically produced goods ranges only between 5 to 10 percent in most cases. This fact was effectively reiterated in the Sam Pitroda report to incite the government to set up the new electronics policy.

There are two inter-related interventions that are worth mentioning here with reference to value addition and demand generation. Using the practical experience that had been garnered through the complicated, but ultimately successful process of defence offsets, the new NPE gives primacy to the 'Made in India' tag. It sets clear benchmarks of 25 percent in the first year and 30 percent in the second year for value addition. It directly puts pressure on international giants like Samsung, LG, Dell and HP that today import as much 90 percent of their hardware. These benchmarks are also directly tied in with the procurement norms for 30 mega mission mode electronic governance projects that are to be rolled out in the next 10 years. This is similar to the procurement norms and linkages that the Chinese government had set up for its Golden Project for IT. It must be mentioned that the combined budget of Rs 11 lakh crores for these projects is comparable to the GDP of Finland and Chile.

Through this strategy, the government aims to achieve two ambitious objectives. The first is to create 100 million jobs in the electronics manufacturing sector in the next ten years, an absolute imperative to achieve the government's dream to increase the share of manufacturing sector to 25 percent of the GDP. The second is to substantially increase India's share in the global electronics production, currently at 0.5 percent, to over 15 percent.

The second challenge is more practical and logistical. Over the last two decades India has acquired a certain degree of expertise in chip design, primarily due to its indigenous efforts to develop high-end defence products. A notable example is the downstream and upstream technologies associated with chip design that have accrued from the Light Combat Aircraft project. The challenge then, as is the potential, is to develop the ESDM sector on a commercial scale so that technologies, systems, processes and trained manpower are diffused enough to create a commercial base. As mentioned earlier, India is hobbled by the constraints of zero import duty and an inverted tax structure.

Again, two specific policy sets are being used to build and enhance expertise in VLSI and chip design in order achieve an ambitious turnover of US$ 55 billion by 2020.The two sets are also used to build a strong supply chain of raw materials, parts and electronic components to ensure that finished products have at least 60 percent indigenous hardware by 2020.[15] It is estimated that ESDM exports will shoot up from the current US $5.5 billion to US$80 billion by 2020. It is within these two broad policy contexts that the specific mechanisms of Electronics Manufacturing Cluster (EMC) scheme, Modified-Special Incentive Package Scheme (M-SIPS) and modified rules for setting up semiconductor fabrication plants have to be located. The EMC scheme, for instance, not only provides the conventional hard infrastructure of roads, 24/7 power, water and Effluent Treatment Plants (ETPs), but also provides world-class independent and certified testing centres for achieving global quality parameters. All these facilities amount to a subsidy of US $10 million per 100 acres of land. Similarly, M-SIPS provides for a subsidy of 25 percent in the form of reimbursement of CVD/excise for capital equipment in non-SEZ units, reimbursement of central taxes and duties for ten years in high-technology units involved in VLSI and chip and semiconductor fabrication.

The third challenge is specific, and deals with acquiring and sustaining national expertise in research, development and commercial-scale production of high-technology products and services. Not only is this linked to the larger issue of creating a manufacturing base for electronics products, this challenge is by extension one of national security as well. Jolted by the number of cybersecurity attacks, and increasing awareness of the vulnerabilities of relying on externally sourced hardware–case in point: the manner in which the Siemens supplied hardware of the Iranian nuclear plants was compromised by a cyberattack–the government, quite rightly, wants a greater Indian control over the entire value chain of the hardware and software infrastructure in strategic and core areas.

The NPE seeks to create long-term partnerships between ESDM and core infrastructure sectors of defence, atomic energy, space, railways, power and telecommunications. It does this through two sets of policy tools, one hard and the other soft. The hard set of tools includes the EDF with a corpus of US $2 billion. EDF is structured as a series of subfunds called 'daughter funds' to promote, in a focussed manner, four objectives of innovation, intellectual property creation, research and development and product commercialisation in ESDM, nanoelectronics and information technology. Other tools include mandating standards and a network of BIS-certified testing labs. The soft set of tools includes the setting up of an Electronics and Telecom Sector Skill Council, over 30 ICT and electronics academies, and manpower development programme for 10,000 students for VLSI and chip design. The high point in this set of soft tools is the commitment to produce 2,500 high quality PhDs every year specifically for the electronics manufacturing sector.

But the most important tool is the Preferential Market Access (PMA) scheme[16] and its enabling framework, currently the source of a WTO complaint, which mandates that the government procurement from domestic manufacturers will not be less than 30 percent of the total procurement. This has not gone down well with several multinational companies. The US, through its Senate Finance Committee[17] and industry bodies like the US-India Business Council, has expressed displeasure at what it terms as 'unfair trade practices'. The PMA has been reviewed[18] by the outgoing Indian government. It is precisely here that the new government must take a leaf out of the Chinese mobile telecommunications policy in revisiting the review performed by the outgoing government, keeping in mind that the Chinese policy led to a robust situation of domestic manufacturers not only occupying close to 80 percent of the Chinese market, but also making significant impact in the global mobile telecommunications sector both in handsets and infrastructure equipment.

Conclusion

India will have to take into consideration that many of China's policies to promote domestic industry, technology incubation and preferential access to markets were initiated at a time when the WTO regimes were not in operation. Additionally, there is always the danger that the Indian policy makers may end up treating electronics manufacturing as a silo, and fund its research and development in a narrow manner. Creating a genuinely organic and sustainable base for electronics manufacturing, wafer and semiconductor fabrication requires the creation of an ecosystem where overall investment in science and technology, innovation, incubation and research and development is increased.

This requires focus on three issues. The first critical issue is to substantially increase investment in science and technology, build more world-class research institutions and higher education centres, entrepreneurship development cells and technology incubation centres, and bring in a greater industry-academic interaction. The second one is to achieve the right balance between high-technology investments and mass production of medium and low-end components. It is in getting this proportion right that holds the key to putting India into the next development orbit. The third issue is to ensure that the domestic industry is protected, nurtured and allowed to grow, without creating a stifling policy environment for foreign companies, technology transfers and joint ventures. Foreign partnerships and technology transfers are necessary for India to cut down learning curves and promote high-end research techniques and practices. At the same time, domestic manufacturers must be guided appropriately to ensure that neither do they indulge in white labelling goods and commodities produced abroad, nor do they feel disheartened not to promote investment in indigenous research and development.

A good enabling policy environment has been created in the last ten years, and the NPE 2012 can rightly be called the spearhead for India's push to become a global power in high-end electronics manufacturing, chip and semiconductor fabrication, nanotechnologies and large scale integration. On the one hand, it provides the right context and encouragement for domestic manufacturers to scale up their efforts in indigenisation, research and development and foreign partnerships. On the other, it gives foreign collaborators various policy ecosystems to establish everything from special electronic zones to individual factories.

The real challenge is to protect this carefully crafted ecosystem from being contaminated through a set of external pressures and lack of internal processes and intent. The new government and its policy makers must have the ability to pursue pragmatic tactics that take advantage of Transfer of Technologies (ToTs) frameworks, while ensuring that the domestic and indigenous capacity in chip design, fabrication and commercial production is protected and enhanced in a rapid manner. India can learn a crucial lesson in this regard from China on how to utilise ToT frameworks to rapidly build a manufacturing ecosystem. China has displayed an uncommon ability to create and scale up domestic manufacturing capacities in areas ranging from high speed rail networks to telecommunications infrastructure. However, India should guard against complacent efforts in indigenisation, as substantiated by several private companies displaying so-called home-grown 155mm howitzers that are nothing more than blueprints of their foreign partners put together in India. The country should equally guard itself against indigenisation efforts that conceive of self-sufficiency in terms of designing and manufacturing every single component of a system, as evidenced by several pending government defence projects, resulting in time and cost overruns. The NPE 2012 strengthens the framework of the emerging ecosystem for self-sustaining development of an electronic manufacturing base in India. The key, as is the case with every policy, lies in implementing it in spirit, in principle and in letter.

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