NEW PRODUCTS AND CHANGING ECONOMICS OF PRODUCTION

ANNAVAJHULA J.C. BOSE

New technology by way of microchips, computers, telecommunications, software, and (light and touch) sensors has been increasingly applied in industrialized countries to thoroughly redesign products, plants and organisations in order to win or survive the ruthless high-quality, low-price competitive race. The descriptive analysis in this 'Note' is mainly concerned about nature and effects of emerging trends in product development, and is organised as follows: Section I considers the long-term objectives of product redesigning and Section II, the changing pattern of products and processes in calculator, timepiece and television industries. Finally, Section III derives certain concluding observations.

Section I

In the amazing field of product development, there has been rapid shortening of product life-cycles. This shortening arises due to two factors. First, the manner in which manufacturers, especially in the electrical appliance industry, deliberately build obsolescence into their product designs.[1] The strategy of the appliance makers has been to "delete old products as new ones come on stream and to hold the size of a product range in check", and then make the spare parts for the appliances so expensive that consumers are discouraged from hanging on to their appliances of more than a few years vintage.[2]

Secondly, and more importantly, the shortening has been due to competitive innovation, which has brought about dramatic changes in the design structure of various consumer and professional electronics products. Designs have been simplified to incorporate low cost, low component count. This has reduced the number of soldering connections needed to interconnect the components in many products. Hence the low sub-assembly and final assembly costs and the consequent low labour intensity of production. Traditional mechanical and electro-mechanical items of high value have been re-

---

Mr. Annavajhula J.C. Bose is Lecturer, Department of Economics, Shri Ram College of Commerce, University of Delhi, Delhi.

placed by low-value electronic components. Within electronic items, the traditional ones have been replaced by cheap, high-density integrated circuits (ICs)—microchips or microprocessors—which are getting cheaper. The Japanese were the first to put the chips into their consumer-grade equipment and achieve an early edge over their counterparts.

The microchips reduce bulk, conserve energy, improve control of quality, reliability and versatality, and facilitate easy repair (by taking one chip out and putting in another). They pare material and labour costs in such a way as to remove altogether 'cheap labour' competition. Finally, they increase user convenience and market appeal of the products. Thus the ultimate objectives of product development or redesigning are aptly summed up in the Japanese industrial circles by four adjectives—"lightweight, slim, short and small" ("kei, haku, tan and sho").[3]

As the IC makers invest massively and bring about 'super-chips', the products tend to become lighter, slimmer, shorter and smaller, and consequently open up possibilities for big business; markets are created constantly anew. Moreover, developments on these lines have already had a negative impact on the "buy-in" decisions of the top managements; standardized as well as subcontractable components and assembly operations are progressively eliminated.

The products that have been overhauled by microchips are cookers, sewing machines (one chip has replaced about 350 standard parts[4]), washing machines, toasters, vaccuum cleaners, clocks and watches, toys, cash registers, musical instruments, motor vehicles, telecommunications, home computers, word processors and other office equipment, and audio-visual equipment (radios, TVs, video tape recorders etc.). For example, in Japan, stereo players are not much larger than the cassette tapes that are slipped into them. Cameras have become lightweight due to "photo electric-cell circuits for foolproof automatic focussing". Bicycle owners are "abandoning their pedal-powered conveyances for compact 50cc-minibikes".[5] In motor vehicles, microprocessors placed under hoods of new cars, monitor and control engine functions for greater fuel economy and emission controls. They also improve the performance of breaking and electrical systems.[6]

Section II

Let us consider, in particular, how technological change has altered the product and organisation of production in three industries making calculators, timepieces and TV sets respectively.

Calculators

Any calculator has three essential elements—electronic circuitry, keyboard and display device. It is the circuitry, the brain of the machine, that has been overhauled by innovation through four phases.[7]

In the first phase, about 5000 discrete components—transistors, resistors, capacitors, diodes and the like—were interconnected to build the complete electronic circuit on single-layer circuit boards. In the second phase, the discrete items were replaced by several ICs to begin with and later on by fewer MOS/LSI (metal-oxide-semiconductor/large-scale integration) ICs which substantially reduced the total number of components.

The third phase saw "calculator on a chip", which pieced together only one chip combining 40 components plus the display device, the keyboard and few other discrete components. The fourth phase saw the advent of "calculator on substrate" (COS). The component count was thereby further reduced; the conventional circuit board was replaced by soda-glass substrate which held the chip and also contained the keyboard contacts. It also served as "the front half of the glass package for the display device". The Table below shows how these changes reflected in the substantial reduction in cost, price and labour intensity. Added to these were the benefits of greater dependability, versatality and economy in power use. The newer models became battery-operated, adding to their flexibility. We may add one more phase to the Table—the phase of even more compact, efficient and relatively inexpensive solar-powered calculators which look like a credit card.[8]

TABLE: Changing Pattern of Products and Processes Since 1962

Phases	Process/ component type	Product type	No. of total components	Changes in initial cost ($)	Changes in price ($)	Change in labour intensity (%)	Origin
I (1962-66)	Discrete components	Desktop	5000	170	602	30	US/UK
IIa (1967-68)	ICs	Portable	840	125	439	28	Japan
IIb (1969-70)	MOS/LSI (several chips)	Handheld	57	60	255	24	Japan
III (1971-72)	One-MOS/LSI chip	Pocket-sized	40	20	193	10	US
IV (1973-)	COS	Pocket-sized	39	5	62	8	Japan

Source: Badiul Alam Majumdar, *op.cit.*

The point is that these developments have given death-dealing blows to the competitive advantage (based on cheap labour) of industrial sitings in the less developed peripheries. Manufacture of calculators could now be integrated with automated techniques either in the industrialized countries or in certain peripheral locations (according to the logistics planning of the transnational companies). Alternatively, there could be scope for commercial subcontracting, with firms (in the industrialized 'centre' or less developed 'periphery') selling their products under the established American or Japanese labels.

Not only in calculators but in several other electronic equipment a very important offshore subcontracting operation for quite some time has been the labour-intensive assembly of components on (printed) circuit boards. But as components became fewer and fewer with the impact of microelectronic technology, and as the automated components insertion techniques are being progressively used, there would be no scope for labour-intensive international subcontracting in this regard.[9]

Timepiece Industry

Traditionally, this industry[10] all over the world was characterised by its fragmentation among hundreds of small assemblers and components makers. A classic example was the Swiss industry with about 500 brand names. The assemblers designed models and then invited bids from specialist subcontractors for various parts. But with the onset of microelectronics revolution and the advent of cheaper and more accurate quartz (analogue and digital) timepieces, the traditional finely tooled (handicraft) mechanical industry received a convulsive quaking. Within the US the quartz age forced out many established makers. In Switzerland and West Germany, in the face of Japanese and American competition, the traditional system became so uneconomical that many assemblers and with them many a subcontractor went bankrupt. The survivors coalesced into combines in order to support high costs of R&D, advertising and distribution networks. Thus the transition to quartz era has undergone restructuring by way of industrial concentration everywhere.

By late 1970s, the global timepiece industry was dominated by nine major firms—three Japanese, three American, two Swiss and one Soviet state monopoly. They controlled two-thirds of the world market in unit terms. These makers, with the Japanese at the forefront, are constantly pitted against each other's uncanny abilities to "hit the mark on fashion, features, user preferences and everything else that might motivate the consumer." They have segmented the market into high price range, middle range and low range by differentiating the models on a continuum between the extremes of simplicity on the one hand and models equipped with special functions (like chronographs, calendar, stopwatch, alarm, miniaturised calculators and even TV receivers) on the other.

Unlike the mechanical era which permitted subcontracting, the "economics of quartz watches, with fewer parts . . . , favour integrated operations using highly automated equipment on long production runs." These integrated operations are under a single roof or between plants widely dispersed. All the major producers such as the American Texas Instruments or the Japanese Hattori or the Swiss company Bulova have integrated operations.

For instance, in 1976, Texas Instruments had internal sourcing of electronic circuits, plastic cases and other components. Metal cases and crystals were procured from outside parties. The IC chip in its digital watches was initially ultrasonically wire-bonded to a ceramic substrate. This was a labour-intensive process which was later done away with by molding the IC chip inside the IC. Then a module of six electronic parts was assembled to the IC. The light-emitting diode time display was soldered to the IC by the method of batch processing but, the whole module assembly was about to be converted into a continuous process. The final assembly lines turned out plastic-cased watches.

Consider the world's most celebrated Seiko (meaning 'precision' in Japanese) brand manufactured by the Hattori group. Hattori does just final marketing. It has R&D units which keep innovating technology and redesigning. Further, it has two manufacturing companies, which are linked to Hattori through Hattori's family shareholdings. They are 'integrated' companies with their own component affiliates, which make all components and some special batteries. Many standard batteries are purchased from Union Carbide. These two companies have automatic assembly processes. Both of them make Seiko pieces, but they are very keen competitors, always at war with each other, in designing and pricing and obtaining Hattori's acceptance. Thus, while Hattori group appears as a vertically integrated one, it can also be described as structured in terms of an internal mix of commercial and industrial subcontracting relations.

Television Industry

Finally, consider product development and low cost rationalisation in making TV sets.

During the 1970s, microcircuits began to replace traditional electronic components. Numerical control machine tools were used for partial automation of assembly. Soldering, welding, fastening, indexing and component feeding equipment and computer controlled assembly of circuits and production of resistors came into existence.[11] And since assembly jobs could be easily separated from sophisticated research and engineering tasks, they could be farmed out for international subcontracting to reduce labour costs. However, in general, by early 1980s, the industrialized country-firms' need for international subcontracting fizzled out as the lower component count and substantial amount of automated assembly led to fall in production time.[12]

The way the American and European manufacturers have been forced to review their production procedures with the Japanese incursions into overseas television and stereo markets is well-known.[13] But it is worth noting how the Japanese producers developed their out-competing capacity. In the early years of colour television, the Japanese government allowed substantial reductions in high commodity taxes on all the colour sets incorporating microelectronic devices. This policy had two mutually reinforcing effects: first, it stimulated consumer demand; secondly, the competition it generated between the manufacturers to beat the opponents in "going solid state", created spirals of innovations in semiconductor devices as also in functional equipment design. The more the ICs used, the less the component count became.

This in turn opened up possibilities of automatic component insertion, which by late 1970s rose to about 80 per cent of assembling and testing operations. The number of man-hours and power consumption per set came down drastically while the reliability of the end-product soared.[14]

While these profound changes were taking place in Japan, the American producers, with their obsolete technology lagged behind. Unlike the profit-maximising colour TV makers in the US, who persisted with obsolete techniques in late 1960s and early 1970s, the Japanese have been value-added maximising firms with more or less uniform cost curve and under constant pressure to scrap old equipment and induct fresh technology. "If one firm in the electronics industry introduces new technology, putting downward pressure on prices, as maintenance costs with existing equipment rise,firms throughout the industry are under pressure to replace existing technology with new. *The action-response time-frame is virtually immediate.* And, since the Japanese electronics industry has been expanding rapidly, firms in the industry, assuming they are producing near capacity, are under constant pressure to improve their production technology in order to gain or retain market share."[15]

The new technological trend over the 1980s has been to use in TV sets, ICs called microprocessors and microcomputers in order to produce computerised television.[16] The microcomputer chips are known for their low cost, low component count effects apart from the "ease with which instructions (and thus the functions the devices will perform) can be changed by the IC manufacturer to cater for different applications."[17] Components like resistors (various types), capacitors (various types) and coils (or inductances) "are dying out in television application. Soon only the deflection coils will remain."[18] Even the picture tubes are replaced by front panel displays (circuitry complex) leading to lower cost, higher reliability, miniaturisation and lower power consumption of television sets.[19]

In this milieu, modularisation is a new trend in product designing, especially in electronics, facilitated by the introduction of microelectronic components. The wide ranging product differentiation has been accompanied by a standardization of the major modules (subassembled parts) of the product. These modules could be made under different roofs and composed into the end-product later on. For example, in television sets, the earlier method of long line, linear assembly whereby the chassis or framework of the TV set would be put on the line and then individual parts are mounted, has become outmoded. Modularisation has made the final assembly a much shorter process. Decentralisation through subcontracting of modular production and automation of final assembly have smashed worker militancy in industrial countries.[20]

However, with the micro-miniaturization of components and circuits and the progressive reduction in the size of the end-product, the number of modules as well as the number of parts within each module would further diminish to such an extent as to make centralization of automated modular and final assembly under one central computer control a better option. This has been witnessed in recent times.

Because of microminiaturisation, the Japanese could recently create a new market for small screen television sets in Europe; they could get round the barrier imposed by the "Telefunken patent on the British and German TV system (PAL), which prevented the import of foreign color TVs above 20 inches."[21] In 1983, Matsushita Electric Industrial Co. put into market what was then considered the smallest colour TV.[22] This year Casio Computer Co. is set to start marketing what it claims is the world's smallest and lightweight colour TV.[23] In 1984, pocket-sized black and white TVs were introduced in Japanese and western markets; the Japanese brought out monochrome liquid crystal TVs and the British Sinclair brought out TVs based on flat screen picture tube.[24] Another new development was the onset of Japanese "digital TVs", "Component TVs" or "high-definition TVs" with a lot of peripherals attached to them.[25] The automated, cheap mass production of these sets "will achieve for television what the transistor radio did for wireless: a one-per-person product."

Section III

Hence, what follows is that the new technological trends have transformed the economics of production. The direct labour component is made minimal or eliminated with the use of automated production techniques. Large numbers of components have been concentrated on a single microchip. The low component count achieved and the prospect of further integration of components on single super-chips has made or makes the components (discrete or integrated passive and active components and electro-mechanical components) procured from other firms (whether on subcontract or not) irrelevant. And since subassemblies and final assembly could be automated in such a way as to outcompete labour-intensive subassembly and final assembly, subcontracting of even these becomes irrelevant. The tendency is towards integrated and automated manufacture, as available evidence with respect to certain products, as portrayed above, indicates.

NOTES AND REFERENCES

1. This point is owed to John Kelley, 'Useful Work and Useless Toil', *Marxism Today*, August 1982, p. 14.
2. "Motors would burn out after a few years and by setting replacement costs for parts at or above the retail price for the whole product, consumers had no incentive other than to fill up their dustbin and replace appliances every few years." *ibid.*
3. See *The Hindu*, 'Slim, Short, Small', Special Feature: The Changing Atmosphere in Indo-Japanese Relations, May 3, 1984, p. 27; Sir Ieuan Maddock, 'Microprocessors, Luddites and Their Economic Consequences', *The World Economy*, Vol. 3, No.3, November 1980, pp. 304-305.
4. A. Sivanandan, 'Imperialism and Disorganic Development in the Silicon Age', *Race & Class*, 21, 2, p. 118.
5. *The Hindu* (1984), *op.cit.*
6. See Moira Johnston, 'High Tech, High Risk and High Life in Silicon Valley', *National Geographic*, October 1982; Juan Rada, *The Impact of Microelectronics* A Tentative Ap-

praisal of Information Technology, ILO, Geneva, 1980, p. 41.

7. We draw from Badiul Alam Majumdar, 'Innovations and International Trade: An Industry Study of Dynamic Competitive Advantage', *Kyklos*, Vol. 32, 1979, pp. 563-64.
8. *The Hindu* (1984), *op.cit.*
9. This point is made by Gareth Locksley, 'Information Technology and Capitalist Development', *Capital & Class*, No. 27, Winter 1986, p. 101; also see *Financial Times*, 'Fixing Electronic Components on to Printed Circuit Boards', February 17, 1983.
10. We draw from Juan Rada, *op.cit.* p. 40; *Business Week*, 'Texas Instruments', May 31, 1976, pp. 62-63; *Business Week*, 'How Innovation Shook Up an Industry', February 16, 1976, p. 60; *Business Week*, 'Seiko's Smash: The Quartz Watch Overwhelms the Industry', June 1978, pp. 86, 88-90.
11. Jeremy Brecher, 'Roots of Power: Employers and Workers in the Electrical Products Industry', in Andrew Zimbalist (ed.) *Case Studies in the Labour Process*, Monthly Review Press, New York, 1979, pp.211-12.
12. Robert Ballance and Stuart Sinclair, *Collapse & Survival: Industrial Strategies in a Changing World* (World Industry Studies: 1), George Allen & Unwin, London, 1983, p. 132; according to these writers, average-sized TV sets in the 1980s required one-third the number of components used in 1970 while over 70 per cent of chassis assembly was automated and production time had reduced to one-tenth of the former level.
13. See Annavajhula J.C. Bose, 'International Subcontracting in Automotive and Electronic Industries—Retrospect & Prospect', *The Indian Economic Journal*, Vol. 38, No. 2, October-December 1990.
14. See the excellent account by Gene Gregory, 'The Japanese Propensity for Innovation: Electronics', *Institute of Comparative Culture Business Bulletin*, No. 86, Sophia University, Tokyo 1982, p. 19; Raphael Kaplinsky, 'The International Context for Industrialization in the Coming Decade', *The Journal of Development Studies*, vol.21, No. 1, October 1984, p. 81; S.A. Sapre, *Productivity in Japan: Lessons for India*, Forum of Free Enterprise, Bombay, September 13, 1982, p. 3; according to Gregory, the man-hours per TV set fell to 1.15 hours by 1978 and according to Sapre, power consumption per 20-inch set fell from 325 watts in 1972 to 95 watts by late 1970s; a more recent source points out that the labour input in the production of colour TV sets has fallen so significantly that the unit construction time has reduced to one hour. See *Business Week*, 'Philip's High-Tech Crusade', July 18, 1983, pp. 96-103.
15. These points are made by Gene Gregory, *op.cit.* p. 26 (emphasis supplied).
16. See *Television*, Vol. 30, No. 4, Issue 352, February 1980 p. 194; it is mentioned here that microprocessor and microcomputer ICs enable a great deal of digital signal processing to be carried out in a single chip, and that the difference between the two types of IC relates to the internal memory arrangements. A microcomputer chip is considered more flexible than a microprocessor because the former has a RAM (random-access memory which holds and releases data as instructed) in addition to ROM (read-only memory which provides outputs as required but data cannot be fed and retrieved later).
17. *ibid.* p. 194.
18. *Television*, 'Components for TV', Vol. 30, No. 5, Issue 353, March 1980.
19. A. Razzaque, 'Present and Future Technological Trends in TV', *Electronics Today*, Vol. 13, No. 2, February 1980, pp. 53-54.
20. See Fergus Murray, 'The Decentralisation of Production—The Decline of the Mass-collective Worker?', *Capital & Class*, No. 19, Spring 1983, p. 78; here he points out that modularisation would be used elsewhere too, for example, in motor industry by the Italian Fiat.
21. Bill Johnston, 'The House of the Future, Peppered with Electronics', Special Report, Japanese Technology, *The Times*, June 14, 1983.
22. *The Japan Economic Journal*, 'World's Smallest Color TV is Made', June 7, 1983, p. 14; this is a hand-held TV 1.5 inch screen/weight 600 grams/measures 38 mm x 110 mm (W) x 180 mm (D).

23. *The Hindustan Times*, Economy & Business, July 6, 1992, p. 13; this set weighs only 170 grams and is 2.4 cms thick, 9.1 cms high and 6.0 cms wide.
24. See *The Hindu*, 'Clearer Liquid Crystal TV', March 21, 1984; this monochrome set 'features a mirror on which images are reflected through liquid crystals. The pocket size TV gives brighter view as it becomes clearer, by the use of existing light.' Also see *The Hindu*, 'New Flat-screen Pocket TV', April 1, 1984; this set has a flat screen picture tube which is very small compared to the funnel-shaped glass tubes that form the bulk of the conventional TV sets. The heart of it is a special chip which forms the bulk of the pocket sized set. It manoeuvres the electrons to hit the screen without any distortions; and it has eliminated most of the individual components of a conventional set. It gives three times the screen brightness of a conventional set but with only one-tenth of the power consumption. It is the world's first TV set which can adapt itself to nearly all the technical standards governing the world's transmission programmes broadcast.
25. *The Japan Economic Journal*, 'Sony Develops Digital TV Featuring Clearer Picture', January 31, 1984, p. 10; this set which displays a very high quality picture, has 'circuitry that digitally processes colour TV broadcast signals throughout the entire video circuitry... The use of digital circuitry promises to reduce the number of required components, decrease the adjustment steps during production, and contribute to overall reduction of costs.'; Bill Johnston, *op. cit.; IEEE Spectrum*, 'Applications Consumer Electronics: Component TV", Vol. 20, No. 6, June 1983, pp. 38-43; the peripherals attached to a TV set could be video-cassette recorder, video-game unit, video-camera, video-disc player, cable TV-tuner, personal computer, high-fidelity stereo system etc. Also see *Newsweek*, 'The Video Revolution', August 6, 1984, pp. 36-42.