The Effects of ICT on the Manufacturing Transnational Corporation

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This paper is concerned with the development of information and communication technology (ICT) since the 1970s and its effect on the manufacturing transnational corporation (MTNC) in four key areas: management control, design, manufacturing process, and the office. Management control is examined in two areas: the coordination and monitoring of functions. ICT assists in both the improvement of policy decisions and in added flexibility and negotiating power. The design area relates the usage of CAD/CAM to the collaboration on design work. The manufacturing process reviews the introduction of Numerical Control (NC) machines, robotics, flexible manufacturing systems (FMS), and Computer-Integrated Manufacturing (CIM) thereby leading to the unmanned factory using an FMS linked with the electronic office and other information systems. The effects of ICT on the office environment, considered the area most affected, include personnel losses and the introduction of the knowledge worker. The conclusion is that the primary effects of electronic-based technology in the factory and office are associated with rationalization and efficiency rather than expansion.

The modern manufacturing industry is being dramatically changed by developments in microelectronics providing, inexpensive, reliable, and sophisticated control systems. This, together with developments in communications, means that highly complex automated factories can be built at a cost-effective price. The convergence of information and communications technology (ICT) has enabled the unmanned factory and office of the future to become a reality. This paper traces the development of ICT since the 1970s and its effect on the manufacturing transnational corporation (MTNC) in four key areas: management control, design, manufacturing process, and the office. The paper also highlights how information is becoming more important to the corporation in order to maintain its competitive edge.

The early years of the 1970s saw the slow decline of all major economies. Manufacturing industries started to produce a surplus in major industries such as steel and shipbuilding, leading to a worldwide depression and increased competition (Kaplinsky, 1984, p. 3). Some companies went out of business, some reduced investment and labour, others expanded into global markets through takeovers, mergers, or joint agreements, developing into MTNCs operating over many countries and dealing with the manufacture of numerous products. Through the use of ICTs, the coordination of these integrated global operations could be performed from a central headquarters potentially thousands of miles away.

Although there was a diffusion of computer technology throughout manufacturing during the 1970s, major changes in government policies over the communications industry in the 1980s led to an explosion of information and computer technology innovations and greater use of this technology in the manufacturing sector. Deregulation of AT&T in the United States in 1982 resulted in large-scale privatisation of the telecommunications industry throughout the western world, which led to increased competition and internationalisation of the industry. Computer companies moved into communications and vice-versa, accelerating the convergence that led to ICT. The increased competition resulted in lower equipment costs. Major developments included integrated digital services network (ISDN), business satellites, digital exchanges, fibre optics, satellite dishes, transputers, thirty-two bit personal computers, and more sophisticated applica-

tions such as spreadsheet, database, and word processing packages. The development of local and wide area networks and ISDN dramatically enhanced both local and global communications.

The first area affected by the use of ICT is management control–covering the coordination and monitoring of functions within the MTNC. ICT assists management primarily in two ways. The first is the manner in which management obtains current information to improve policy and decision making. Global information about markets, competitors, suppliers, potential customers, and exchange rates is required. MTNC financial transactions have to be dealt with immediately, credit authorisation and stock inventory needs to be available on line, and information regarding sales or purchases is required for corporate functions. Within the global marketplace, up-to-date information is important, and with this commodity companies can make improved policy decisions. For example, Austin Rover introduced decision support systems in 1993 to aid management, resulting in savings of millions of pounds over the last two years (Lynch, 1995, p. 2). Nonconfidential information is also shared with employees, clients, suppliers, and even customers to forge closer links (Evans, 1995, p. 44-46).

The second way in which ICT assists management is in providing added flexibility and negotiating power. A new manufacturing plant can be set up anywhere in the world where there is a communication infrastructure and sufficient energy resources. This has also resulted in strengthening management's position in union negotiations with the possibility of plant relocation. A similar argument could be made in relation to negotiations with suppliers. If the supplier does not supply the correct quantity and quality of raw materials or components at the right price in the agreed time, manufacturers can choose an alternative global source. With communication links to suppliers, bulk ordering through a central purchasing function, and the use of just in time ordering (JIT) (Moore & Steele, 1990, p. 91), companies, such as Austin Rover, are claiming considerable savings in the capital investment of stock, storage requirements, and warehouse labour (Lynch, 1995, p. 2). Through the use of ICT and transborder dataflow, management has greater flexibility for decision making and improved control over resources.

Another important area affected by the use of ICT is design. The requirement for product design is a result of the enterprise either identifying a niche in the market or as a response to a customer request. The design may be of a complex nature and would be required to go through a time- consuming and expensive multi-stage process of agreement before final acceptance. In some instances, this can lead to lost orders. The advent of the microprocessor, mini- and microcomputers, and more sophisticated software in the early 1970s brought about computer aided design and manufacture (CAD/CAM), which gave greater flexibility to designers and, most importantly, substantially reduced the time spent on the design of a product and the agreement process. Design work could be based on components, raw material, supply criteria, and the costs thereby allowing structural analysis and mechanical simulation to be performed (Simpson, 1987, p. 45). The final design could then be used by CAM to produce instructions for the manufacturing process and management control sphere in such areas as management systems, production schedules, reordering of parts, and process planning. The use of CAD/CAM has led to major increases in productivity, faster response to the market, and reduced lead times and costs. Designers today can work closely with suppliers and experts on a global basis - such as Lucas Industries or Austin Rover - through the use of desktop video conferencing (Casement, 1995, p. 33) or by electronic transmittal of design work, leading to further reduction in lead times and costs. The designer of the 1990s has clearly become more of a technocrat and, through the use of ICT, design work is performed on an international stage.

We now turn to the manufacturing process which encompasses the area of production in which raw materials are stored and then processed into the final product for shipment to the distributor or customer. Relevant topics are numerical control (NC) machines, robotics, flexible manufacturing systems (FMS), and computer integrated manufacturing (CIM).

NC machines from the early 1950s limited one person to one machine to perform one operation such as milling or grinding. The early 1970s saw these machines being programmed and linked to mini- or microcomputers for the first time to perform different tasks (Kaplinsky, 1984, p. 57). This development was

closely followed by the linking of several machines to one computer, thus allowing companies to drastically reduce labour and the number of machines used. The introduction of automation replaced people for controlling the pacing of production, and left the remaining NC workers with no control or decisions thereby reducing them solely to a monitoring role.

Another type of machine introduced in the 1970s was the robot. In the automobile industry, robots were programmed to undertake dirty and repetitive work such as welding, paint spraying, loading, and stacking. The benefits of robotics included consistency, the ability to work in hazardous areas, and cost savings in terms of heating, lighting, and labour. Extended developments in robotics allowed second generation "smart" robots with vision systems to perform an increasing number of applications with a reprogrammable memory and sensing devices allowing changes to functionality and to react in an intelligent way to determine optimal solutions for such duties as fitting windscreens or moving sub assemblies around the shop floor (Forester, 1989, p. 173). It is estimated that each robot replaces between five and ten workers (Harman & Peterson, 1990, p. 233), which allows more flexibility in the manufacturing process–e.g., a robotcan work continually until an order has been filled.

The fusion of NC, CAD/CAM, and robotics has permitted the flexible manufacturing system (FMS) to evolve. Through the use of computer communications, a set of machines can integrate all stages of the production process. This has enabled small batches of components to be produced economically and, by varying the product specification, can quickly replace several conventional production lines. This in turn has led to savings in labour and plant space, decreases in work in progress and stock inventory, greater machine utility, and reduced lead times. Most importantly, it has allowed the manufacturer to move away from a mass production base and react quickly to market trends with economics tailored to markets, giving economies of scope as opposed to economies of scale (Dodgson, 1989, p. 128). The threat of the FMS producing mass unemployment has only been avoided because of the expense and complexity of the systems (there were only 120 systems worldwide in 1985). One such system in operation is the Yamazaki plant near Nagoya, Japan. At a cost of $20 million and currently employing only twelve workers during the day and one watchman at night, machines dictate the pacing of the engineering/manufacturing process. In a conventional factory, the manufacturing process would require 200 employees and nearly four times the amount of machinery and take thirty times as long to produce the same number of parts (Rowe, 1990, p. 58). Workers are only required to switch the machines on and off - assuming that the twenty-four hour shift has not arrived.

The convergence of the unmanned factory using an FMS linked with the electronic office and other information systems has resulted in computer integrated manufacturing (CIM), which provides manufacturers with the facilities for monitoring, testing, and material handling, combined with management planning, production planning, and control functions. One such user is the Pirelli factory at Aberdare which manufactures electrical wiring. The £20 million investment allows production of small batches of products. The system switches from one product to another to meet customer orders (Rowe, 1990, p. 66). Within this manufacturing environment, a minimum of multiskilled personnel are required. For example, sales personnel deal with production applications and vice versa, creating a blurring of manufacturing and office work.

Another important area within the manufacturing enterprise affected by ICTs is the office. The office, similar to the manufacturing process, has always been viewed as labour intensive (Dordick & Wang, 1993). Manufacturers, attempting to raise office productivity and reduce costs, have seen the electronic office as a means to meeting these goals. Key developments in the 1970s, such as inexpensive computer storage, local area networks, personal computers, and task-oriented software packages, have enhanced productivity, thus reducing office staffing levels in data entry and typing.

The early 1980s saw developments of ICT affecting all segments of the office. Employment levels of the information worker and the employment levels of middle and junior office management were affected (Mirabito & Morgenstern, 1990, p. 147). Local and wide area networks and ISDN dramatically enhanced electronic communications. With more sophisticated applications, such as electronic data interchange (EDI),

an order placed anywhere in the world could be initiated to the manufacturing process with a minimum of manual intervention. The use of electronic mail resulted in all levels of staff communicating over networks as opposed to using paper. Computers were talking to each other replacing both people and paper. The electronic office had finally arrived and with it the knowledge worker to deal with the retrieval and dissemination of local and global data.

In conclusion, we have seen that technology has had an enabling effect on the manufacturing enterprise, widening the choices open to management. It has allowed greater flexibility in management control, design, and the manufacturing process, leading to reduced design and lead times, better control over resources, and greater productivity. Most importantly, it has allowed the manufacturer to move away from a mass production base and react quickly to market trends with economics tailored to markets, providing economies of scope as opposed to economies of scale. The use of electronic transmission of local and global information within the management control area has contributed to improved decision and policy making. Within the office environment, it has contributed to the displacement of labour. The displacement of the workforce in the manufacturing process area has not been so badly affected due primarily to the high costs of robotics, FMS, and CIM and reduced investments during the 1970s and 1980s. However, automation technologies have taken away control from the shop floor, reduced the skill level of the machine operator, and introduced machine pacing to the production process. Clearly, the primary introduction of electronic-based technology in the office and factory is associated with rationalization and efficiency rather than expansion.

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