Interplay of Technology and Labour Productivity: Emerging Story of Consumer Electronics in India

Bino Paul and Mansi Awasthi

1 Introduction

Over the years, scholars have been unbundling the big word 'capital'. To one extreme extent, it is a stock over a period, while at the other extreme extent, it is an ensemble of tangible and non-tangibles, such as artefacts, discoveries, innovations and capabilities. Whatever be the view, capital has been an active change agent from diverse vantages, be it socially good or bad. While the chronicle of capital goes in hand with expansion of business or production, there seems to be an organic link between capital and human, in particular the production system as a case in point. Is this connect mutually beneficial or a trade off? This question is evergreen. Maybe this connect is not linear, rather enmeshed in diverse milieus like globalisation and value chains. An interesting case in point that embodies the interesting dynamics of technological change, globalisation and change in business models is the consumer electronics. This industry epitomises the commodification of research and development in consumer electronics to the final consumption stage, for example colour television and electronic home appliances. What makes this industry more interesting is that its growth is more dependent on populous large developing economies such as India, wherein product penetration rates are noticeably lower than that of developed countries.

In the case of consumer electronics industry in India, the supply of commodity tends to emanate from the domestic industry or from the abroad through the import. With the emergence of global value chains, the domestic production facilities tend to source products through imports, and then add value before selling. Alternately, reputed brands may contract manufacturing to a production facility on the basis of factors such as cost advantages, relational comfort and so on. So, this means that the sketching of production and trade in the context of global value chain is not

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so straightforward. Moreover, although trading and manufacturing tend to be more flexible, the market structure in aggregate appears to have been becoming more oligopolistic in nature, particularly colour television as case in point.

This paper explores the dynamics of consumer electronics production in Indian during last one and half decades. We juxtapose the analysis of domestic production with insights emerging from the media content and secondary data that narrate the recent dynamics in Indian consumer electronics industry. First, we set the background for the discussion by drawing cues from the extant literature on capabilities and firms. Second, we bring out the emerging chronicle of consumer electronics industry and business in India, using the meta-content drawn from the media coverage. Third, we resort to descriptive and inferential analysis of factory-level data drawn from Annual Survey of Industries (ASI), examining the relationship between technology and productivity. Fourth, we build a structural model from the data in which we explore the determinants of labour productivity, technology and share of profit in net value added (NVA).

2 Technology as a Capability

Technological advance is long understood as the principle driving force of economic growth. To appreciate the importance of technological contributions, it is important to understand the historical relationships between science and technology. The history of science as a subject sheds light on how scientific knowledge has helped technologies to understand artefacts and processes with which they work and tailored them to new purposes. The colossal contribution of science to the development of new technology, as a by-product of scientific enterprise, was possible in large measures because particular disciplines have been put into place for that purpose (Chandler et al. 2003). For instance, the discipline of metallurgy emerged from material sciences and engineering in the second half of the nineteenth century to meet the requirement of steel industry. On the industry side, firms started their own research laboratories focusing upon the specificities of firm's technological needs in the competitive environment. The universities institutionalised research and development through continuous supply of scientists and engineers, and, in return, these industrial laboratories created prospective markets for their university graduates (Chandler et al. 2003). The interdependence between augmented university curricula that would enhance student's usefulness to industry and emerging industrial research laboratories pushed the growth of knowledge to assure the needs of various industries. Meanwhile, new applied disciplines, performed at several universities, for instance, electrical and chemical engineering, were started emerging during late nineteenth century to meet the requirements of the new emerging industry for process and products development. The science led to the breakthroughs in technology and creation of stock of knowledge in subjects of commercial value to industries. Over the decades, technology became complicated through improvements in old technologies in the similar manner as it has taken directions from science and its applications. More

sophisticated industrial scientific research has evolved out of those simple and traditional beginnings, which have helped private industries to capture national and world markets.

This brings us to the next section on growing interest in technological changes and concerns over the prospects for economic growth. The writings on the technology opportunism have highlighted co-evolution of technology, firm performance and industry structure. There is a colossal literature on the contribution of technology in economic growth. While there is no dispute to it, Rosenberg addresses the question on how technological changes come about by looking into the origin and generation of new technologies (Chandler et al. 2003). The technology has not only grown significantly in the last decades but is no longer seen as exogenous element in the stimulation of growth (Rosenberg 1977). A one-dimensional view is being replaced by multifacet complex, encompassing different elements and inherent dynamics within it that goes beyond the traditional information-processing view of technology. The move from the realm of science to technology over centuries invites the economic motives of firm and firm-level technological changes. The firm, discussed here, is the dynamic firm, characterised by the technology it employs, strategies employed, organisational characteristics, concentration of its geographical embeddedness and its role in regional economies (Chandler et al. 2003). It is well understood that a business enterprise creates and uses embedded resources in pursuit to exploit underutilised resources in new markets. This, in turn, generates extra profits in foreign markets, thus giving them greater competitive advantages in global market place. The diverse international environment allows enterprise to develop diverse capabilities, resulting from broader organisational learning opportunities and innovations, which in turn, ensures ongoing growth of the firm. But, what and how well an enterprise develops strategies and organisational capabilities to sustain competitive advantage in a global market place?

The nature and micro-foundations of dynamic capabilities are necessary to understand firms are able to sustain superior performance. Dynamic capability is the capacity to extract rents from current resources as well as build new competencies (Teece et al. 1997). Deploying dynamic capabilities thus involves both capability exploitation and capability building (Luo 2002). Capability exploitation concerns the extent to which a firm exploits rent-generating resources that are firm specific, difficult to imitate, and able to generate abnormal returns. Capability building involves the extent to which a firm commits to building new capabilities through learning from other organisations, creating new skills or revitalizing existing skills in new situations (Luo 2002). These combining capabilities are the key to major source to exploit advantages, and these advantages are only possible when firms continuously reinvent in building new resources. The ability to combine internal resources and external learning is vital to firm's survival and growth in foreign market. However, all firms or industries do not show equal ability and readiness to undertake innovations for continual growth. This conundrum can be answered though historical dimension of innovative activity of electronics industry of USA and Japan at a different point of time.

Chandler et al. (2009) attribute the reason why the Japan overtook the USA in economic performance in electronics industry to differences in strategy, management and enterprise structure. The organisation of Japanese firms after 1950 was a major factor enabling Japanese post-war growth. He traces the course of successful firms in becoming path definers in consumer electronics and computer industry from 1940s to late twentieth century. The distinctive and dynamic capabilities as the basis of competitive advantage of Japanese enterprises reshaped the world consumer electronic market in 1960s. The first movers and their followers, Sony and Matsushita, built integrated leaning bases that helped them to develop, produce and sell in national economies and followed by world markets (Chandler et al. 2009). They grew their bases through reinvestments and diversified into related higher technology and markets. Another important characteristic was the creation of a supporting nexus of large and small enterprises in commercialising new products, thus forming industry's infrastructure that helped them to commercialise the potential of the modern science based technologies. Mowery and Rosenberg (1989) ascribe power to these dynamic capabilities framework in helping to illuminate the importance of enterprise performance to industrial leadership.

The conceptual underpinnings of dynamic capabilities paradigm can be traced to the new behavioural theory of the firms. This framework has been intertwined with contemporary ideas of technological innovations and evolutionary theory of economic change. The foundation of behavioural theory of the firm was laid in 1950s and 1960s on the ideas on 'bounded rationality', 'opportunistic behaviour' and 'routines'. Building on these foundations, both, transaction cost economics and evolutionary theory, have enriched the theory of firm. The evolutionary work by Nelson and Winter (2002) emphasised on the technological advances and performance, the key element in the competitive struggle in the context of economic change at the organisation and industry level. The essence of all the theories is that competitive success arises from the continuous development, alignment and reconfiguration of firm specific assets (Augier and Teece 2009). It is important to outline specifically how firms create new knowledge, shape new investment opportunities,and then transform themselves in the new environment. This involves understanding both technological and organisational change.

Setting the background of centrality of technological phenomena and dynamic capability framework in pushing the growth, the paper makes a modest attempt to examine and to explain the productivity dynamics with choice of technology, consumer electronics industry in India as a case in point.

3 Consumer Electronics Sector in India

The consumer electronics sector in India has been one of the fastest growing industrial sectors. Indian television and consumer durables market have been growing big, but it is primarily driven by imports. However, with the given macroeconomic factors and government impetus with 'Make in India', India is well positioned to increase its

manufacturing base in the consumer durables. The burgeoning consumer electronics market in India presents an attractive opportunity to manufacturers. Most of the global corporations are looking at India as regional hub for manufacturing and sales to cater to not only Indian market, but South Asian Association Regional Cooperation and Middle East and African markets, as well. The size of Indian consumer electronics segment is large, growing and is primarily driven by imports. Indian electronics industry revenue in 2014 was US 32.7 billion dollars in 2014. Of this, consumer electronics accounted for 28%. The consumer electronics is expected to be US 29-billion-dollar market by 2020 from US 10 billion in 2015 (FICCI and EY 2015).

There is a huge opportunity for manufacturing in India. First, the demand for flat televisions, refrigerators, washing machines and air conditioners is on rise with increasing disposable income and urbanisation of consumers. Market for white goods and televisions has been growing at close to 14% and is expected to accelerate in coming years. Second, there has been a rise in imports from low-cost regions, China and South-East Asia to meet the rise in demand. Third, companies are planning to expand their local manufacturing in India to meet rising local demand and make the country an export hub. The Indian consumer durables markets have traditionally been a 'high spend', priority sector. Consumer durables account for more than 40% of end consumer spending in India (FICCI and EY 2015). According to Consumer Electronics and Appliances Manufacturers Association, the sector contributes to more than 5.5% of Index of Industrial Production. Figure 1 shows the growing market for fours items in consumer electronics: television (TV), air conditioner, refrigerator and washing machine.

Of late, exports from India have been on a rise. The compound annual growth rates of exports of air conditioners, washing machines, refrigerators and televisions are 20%, 55%, 8% and 3%, respectively, during 2010–2014 (FICCI and EY 2015). UAE, particularly Dubai is a major import hub for India. India is well positioned

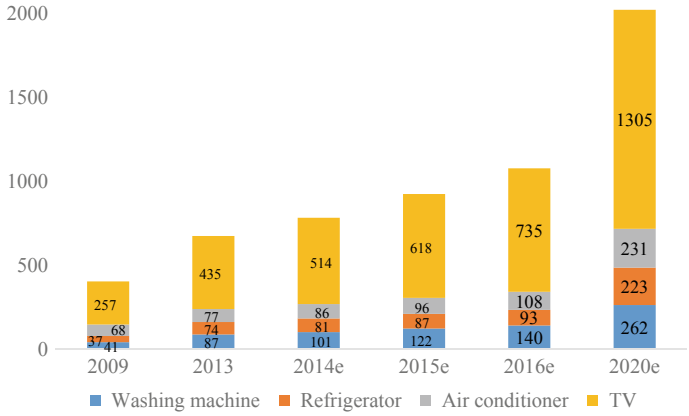

Fig. 1 Indian consumer electronics market size (rupees billions). *Source* FICCI and EY (2015). *Note* '*e*' mean estimate

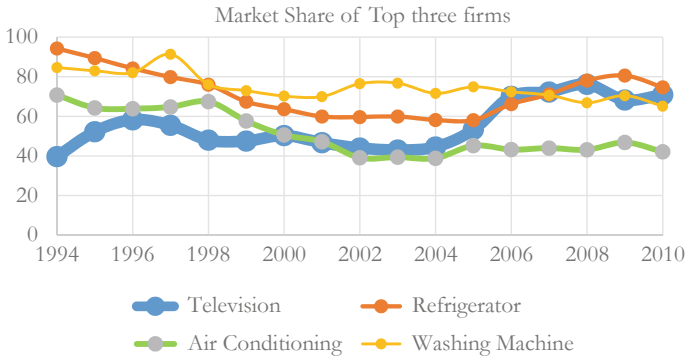

Fig. 2 Market share of top three firms in consumer electronics and home appliances in India. *Source* Industry: Market size and shares, Centre for Monitoring Indian Economy. *Note* Figures are in per cent

to increase its manufacturing base. India is the second-largest population with 0.5 billion in labour force. The 'Make in India' initiative is pushing investments in infrastructure, tax incentive and other policies, facilitating ease of doing business and streamlining exports and imports. But there are some impediments to expanding the local manufacturing base—tax and duty structure, limited scale and quality from domestic suppliers, increasing competition from Chinese and South-East Asian manufacturer, capital intensive nature of business, ease of setting up and running businesses, infrastructure bottlenecks. Also, majority of the parts going into locally manufactured products are imported from China, Japan, Indonesia, Malaysia and Taiwan.

As shown in Fig. 1, across the years, television forms largest share, hovering around two-third, of the consumer electronics market. This makes television industry as a special case in point. During 1994–2010, spanning over fifteen years, share of top three firms in television market increased from 40 to 71% (Fig. 2). Quite important, except for air conditioner, for other products, in 2010, market shares of top three firms account for two-third to three-fourth. This pattern appears to unravel some interesting dynamics. Drawing cues from this trend, it is sensible to posit that the market structure tends to become more oligopolistic while it is moving away from a competitive structure. To have this story, we may connect diverse nods like data points and contents. As an interesting corollary to these dynamics, Fig. 3 depicts that around 2011 value of imported TVs exceeded the domestic production, and this has been continuing, since then. Further, as depicted in Table 1, during 2008–2009 to 2016–2017, East Asian Countries, in particular Malaysia and China, remained as top importers. How we narrate this pattern, further, by using supporting contents? Is this behaviour valid for the whole consumer electronics? To explore these interesting questions, we have created a meta-content of the news from the media, concerning the

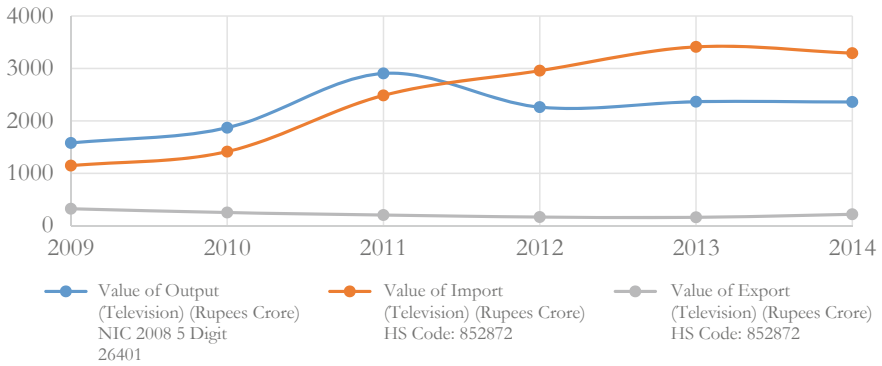

Fig. 3 Domestic production, import and export of television. *Source* Value of output was extracted from Annual Survey of Industries; unit records values of import and export were obtained from http://commerce.nic.in/eidb/default.asp. *Note* Figures are in per cent. NIC = National Industrial Classification, HS = Indian Trade Clarification based on harmonised system of coding

Table 1 Top three TV importing countries to India

Year	Top three TV importing countries to India
2008–09	Malaysia, Thailand, China
2009–10	China, Thailand, Hong Kong
2010–11	Malaysia, China, Hong Kong
2011–12	China, Malaysia, Indonesia
2012–13	Malaysia, China, Thailand
2013–14	Malaysia, China, Thailand
2014–15	Malaysia, China, Indonesia
2015–16	Malaysia, China, Thailand
2016–17	Malaysia, China, Thailand

Source Extracted from http://commerce.nic.in/eidb/default.asp

consumer electronics, by using India Business Insight,[1] capturing the news content during 1995–2017. As given in Appendix 1, we divide the meta-content into three broader segments: value chain, research and development and market. The ensuing discussion is based on the meta-content given in Appendix 1.

[1]India Business Insight is a comprehensive online research tool to Indian business and industry information. The database encompasses daily newspapers, magazines and accesses information disseminated through government sources.

4 Foreign Conglomerates Forays into Indian Consumer Electronics

The relaxation of licensing requirements during mid-1990s effectuated multinational conglomerates into Indian markets of consumer electronics. The onslaught of foreign brands has revamped up their penetration into Indian markets in the last two decades, elbowing out domestic enterprises. The competition from rivals', majorly Korean consumer giants, LG and Samsung, besieged the broken domestic companies—BPL and Onida, most prominent of them in late 1990s. The domestic enterprises did not invest in scale or new technologies during the period of protection, and, as a result, could not adjust to the increased competition from foreign investors who started setting up their local production. Consequently, Indian consumer electronics industry was dominated by multinational corporations such as LG, Samsung and Sony through surpassing in products, features and design.

The broad liberalisation provided ingress to several foreign private conglomerates. In 1995, Samsung invested $1 billion in India. Hyundai electronics made an entry into consumer electronics market in India, through several models of colour televisions in 2004 and later rolled out air conditioners, refrigerators and other consumer electronics by mid-2005. The three consumer electronics giants of China, TCL, Shinco and Aigo made an entry in India as the industry started booming. Shinco tied up with Future Techno Designs (FTD), India, to start product localisation in India by 2008. Aigo, another leading information technology brand, launched its range of digital and self-assembling products in India in 2009. Seagate Technology floated joint ventures to enter Indian market in 2001. Some companies, for instance, Akai made a comeback to Indian markets in partnership with Global Brands in 2010.

Multinationals posted strong growth in sales and profit in their businesses. LG electronics entered Indian market with manufacturing television sets in 1997 and in the next two years, its turnover crossed Rs 1000 crore and topped in the colour television, semi-automatic washing machine, microwave oven, air conditioner and frost-free refrigerator segments of the market by 2002. Similarly, Sony India witnessed sales of Rs 615 crores during 1999–2000, Samsung recorded a sales turnover of Rs 1700 crore during 2002, Panasonic registered sales of Rs 150 crore from its consumer electronics business in 2005–2006, and Videocon achieved sales of Rs 23,000 crore in 2007–2008. The consumer electronics industry in India has been on a high growth path and achieved double-digit sales growth at Rs 26,000 crore in 2008–2009. Multinational companies with superior technology and better-quality control accounted for 70% of the overall market in 2011–2012. Samsung and LG followed the same path into leadership in sale and built commanding lead in the market. Both retained their top spots in the Indian consumer electronics markets in terms of revenue. LG sales grew to Rs 12,958.6 crore in fiscal year 2014–2015, and net profit rose 20% to Rs 761 crore. The Indian consumer electronics market has become more active, exciting and intense with the announcement of investments by foreign private players. However, South Korea-based LG and Samsung duo continued to strengthen their position within Indian market.

The positive numbers of sales have led companies to expand its manufacturing plants all over India. The consumer electronics companies have invested in India to construct new production lines with an extensive focus on domestic manufacturing, following their foray into consumer electronics segment. Over the years, all conglomerates have expanded its portfolio of products to grab market share through attracting local customers with a customised marketing approach. All drew up plans to get more from India by focusing on investments on capacity building, new manufacturing units and new product range on account of rising demand for consumer durables in the region. Philips lined up Rs 200 crore investments to regain double-digit market share in colour television segment during 2003–2004. Hyundai electronics has set up a facility for manufacturing colour televisions (1.2 million per annum) and air conditioners (0.2 million per year) in Uttarakhand for Rs 100 crore. Likewise, Samsung has invested additional Rs 350 crore in its facility in Sriperumbudur to manufacture consumer electronics products and information technology products. LG Electronics has spent Rs 380 crore to create new production lines in 2007 and Rs 1000 crore in setting up new plants for manufacturing 3D appliances in 2013. The consumer electronic companies have invested Rs 3500 crore cumulatively to enhance manufacturing in India through the modified special incentive package scheme. They have put bolstering efforts to expand their presence in India by introducing innovative products and marketing schemes that are specially tailored for Indian consumers.

5 Emerging R&D Destination in India

Indian economy has become a significant recipient of foreign direct investments from the electronic majors. The trends emerging in the market involves convergence of intelligence and smart technologies in appliances to ensure next level user experience. Nearly, all companies have set up their R&D units across the country to develop internal technology focusing on innovative products with intelligent features.

Proliferating their capital expenditure, companies invested into identify consumer insights to incorporate consumer purchase behaviour in product development and marketing strategies. Recent and upcoming technology-ingrained products in the Indian market reiterate the emphasis of product innovation and development to lead the way in future. In a bid to capture market share, companies have changed their strategy by building products specifically to suit Indian needs and by soaring its marketing and R&D expenditure. Samsung and LG earmarked $5 and $9 million, respectively, for R&D during their initial years in India. Subsequently, LG invested Rs 800 crore on new products range, technology platform for manufacturing and India specific R&D. In 2011, Philips developed innovation hub for more locally relevant products in the appliances segment and LG invested Rs 1000 crore for capacity building in the next two years. Panasonic has also set up a R&D centre along their manufacturing plant in Haryana in 2012. Videocon invested Rs 900 crore on R&D for new range of niche products in 2015–2016. Recently, in 2017, Panasonic has set up its R&D unit in Bengaluru.

Technology leadership is the key for the good growth and strengthening the market leadership in consumer durable industry. The development of companies' portfolios of patents and R&D investments parallels their technology development. The electronics makers have continued to invest significantly in R&D and pile up patents and invest higher per cent of sales. Most of the companies have revamped up their research and development spending and started accumulating technology. Samsung has set up consumer laboratory in Indian Institute of Technology, Delhi, to analyse product aspects like aesthetics, ergonomics and user interface. Samsung spends 7–8% of out of revenues each year that gives competitive edge in customizing products for domestic markets like digital signage and edutainment solutions.

6 Production Chain of the Indian Consumer Electronics Industry

Industry-level restructuring in response to trade liberalisation involved consequent changes in the involvement of domestic enterprises. It is important to examine the production chain of the vertically integrated makers of consumer electronics and domestic appliances. The dominant makers outsourced a substantial portion of the parts in its product making, thereby increasing the percentage of local component manufacturing in India. Since their entry into Indian market, foreign private players have entered into contract manufacturing agreements with local partners. LG made pact with Ahmedabad-, Bhopal-, Calcutta-, Chennai- and Nashik-based units for television sets and sought original equipment manufacturers for making refrigerators in South India during 2001–2002. In 2002, Voltas started manufacturing refrigerators for Samsung under contract. Even there is a presence of sub-contracting in case of Haier, Haier has given contract of manufacturing of its products parts to Dixon, which has given sub-contract to Hotline unit in Noida. In 2003, Blue Star outsourced logistics from AFL, and likewise, Anchor electricals started manufacturing consumer durables of Daewoo electronics. These tie-ups with local enterprises in making products locally instead of importing from outside gave solutions to lower costs and saving their crucial time.

The trend to outsource non-core operations is growing along with the vertical integration of core competencies. The need for outsourcing is attributed to rapid technology growth requiring complex manufacturing capabilities and low-cost manufacturing. The outsourcing has created opportunities for companies to locally procure goods and secure suppliers that give competitive advantage. However, designing and engineering processes, the fundamental activities in creating value, are not the areas of partnership with other original equipment manufacturers or local agents.

7 Understanding the Domestic Production System of Consumer Electronics in India

The dynamics narrated above shows that the consumer electronics industry in India has been evolving as globalised activity wherein multinational enterprises consolidate their market share through products embedded by new technologies, global value chains and investing in domestic production systems. More pertinently, television industry as a case in point, the burgeoning domestic demand from India appears to have been met by import during recent times. Is this narrative or set of patterns pointing that firms envisaging more flexible business models that connect domestic production systems and global value chains, while the domestic system destines to be a periphery of operations rather than a source of dynamic capabilities? To examine these questions, we look into the unit records of ASI.

We pool unit records of ASI for the period from 2000–2001 to 2013–2014 for creating database of production units that are engaged in the consumer electronics industry in India. From the database, we got a tally of 3736 factories that were operating during this period. Since we could not ascertain whether units of analysis found repetitive entry in the database, we did not create a panel data. Instead, we pool the data across the years. In order to identify which producing units fall in the category of consumer electronics, we used a concordance table that synchronise National Industrial Classification (NIC) 1998, 2004 and 2008 (Appendix 2). By using the data, we intend to plot three basic relations: (a) net value added per labour and capital labour ratio, (b) share of wage in NVA and share of profit in NVA and (c) capital labour ratio and share of wage or profit in net value added.

Exploring these three relations, we set the context for elucidating narratives and context of dynamic changes in the industry. First, real NVA[2] per person employed (alternately called NVA per labour) appears to be a proxy for average productivity of the system of production, while real capital[3] per person employed (alternately called capital labour ratio), to a greater extent, seems to be an indicator of the type of technology—capital intensive or labour intensive. Since we are concerned about proportionate change rather than absolute change, we transform these variables into natural logarithms. This implies that the slope becomes the ratio of proportionate changes, called elasticity. Second, our concern is about linkage between distributive context and the choice of technology. Needless to say, this is a complex issue, embroiled in plural contexts. Our objective is to get basic intuition about what happens to capital per person when share of wage or profit in NVA changes. Quite important, we simplify the complex concept of technology as capital labour ratio,

[2]Real NVA was computed by discounting nominal NVA by wholesale price deflator for consumer durables.

[3]Real capital computed by discounting nominal value of plant and machinery by machinery and machine tools price deflator.

while net value added per person represents productivity. Moreover, the distributive aspect with respect to net value added is captured by share of wage or profit in NVA.

While Fig. 4 depicts the relation between NVA per labour and capital labour ratio, relation between shares of wage in NVA and profit in NVA is plotted in Fig. 5. Capital labour ratio is plotted with respect to share of profit in NVA and share of wage in NVA, in Figs. 6 and 7, respectively. As shown in Fig. 4, there appears to be a direct relation between NVA per labour and capital labour ratio, tenable across the years. On the other hand, as depicted in Fig. 5, as share of wage in NVA dips, share of profit tends to go up, valid for all the years. Although discernibly scattered patterns, there seems to be a weak direct relation between share of profit in NVA and capital labour ratio (Fig. 6), while there appears be a weak inverse, but pronounced than the former pattern, relation between share of wage in NVA and capital labour ratio (Fig. 7). In brief, plots in Figs. 4, 5, 6 and 7 point to presumably posited relations between technology (capital labour ratio) and productivity (NVA per labour), and relation between technology and distribution of value added to wage and profit, although shrouded in the noises generated by the outliers. Moreover, we disaggregate the whole data with respect to type of organisation. Figure 8 plots capital labour ratio with NVA per labour, segregated for each type of organisation. The relation between capital labour ratio and NVA per labour appears to be markedly steep for two categories—public limited and private limited—than the rest. This points to the impact of governance on technology-productivity relationship.

Fig. 4 Real net value added per person employed and real capita per person employed (2000–2001 to 2013–2014). *Source* Extracted from unit records of Annual Survey of Industry, 2000–2001 to 2013–14. *Note* Year (from 2000–2001 to 2013–2014). 1 is 2000–2001, while 14 is 2013–2014. *N* = 3736 Factories

Fig. 5 Share of profit in net value added and share of wage in net value added (2000–2001 to 2013–2014). *Source* Extracted from unit records of Annual Survey of Industry, 2000–2001 to 2013–14. *Note* Year (from 2000–2001 to 2013–2014). 1 is 2000–2001, while 14 is 2013–2014. $N = 3736$ Factories

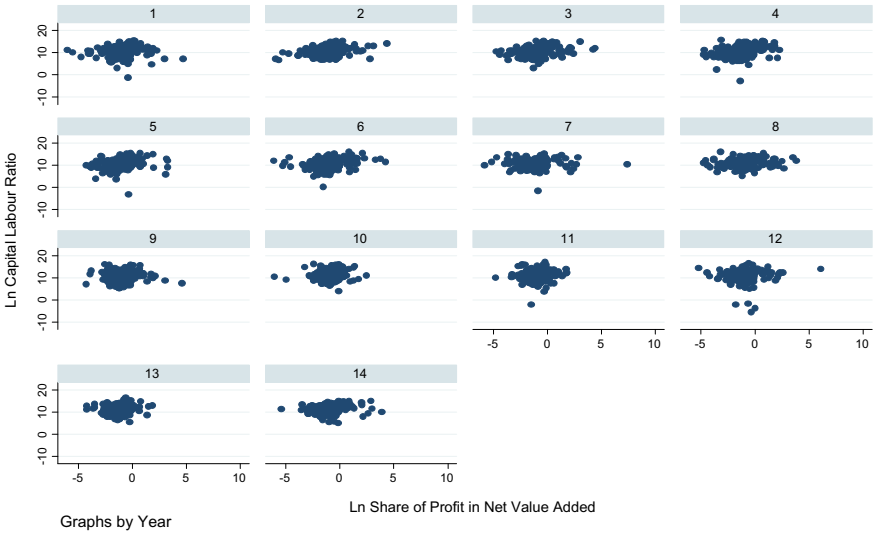

Fig. 6 Share of profit in net value added real capita per person employed (2000–2001 to 2013–2014). *Source* Extracted from unit records of Annual Survey of Industry, 2000–2001 to 2013–14. *Note* Year (from 2000–2001 to 2013–2014). 1 is 2000–2001, while 14 is 2013–2014. $N = 3736$ Factories

Fig. 7 Share of wage in net value added real capita per person employed (2000–2001 to 2013–2014). *Source* Extracted from unit records of Annual Survey of Industry, 2000–2001 to 2013–14. *Note* Year (from 2000–2001 to 2013–2014). 1 is 2000–2001, while 14 is 2013–2014. $N = 3736$ Factories

As a pooled database, the data are a mix of noise and voice. Not only noise arises from residual part of cross-sectional observations, variation in time also brings a share of noise. On one hand, we may bundle all the observations across the period, or we capture changes in time and identities such as type of organisation and state by using binary coded variables called dummies. In this paper, we use both the options. Moreover, we also let these dummies to interact with explanatory variable; this is to gauge about variance of parameters like slope. Quite interestingly, above-mentioned noises seem to have been combining with the problem of outliers in the data, generating phenomenon like heteroscedasticity that potentially cripples credibility of inferences. In view of this, we use two strategies to gauge estimates. First, we run regression that is subject to robust standard error. Second, we allow central tendency to move from one tail to another by using simultaneous quantile regression, letting us to account for the sensitivity of parameters to lower, middle and upper tail values.

As shown in Table 2, natural log of NVA per labour was regressed on natural log of capital labour ratio, by using five different models. First model is a two-variable ordinary least square regression. Second model is the same except we use the robust regression. Third model has four independent variables—natural log of capital labour ratio and binary-scaled dummies with respect to year, state where the factory is located and type of organisation. Fourth model is the exactly the third

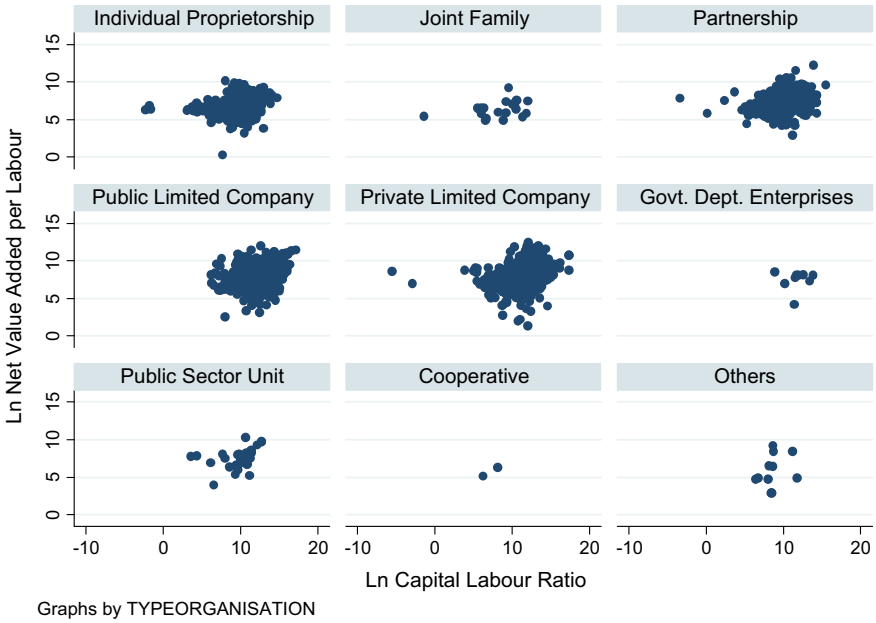

Fig. 8 Real net value added per person employed and real capita per person employed (by type of organisation) (2000–2001 to 2013–2014). *Source* Extracted from unit records of Annual Survey of Industry, 2000–2001 to 2013–14. $N = 3736$ Factories

model except robust regression. In fifth model, we retain all the variables in third model, while adding three interactive variables—natural log of capital labour ratio multiplied by dummies with respect to year, state and type of organisation. While dummies provide cues about variation emanating from the identities, interactive variables capture if these identities explain change in slope of the relation between NVA per labour and capital per labour. However, for the fifth model, we do have only OLS regression. We refrain from having robust regression since the coefficient with respect to capital labour ratio is statistically insignificant.

As shown in Table 2, across regression models except fifth model, coefficient with respect to capital labour ratio remains statistically significant at one percent. The coefficient across regression models is positive. Since we regressed logarithm of NVA per labour on capital labour ratio, the partial slope or coefficient is the ratio of proportionate changes, called elasticities. The values of elasticity vary in the range of 0.14 (fourth model) to 0.26 (second model). This indicates that, for model 2, with one per cent proportionate change in capital labour ratio, there will be 0.26% proportionate change in NVA per labour. Were this estimate closer to one, we would have concluded that for a unit proportionate change in capital labour ratio, there would be equal proportionate change in NVA per labour. However, our results indicate that none of the coefficients appear to be closer to equiproportionate change. Treating capital labour ratio and NVA per labour as proxies of technology and productivity,

Table 2 Results of regression of Ln real NVA per labour on Ln capital labour ratio of consumer electronics and domestic appliances, 2000–2001 to 2013–2014

Index	Ln real NVA per labour (OLS) Model 1	Ln real NVA per labour (Robust) Model 2	Ln real NVA per labour (OLS) Model 3	Ln real NVA per labour (Robust) Model 4	Ln real NVA per labour (OLS) Model 5
Constant	4.8144***	4.6033***	4.8919***	4.9426***	5.4949***
Ln capital labour ratio	0.2431***	0.2605***	0.1422***	0.1412***	0.0657
Year dummy	No	No	Yes	Yes	Yes
State dummy	No	No	Yes	Yes	Yes
Organisation dummy	No	No	Yes	Yes	Yes
Year dummy * Ln capital labour ratio	No	No	No	No	Yes
State dummy * Ln capital labour ratio	No	No	No	No	Yes
Organisation dummy * Ln capital labour ratio	No	No	No	No	Yes
R^2	0.1668		0.3102		0.3380
N	3736	3736	3735	3735	3735

$p < 0.01$***
N Number of observations
Source Ministry of Statistics and Programme Implementation, unit records of Annual Survey of Industries, 2000–01 to 2013–14

respectively, presumably, inferences from Table 2 point to that productivity does not appear to be discernably sensitive to the change in technology.

To examine the impact of capital labour ratio on distribution of NVA to the factor of production, we regress natural logarithm of share of wage in NVA on natural logarithm of capital labour ratio. We retain five models here, as well. Table 3 provides the results of regression. Except fifth model, coefficients with respect to capital labour ratio are statistically significant at one per cent; all statically significant coefficients are negative, varying in the range of −0.08 (model 4) to −0.71 (model 3). It is important to note that models 1 and 3 suffer from heteroscedasticity. Therefore, we restrict our comparison only to models 2 and 4. For the model 2, the coefficient is −0.1. The result indicates that, while there is an inverse relationship between technology and labour income, the sensitivity of change is of perceptibly lower magnitude. Having been curious about the impact of technology on share of profit in

Table 3 Results of regression Ln wage share on Ln capital labour ratio of industry consumer electronics and domestic appliances, 2000–2001 to 2013–2014

Index	Ln wage share (OLS) Model 1	Ln wage share (Robust) Model 2	Ln wage share (OLS) Model 3	Ln wage share (Robust) Model 4	Ln wage share (OLS) Model 5
Constant	−4.8081***	−4.7262***	−4.7375***	−4.6747***	−4.8827***
Ln capital labour ratio	−0.1036***	−0.1086***	−0.710***	−0.0759***	−0.0439
Year dummy	No	No	Yes	Yes	Yes
State dummy	No	No	Yes	Yes	Yes
Organisation dummy	No	No	Yes	Yes	Yes
Year dummy * Ln capital labour ratio	No	No	No	No	Yes
State dummy * Ln capital labour ratio	No	No	No	No	Yes
Organisation dummy * Ln capital labour ratio	No	No	No	No	Yes
R^2	0.0445		0.2264		0.2473
N	3734	3734	3733	3732	3733

$p < 0.01$***
N Number of observations
Source Ministry of Statistics and Programme Implementation, unit records of Annual Survey of Industries, 2000–01 to 2013–14

NVA, we ran a regression specifying share of profit in NVA on capital labour ratio (not reported in the paper). With respect to this regression, elasticities were positive but of much lower magnitude. So, this means, albeit not so strong, more capital per labour seems to have been generating higher share of profit in NVA. This aspect will be taken up for discussion when we view productivity and technology as a structural system in the later part of the paper.

Now, we go back to Table 2 that brings forth the relation between capital labour ratio and NVA per labour. Postestimation results of models 1 and 3 in Table 2 clearly indicate the presence of heteroscedasticity, rendering estimates not reliable. To obviate this problem, we ran models 3 and 4. We have already discussed the results of these models. Alternately, we may let the central tendency to move from the lower tail to upper tail of the dependent variable. For this, we resort to simultaneous quantile regression that lets regression to be run with respect to 0.2, 0.4, 0.5, 0.6 and

0.8 quantiles. Table 4 reports the results. We ran two models: one without dummies and one with dummies for year, state and type of organisation. Across quantiles and models, there is a direct relation between NVA per labour and capital per labour. Quite important, there appears to be no discernable differences between results in Tables 2 and 4.

8 Productivity, Technology and Relative Factor Prices: A Structural Model

Drawing cues from our previous discussion, in particular Table 2, there appears to be a direct relation between technology and productivity, although this sensitivity is of lower magnitude. An important challenge with this inference is how exogenous is this explanation. Or, this calls for exploring into embedded explanations within the technology. Presumably, technology, while it is complementary to resources in the firm, tends to be swayed by changes in relative prices. For example, change in wage in terms of capital price may directly impact change in technology. Put differently, if the ratio of wage to capital price goes up, capital per labour tends to increase. As shown in Table 3, change in capital labour ratio may weakly impact share of wages in NVA. As elucidated before, corollary to Table 3 is a weak positive relation between capital labour ratio and share of profit in NVA. So, to bring these dimensions together, we envisage a system of three equations in contrast to previous systems of single equations. The structure, we put forth, has three functions. First, we regress NVA per labour on capital labour ratio and share of investment in hardware and software out of total fixed assets. Second, we regress capital labour ratio as a function of ratio of real wages to price of capital. Third, share of profit in NVA is regressed on capital labour ratio. Across these models, we use dummies of time, industry and type of organisation as control variables. In the previous discussion on single equation models, we used industry as the single entity. However, here, we classify them into two: (a) consumer electronics (predominantly colour televisions) and (b) domestic appliances (refrigerators, washing machines and air conditioners). As far as type of organisation is concerned, we prune codes into two: (a) public or private limited and (b) others. In comparison with single-equation models, we dropped state dummies in the structural model, primarily to ease the degree of freedom. Moreover, in single-equation model, results were not sensitive to state dummies. We use three-stage least square (3SLS) multivariate regression model to estimate. Table 5 and Fig. 9 provide the results.

Figure 9 captures statistically significant results reported in Table 5. As shown in Fig. 9, capital labour ratio directly impacts NVA per labour, reporting a partial elasticity of 0.26. Interestingly, this result is not discernably different from result in Table 2. Moreover, share of investment in hardware and software in fixed assets appears to positively impact NVA per labour, although the coefficient is of lower

Table 4 Results of quantile regression Ln real NVA per labour on Ln capital labour ratio for consumer electronics and domestic appliances, 2000–2001 to 2013–2014

Index	Ln real NVA per labour					Ln real NVA per labour				
	0.5	0.2	0.4	0.6	0.8	0.5	0.2	0.4	0.6	0.8
Constant	4.6899***	4.3055***	4.4799***	4.8254***	5.2129***	4.9097***	4.7786***	4.8747***	4.9279***	5.2395***
Ln capital labour ratio	0.2497***	0.2187***	0.2483***	0.2574***	0.2800***	0.1447***	0.1168***	0.1354***	0.1454***	0.1478***
Year dummy	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
State dummy	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Organisation dummy	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.1129	0.079	0.1082	0.1172	0.1122	0.2246	0.1812	0.2153	0.2342	0.2468
N	3736	3736	3736	3736	3736	3735	3735	3735	3735	3735

$p < 0.01$***

N Number of observations

Source Ministry of Statistics and Programme Implementation, unit records of Annual Survey of Industries, 2000–01 to 2013–14

Table 5 3SLS (multivariate) regression

	Ln real NVA per labour	Ln capital labour ratio	Ln profit per NVA
Constant	5.0433***	7.9472***	−2.0393***
Ln capital labour ratio	0.2609***	–	0.0707***
Ln software per fixed asset	0.0602***	–	–
Ln real wages by capital price	–	0.4382***	–
Organisation	0.3098***	0.3083***	−0.0407
Industry	−0.2732***	0.1360*	−0.0522
Year	Yes	Yes	Yes
N	2410	2410	2410
R^2	0.2900	0.2211	0.0251

$p < 0.1$*, $p < 0.01$***
Note Organisation: 1—Public or private limited; 0—Others
Industry: 1—Domestic appliances; 0—Consumer electronics

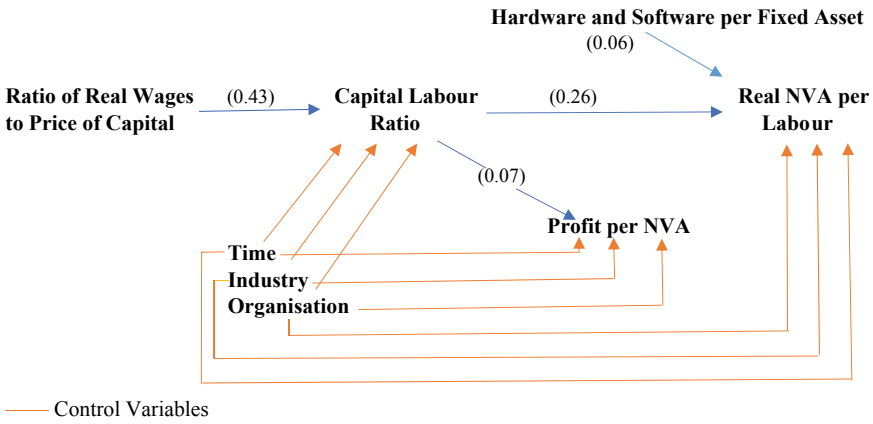

Fig. 9 Productivity, technology and relative factor prices: a structural model. *Source* Based on Table 5. Figures in parenthesis are elasticities

magnitude. Referring to Table 5, if an organisation is public/private limited, the constant of the equation tends to increase by 0.6%. This is an important result that says the governance of organisations has an impact on translating technology to productivity. So, going by this result, changing the type of organisation from something like proprietorship to public private limited enables the firm to transform organisational capacities to payoffs like productivity. Another important result is that the type of

industry does impact NVA per labour. If we change the type of industry from consumer electronics to home appliances, the intercept drops by 0.56%. This behaviour seems to have been emanating from the trend of consumer electronics being more globalised than the home appliances (as discussed previously using the meta-content of news in the media during 1995–2017). Quite important, the second model conveys the sensitivity of capital labour ratio to relative factor price, reporting an elasticity of 0.43. The third function is almost identical with the single equation estimates, showing a discernably weak relation between capital labour ratio and share of profit in NVA.

What we gauge from these results is that while the consumer electronics industry in India has been evolving during last two decades from not so globalised to more globalised, amply manifesting in influx of multinational enterprises and renowned brands, it appears the conversion of globalisation process has not yet translated into creation of core capabilities such as creation of new products, generation of innovation and extensive foray into the exports. If we accept factory as the fundamental unit of production and capabilities, drawing cues from descriptive and inferential analysis, we have ample evidence to say that technology in this industry hardly convert to value added per labour. Is this signifying the limits of global capital? Do we see the global capital foraying into populous developing geographies, mainly to tap the bourgeoning market sizes, rather than creating capabilities through innovation and technology transfer? Our results point to these questions while envisaging more constructive research in future on these issues.

9 Conclusion

The consumer electronics industry in India, enveloping colour televisions to home appliances, has been growing exponentially over the years, more pertinently during last one decade. This growth as a milieu is also a chronicle of entry of technology-orientated multinationals, in particular those located in East Asia, to India. They have been using flexible business models and trading arrangements to grow in the market, by consolidating market shares and innovating novel products and so on. What does this mean for domestic production of consumer electronics in India, covering television and home appliances?

We look into the fundamental unit of analysis, i.e. factory for exploring these questions. This paper, by using the factory unit records from Annual Survey of Industries, examines the relation between technology and value added per labour. Our exercise revolved around the pooled data of factories, spanning over 2000–2001 to 2013–2014. Our descriptive and inferential analysis of data conveys that change in technology, measured by capital per labour, has not translated to change in labour productivity, measured by NVA per labour. Interestingly, this result remains more or less same across diverse empirical settings, be it single-equation models with or without dummies and interactive variables or simultaneous equation system. Drawing cues from the meta-content and the analysis of data, the expansion of consumer

electronics market in India seems to have been not corresponding to expected growth in shaping of technological and business capabilities of domestic firms, whether they are part of multinational enterprises or not. As evident in the trade data, import has been emerging as the principal source of supply in Indian consumer electronics market, which is shaping as an oligopolistic structure, in particular colour television as a case in point.

From a policy point of view, our conclusion raises interesting options. Perhaps, time is ripe for envisioning a creative innovation structure that fuses the culture of venturing, scientific discoveries, innovative branding, higher order skills in production, globally benchmarking production standards and dynamic governance models. If the current conundrum of progressive accumulation of capital that does not create production capabilities goes on, presumably it tends to create a vicious cycle of exponentially growing markets that plough money towards an ever-expanding capital accumulation, but not much to socially desirable productivity and spillovers.

Appendix 1

Select meta-content on media coverage of value chain, R&D and market share of Indian consumer electronics industry

1. Value chain	
1997	• Thomson Electronics sets up TV plants in Chandigarh with JV Partners of Chennai
	• Daewoo Anchor Electronics plans to source refrigerators from Godrej
1998	• Thomson Consumer Electronics ties up with regional contract manufacturers for colour TVs in Chennai, West Bengal, Punjab and Maharashtra
	• Samsung to source direct cool refrigerators from Videocon's plant at Aurangabad
	• Samsung tie-up with Voltas Limited for contract manufacturing of washing machines
2000	• LG Electronics to source 12 lakh fridges from Voltas Limited; bags order Rs 900 crore
2001	• LG Electronics alliances with Polygenta Technologies, Nashik, for contract manufacturing colour TVs. Polygenta undertakes contract manufacturing for BPL, TCL, Aiwa and Salora too
	• LG plans contract manufacturing of TV sets to local OEMs in Calcutta, Nasik, Bhopal, Chennai and Ahmedabad
2002	• LG seeks OEM pacts with Voltas Limited in Hyderabad for consumer electronics, home appliances and computer peripheral products
	• LG signs contract manufacturing agreements of Rs 10,000 crore with local producers in Gujarat
	• Voltas Limited signs a contract of Rs 900 crore to manufacture refrigerators for Samsung
	• LG Electronics ties up contract manufacture of colour TVs in Guwahati, Patna and Jammu

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2003	• Haier selects BPL and Voltas Limited as OEMs for TVs, refrigerators and air conditioners for Indian market
	• Anchor Electronics manufactures consumer durable products of Daewoo in India
	• Blue Star outsources logistics for finished goods from AFL Logistics
2004	• LG Electronics ties up with West Bengal Electronics Development Corporation to manufacture colour TVs from 2003
	• Haier TVs rolls out of Hotline unit in Noida (Haier has given contract to Noida-based Dixon which has given sub-contract to Hotline to manufacture TVs)
	• Citrix solution helps LG Electronics to optimise operational costs for consumer durables
	• Hyundai Electronics talks with Videocon Group and other local OEMs to roll out consumer electronics products in India
2006	• Shinco Consumers ties up with Future Techno Designs, India, for product localisation an DVD assembly unit in India by 2008
	• Sanyo signs contract manufacturing for refrigerators and other home appliances instead of imports from its plants in Thailand and Vietnam
2009	• LG Electronics opts for contract manufacturing of low-end durables and upgrades its Noida facility to manufacture premium products
2011	• Toshiba invests Rs 450 crore to start contract manufacturing for LCDs, refrigerators and washing machines
2012	• Toshiba sets up facility for exclusive contract manufacturing of TVs and other digital players in Dehradun
2015	• Sony's LED TVs will be contract manufactured in Sriperumbudur
2. Research and development	
1998	• Philips plans corporate R&D centre in India to execute software projects and products
1999	• BPL plans Rs 25 crore R&D centre in Bangalore to design and develop colour TVs to satisfy the desires of Indian costumers
2000	• LG Electronics lines up $20 million for digital R&D and focusses in the areas of multimedia products
	• Samsung sets up $5 million R&D centre in Noida to design and develop TV sets for Indian customers
2001	• LG Electronics sets up an international development centre in Bangalore at an investment cost of $1 million
2002	• Seagate Technology, Singapore, in talks for technology transfer for product development and security solutions alliances with consumer electronics manufacturers in India
	• Samsung earmarks $5 million for R&D and aiming to become largest company in colour TV segment
2003	• Samsung sets up consumer laboratory at IIT Delhi to analyse product aspects and customise products
2004	• Haier sets up R&D centre along with assembly unit in India for colour TVs, entailing an investment of $3–5 million
	• Philips sets up homelabs to test new technology prototypes
2005	• LG plans to invest $30 million for R&D in air conditioners over next five years

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	• Samsung invests $12.5 million to build R&D operations at Noida for developing software for worldwide requirements for colour TVs and local manufacturing of DVDs and audio products instead of importing from Korea
2007	• Sony mulls R&D centre for high definition products, like digital cameras, camcorders and colour television sets, as part of its 'global localisation' plans
	• Samsung invests $5 million in expanding R&D operations for digital media products
2008	• LG Electronics invests $38 million on new technology platform for manufacturing and R&D
	• Samsung invests $13 million for product customisation to focus on mass products; formed separate hardware R&D centre in Noida
	• Philips sets up R&D centre for lighting electronics at Gurgaon; address the needs of not only the Indian market but also of the Asia-Pacific region, Europe and North America
2009	• Videocon spend Rs 300 crore on new technologies as well as for research and development in 2009–2010
	• LG Electronics doubles its spending in R&D at Rs 400 crore during 2009–2010
2010	• LG Electronics invest Rs 1500 crore for capacity expansion and setting up of research and development centre in 2010 to develop export-oriented models
2011	• LG Electronics invests Rs 1000 crore for capacity building during 2012–2013
	• Panasonic sets up R&D centre by 2012 in Haryana
	• Videocon invests Rs 1 billion in R&D and capacity enhancement during 2012–2013
	• Hitachi opens R&D centre in Bangalore as part of its efforts to develop products based on local needs
	• Philips looks at R&D hub to develop locally relevant products in appliances segment
2012	• Samsung spends 7–8% out of revenues in R&D each year
2014	• LG Electronics invests Rs 800 crore on R&D and production in 2014
2015	• Videocon invests Rs 900 crore on R&D for new rage of niche products in 2015–2016
	• LG Electronics invests Rs 1000 crore to boost marketing, research and development and product localisation
2017	• Panasonic–Tata Elxsi sets up an R&D unit in Bengaluru to develop artificial intelligence and robotics for domestic and global markets
3. Market	
3.1 Entry	
1995	• Samsung invests $1 billion in Indian market
1998	• Seagate enters consumer electronics market in the set-up box segment
1999	• LG Electronics makes India its export hub; invests Rs 350 crore to export colour TVs, refrigerators and top-load washing machine
2004	• Hyundai Electronics enters consumer electronics; targeting customers in major cities
2005	• Matsushita builds consumer electronics business through investments and new product range of audio-visual products, colour TVs and industrial components
2006	• INTEX diversifies into consumer electronics, spends Rs 10 crore on marketing initiatives

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2007	• China's TCL sets up manufacturing plant in India to manufacture colour TVs and DVDs in Noida
2009	• China's Aigo launches range of digital and self-assembling products
3.2 Sales	
1998	• Thomson turnover Rs 400 crore during 1997
1999	• LG Electronics crosses Rs 1000 crore; holds 9% in televisions
2000	• Samsung banks on home appliances for Rs 5000 crore turnover
2001	• Samsung records a turnover of Rs 340 crore; sales of TV rose by 8%
2002	• LG Electronics crosses 13.84% share in television; achieved sales of over 9 lakhs sets
	• Samsung records 12% growth; consumer electronics segment contributes 58.5% of its total sales
2003	• LG Electronics records 36% growth in turnover at Rs 4500 crore in 2003
2004	• Philips earns Rs 650 crore from sales in 2003
	• Samsung revenues increases to Rs 5000 crore from sales in 2004
	• LG Electronics posts Rs 205 crore net profit
2005	• Panasonic registers sales of Rs 150 crore from consumer electronics
	• Samsung targets total sales of Rs 6500 crore from consumer appliances export as well as domestic sales
	• Philips's revenue from India to reach Rs 5000 crores by 2008 against current turnover of Rs 3000 crore
	• Hyundai Electronics targets Rs 600 crore turnover; growing at 30%
	• Hitachi earns 10% market share in air conditioners in India
2007	• Sony revenues at $1 bn in 2006–2007, expects $2 billion by 2009–2010
2008	• LG achieves a turnover of Rs 11,500 crore; aims at 20% top-line growth
	• Reliance eyes Rs 15,000 crore from electronics business by 2012
2009	• Samsung eyes $3 billion sales in 2010; aims a growth of 40% over 2009
3.3 Capital expenditure	
3.3.1 Location	
1998	• LG Electronics sets up new air conditioner manufacturing facility in Himachal Pradesh and in southern India
2004	• Hyundai Electronics sets up for manufacturing colour TVs plant, air conditioners and DVD players in Uttarakhand at cost Rs 100 crore
2008	• Videocon lines up Rs 2000 crore project to manufacture electronic products in Tamil Nadu along with its subsidiary VDC Technologies, Italy
2009	• LG Electronics invests Rs 1000 crore in setting new plants for manufacture of 3D appliances to increase its global market share by 12%
2010	• Samsung expands plant at Rs 350 crore to manufacture consumer electronics and information technology products in Sriperumbudur
2016	• Daiken sets up new air conditioners plants in South India to export to Africa
3.3.2 Product diversification	

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1999	• LG Electronics introduces a range of digital products in Indian market; aimed at the upper-end of the market
2005	• Panasonic launches a range of plasma and LCD along with digital cameras
2008	• Samsung shifts focus on premium consumer electronics, flat panel TVs, high-end DVDs and Blue-ray player
2013	• Panasonic increases product lines; launches washing machines to meet growing demand within domestic appliances
2015	• Hitachi re-enters TV segment with strategic partnership with Croma

Source Indian Business Insight, http://indiabusinessinsight.com/ibi/

Appendix 2

Concordance between 3-digit industry classes of NIC 1998, 2004 and 2008

Industry	NIC 1998 3-digit	NIC 2004 3-digit	NIC 2008 3-digit
Consumer electronics	323	323	264
Domestic appliances	293	293	275

There are three different classifications (NIC 1998, NIC 2004 and NIC 2008) in use over the 2000–2001 to 2013–2014. The first step in developing comparable data over time is to prepare a concordance across the different classifications. A concordance for consumer electronics and domestic appliances is done at the three-digit level—as according to NIC 1998 and NIC 2004, consumer electronics has the industrial code of 322 and domestic appliances has industrial code of 293; for NIC 2008, industrial code for consumer electronics is 264 and domestic appliances is 275

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