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1. GLOBAL COMPETITIVENESS

1.1. The Emergence of The Information Age

American futurist Alvin Toffler has described three periods of economic evolution: the agricultural age, which lasted from 8000 BC to the mid eighteenth century; the industrial age, which lasted until the late twentieth century; and finally, the information age that began in the 1960s and will last for many decades to come (Toffler 1980). These dates are of course approximate and overlapping. The agricultural age was driven by physical labour and the key sources of wealth were land and natural sources. The critical factor of economic success was land: those who could dominate and possess land were guaranteed controlling role in creating wealth.

The industrial age was driven by machines and blue-collar workers. During this period, a dramatic shift took place: from land to capital as the primary factor in generating wealth. The addition of more capital to the process of creating material wealth led to considerable increases in the effectiveness and efficiency of technological and commercial activity. Consequently, in this age, wealth passed from those who controlled the land to those who controlled access to capital. The rich were no longer the landowners; they were the owners of capital. The ability to finance industrial endeavors became the scarcest commodity of production.

The information age (treated here as synonymous with 'information economy') is driven by information technology and knowledge workers, in concert with change in the nature of work 6 and workers. It is also characterized by the emergence of information or post-industrial society (Bell 1973), which is dominated by knowledge workers-those working with information rather than producing goods. After World War II, capital started loosing its scarcity because of enormous accumulation. Technology also began to change-telecommunications, television, computers, commercial air travel, and so on-making capital far more fungible and resilient, easier to move around and, therefore, less scarce. With capital easily available, the critical production factor shifted to people. But it did not shift to simple labour. Instead, knowledge displaced capital as the scarce production factor and information became a strategic resource. Those who had knowledge and knew how to apply it would henceforth be the wealthiest members of the society. Information thus became the source for knowledge as well as the medium to apply knowledge (Toffler 1990).

Business in the industrial and information age had different characteristics in various areas as shown in Table 1.1

Area	Industrial Age Business	Information Age Business
Economic	Assembly line production	Customization of products
	Stable markets and suppliers	Fluid markets and suppliers
	Domestic competition	International competition
Organizational	Inside out (Bottom-up)	Outside in (Top-down)
	Complex business processes	Reusable, simple processes
	Intra-organizational communication	Inter-organizational communication
	Domestic reach\ ambition	Global reach and ambitions
Technical	Mechanical technology	Electronic technology

Area	Industrial Age Business	Information Age Business
	Proprietary standards	Open, inter-operable standards
	Predictable innovation	Rapid unpredictable innovation
Socio-cultural	Authoritarian, hierarchical	Horizontal, team consensus
	Business task focus	Business process focus
	Individual responsibility	Team responsibility

In the industrial age, wealth was created by manufacturing and the process of making things was changed by technology. Industrial organizations grew around manufacturing operations and had owners, managers and workers. Information was needed on what to make, how much to make, how to make it and the financial status of the company. Information technology used was 'word of mouth' and 'pen-on-paper'. The industrial organization evolved through most of the twentieth century, building on the process work of Frederick Taylor and Henry Ford, and the organizational work of Alfred Sloan. The industrial age organization reached its pinnacle from the 1960s through the early 1980s. Then new information technology emerged-computer-enabled organizations that could store and process vast amounts of data with computers, companies were able to speed up the execution of their processes. Information became an additional source of power. However, the processes and their attendant procedures did not change significantly till the late 1980s, when the environment started undergoing massive change-changing industry 7 structures, new strategic alliances, new technologies and modes altered the way the business was done. As a result, companies felt the pressures of heightened competition and the business impact of changing technologies. At the same time, the nature of both work and the workforce also started changing. This was the dawn of the information age.

1.2. Competing in the Information Age

Organizations are at present in the midst of a revolutionary transformation: that of competition shifting from the industrial age to the information age. During the industrial age, the success of a company was measured by how well it could capture the benefits from economies of scale and scope. Technology was important, but ultimately success accrued to companies that could embed the new technology into physical assets that ensured efficient mass production of standard products. The emergence of the information era in the last decades of the twentieth century made many of the fundamental assumptions of industrial age competition obsolete. Consequently, companies could no longer gain sustainable competitive advantage by merely deploying new technology into physical assets rapidly. The information age environment requires new capabilities in organizations for competitive success. The ability of a company to mobilize and exploit its intangible assets has become far more decisive than investing and managing physical and tangible assets. Intangible assets enable an organization to develop customer relationships and loyalty, introduce innovative products and services, produce customized high-quality products and services at low-cost and with short lead times, mobilize employee skills and motivation for continuous process improvements, and deploy information technology effectively.

1.3. Business Challenges

Information age competition has initiated some unique challenges that businesses have to cope up with (Luftman 1996). These are described below.

Managing Uncertainty: Uncertainty in the business environment has become a way of life. Consequently, companies are finding it even more difficult to predict changes. Customers are becoming competitors, competitors are becoming partners and unconventional competition is emerging. Businesses, however, must go on despite dramatically new environments that are at present not well understood.

Understanding Customers: It is increasingly becoming important to understand customers' needs and wants, and to translate these into a unique value-added business mission. Companies capturing and applying information at each point of customer contact will, therefore, be better off than those that do not. Thus, companies have to be able to apply and integrate information technology into the entire product process (including research, design, manufacturing, distribution, marketing, and after sales service).

Understanding Globalization of Business: Globalization is defined as a process that cuts across national boundaries, integrating and connecting communities in new space-time combinations (Hall et al. 1992). As information technology (IT) breaks down the barriers of time and location, distinctions are also breaking down between large and small companies. Small, agile Finns are now effectively competing with industry giants because IT can make a consortium of small firms look, feel and get big, reaching out for customers once beyond their grasp. This has given rise to 8 intense competitions, blurring the boundaries between domestic and global markets.

1.4. Operating Environment

In order to compete in the information age, contemporary organizations are being structured on the basis of a new set of operating assumptions, as given below (Kaplan and Norton 1996).

Business Process Orientation: Industrial age organizations gained competitive advantage through specialization in functional skills in areas like manufacturing, purchasing, distribution, marketing, etc. This specialization provided several benefits but over time, it led to enormous inefficiencies, hand-offs between departments and slow response processes. Information age organizations against this operate with integrated business processes that cut across traditional business functions (Hammer and Champy 1993). They combine the specialization benefits from functional expertise with the speed, efficiency and quality of integrated business processes.

Links to Customers and Suppliers: Industrial age organizations worked with customers and suppliers through an arm's-length transaction. Information technology enables today's organizations to integrate supply, production and delivery processes so that operations are triggered by customer orders and not by production plans alone. An integrated system, from customer orders upstream to raw material suppliers, enables all business units of the organization along the value chain to realize enormous improvements in cost, quality and response time.

Customer Segmentation: Industrial age organizations prospered by offering low-cost but standardized products and services. However, information age customers want more individualized solutions to their wants and needs. Therefore, information age organizations must learn to offer customized products and services to their diverse customer segments, without paying the usual cost penalty for high-variety low-volume operations.

Global Scale: Information age organizations are able to compete against the best in the world as domestic borders are no longer a barrier to competition. They must combine the efficiencies and competitive honing of global operations with marketing sensitivity to local customers.

Managing Innovation: In the information age, product life cycles continue to shrink. Competitive advantage in one generation of a product's life is no guarantee of product leadership in the next technological platform (Bower and Christensen 1995). Consequently, companies in industries with rapid technological innovation (such as IT industry) must be capable of anticipating customers' future needs, designing radically new products and services, and rapidly deploying new product technologies into efficient operating processes.

Knowledge Workers: Industrial age organizations created sharp distinctions between two groups of their workers. First, the white-collar managers and engineers, who used their analytical skills to design products and processes, select and manage customers, and supervise day-to-day operations. The second group, the blue-collar workers, consisted of people who actually produced the products and delivered the services. This direct workforce was a principal factor of production for industrial age organizations, but it used only their physical and not mental capabilities. In the information age organizations, the percentage of blue-collar workers has 9 reduced considerably with a corresponding increase in the number of white-collar workers due to high competitive demands. Even the contemporary blue-collar workers are involved more in giving suggestions on how to improve quality, reduce costs and decrease cycle times. Thus all employees are required to contribute value by what they know and by the information they can provide. They are thus becoming knowledge-workers. Consequently, investing in, managing and exploiting the knowledge of every employee has become critical to the success of information age organizations.

1.5. Globalization and International Business

Since World War II, a number of factors have changed the manner of competition in the global business community. The particular catalyst for globalization may vary among different industries, but among the various causative factors are increased similarities in available infrastructure, distribution channels and marketing approaches among countries, as well as a global capital market that allows large flows of funds between countries (Porter 1986). Additional causes include falling political and tariff barriers, a growing number of regional economic pacts that facilitate trade relations and the increasing impact of the technological revolution in restructuring and integrating industries. Manufacturing issues associated with flexibility, labour cost differentials and other factors also play an important role in these market trends. Widespread globalization is also evident in a number of industries, such as software, telecommunications and services. Consequently, economic activity today is becoming not merely internationalized but, more significantly, it is becoming increasingly globalized. 'Internationalization' refers simply to the increasing geographical spread of economic activities across national boundaries, which as such is not a new phenomenon. Globalization of economic activity is qualitatively different. It is a more advanced and complex form of internationa1isation that implies a degree of functional integration between internationally dispersed economic activities. Though globa1isation is a more recent phenomenon, it has already emerged as the norm in a growing range of economic activity. Almost every sector of business is influenced by global forces due to globa1isation (Porter 1986). Globalization is characterized by:

- ✓ Tightly linked global financial market;

- ✓ Global sourcing of inputs, marketing and distribution of production, and manufacturing of products and fina1 products;
- ✓ Increased pressure for improved product quality and reduced product price; and
- ✓ Evolution of business toward more comprehensive and continuous global coordination and integration.
- ✓ To compete successfully in this dynamically changing environment, firms need to be able to address effectively several key strategic issues

Cost-Quality Improvement through Coordinated Manufacturing: Global competitive pressures push strongly to reducing product delivered cost and at the same time to improve significantly the quality of the product and all aspects of customer service. A common strategy used by firms .for achieving this goal is to significantly tighten all aspects of the manufacturing process, which includes coordination strategy, such as 'just-in time' (HI) and overall quality- improvement programmers (Imai 1986; Suzaki 1987). 10

Cost-Quality Improvement through Concurrent Engineering:0 Another key element is better design of the product for manufacturability. To do this, integrated design teams are formed, pulling together product design, engineering and manufacturing. The objective is to design a product for manufacturability as well as for other objectives. In some cases, packing and distribution, marketing and R&D functions are also brought into the concurrent engineering process (Dean and Sussman 1989).

The Order Cycle: In many industry sectors, such as automobiles, the product is built to customer order and customer specific. The 'order cycle' begins when the customer places an order and ends with the delivery of the completed product. In these sectors, therefore, a very key competitive issue is to significantly shorten the time the cycle takes, to be able to deliver the product to the customer as soon as possible after the order is placed (Stalk and Hout 1990).

After-Sales Customer Support: In many cases, customer support after the sale is a critical issue. Customers are demanding a high level of service for maintenance, including spare parts availability and technical skills in service staff. Add-on products and services, such as training, documentation and product upgrades, are also required. A high level of customer support capability is required, but it can also be profitable.

The Design Cycle: In many industries, product life is becoming shorter and shorter. Intense competition results in even shorter product lives. The time it takes to conceive of a new product, design it, put it into manufacturing, and deliver it to the market with a full support network in place-the design cycle-is becoming shorter and shorter. A shorter design cycle also means a newer technology put on the market. Thus, a company that takes six years to design a new car model today must be using 1993 technology, while a company with a three-year design cycle may be competing with 1996 technology.

Globally Coordinated Flexible Manufacturing: Global sourcing of component and sub- assemblies, global distribution into multiple markets and an efficient use of a network of global manufacturing and assembly parts is leading to globally coordinated manufacturing. In this new style of 'flexible manufacturing', the objective is to coordinate production planning and scheduling among multiple

plants in many countries and across product lines, to respond to changing market and production conditions.

Globally Coordinated R&D: Global coordination of research and development" is driven by the need for product development for global markets and by the recognition that unique research competency exists in many different countries and cultures. When a company strives to tap these competencies, it also wants to take a cost effective approach so that undesired duplication and overlap is minimized. Managing R&D in a global situation is especially critical. For example, in the pharmaceutical industry, clinical trials and regulatory approval applications must be undertaken in many countries relatively simultaneously. Consequent to the above characteristics of globalization-global markets and competition the uncertainty and complexity of the environments in which firms must conduct business is increasing with time. Uncertainty and complexity, in turn, bring about the need for an organizational capacity to handle greater and faster communication and information processing. Succeeding in this information-intensive world will, therefore, require a new organizational form and information technology capabilities that operate on a global scale.

1.6. India's Position

According to a report) of the World Bank on global economy, developing countries over the next 10 years will grow by nearly 5 per cent a year compared to a rate of 2.7 per cent in the rich industrial world and by 2020, India should be the fourth largest economy in the world. Unfortunately, India currently ranks number 45 in global competitiveness among 49 countries, according to the 1996 Global Competitiveness Report of the World Economic Forum. From 35th position in 1994 to 39th in 1995, and now to 45th, India's decline in competitiveness is shocking. For a country, such as India, which needs high growth levels to generate enough resources to alleviate poverty levels, this is a dangerous prognosis. It is, therefore, critically important that immediate steps be taken to reverse this trend. Whereas there are many factors contributing to India's poor global competitiveness according to the above report, such as openness, government, finance, infrastructure, technology, the main concern here is the management factor where India has slipped from 39th rank to 43rd.

Manufacturing is the process of adding value to raw materials and resources and is at the heart of an economy. The last decade has witnessed fierce competition in international markets led by Japan and the newly industrialized countries. New management paradigms, emerging mainly from the industrial management practices of Japanese companies, have changed the manufacturing perspective, technologies and past practices. Besides, due to sustained recession in industrialized countries, multinational companies (MNCs) have been increasingly seeking export of manufactured goods and capital in new markets. Unfortunately, in order to compete against these World-Class manufacturers, cheap labour (as in India) is seldom a major competitive advantage. Experience, market share and technology innovations are greater determinants of cost leadership than the cheap labour (Chandra and Shukla 1994). Superior product quality, design innovations, robust delivery performance, customization and excellent after sales service are the distinctive manufacturing characteristics needed to gain competitive advantage. The ability to deliver these capabilities rests on the management's perspective competition and the manufacturing practices of a company. Historically, Indian industries developed management practices that suited the restrictive industrial policies of the past. Until the early 1980s, the demand for most manufactured goods exceeded supply. Consequently, Indian manufacturers preferred to exploit the limited, but adequate, domestic market. Since the restrictive policy regime suited and reinforced their inward

orientation, industrial management practices did not emphasize either consumer orientation or the manufacturing excellence needed in a competitive environment.

The 1980s witnessed a consumerist boom for domestic industrial products, which was accompanied by the appearance of new industrial entrants as well as changes in the global trade regime. Under these pressures, India in the mid-1980s undertook a gradual liberalization of the industrial policy. The opening up of the Indian economy posed new challenges and opportunities to Indian manufacturers. Indian industries started seeking export markets that had become attractive following the decline in the value of the Indian rupee. But an industry's competitive advantage cannot be built nor sustained solely by export market orientation. Development of the 12 domestic markets is a vital determinant of the competitive advantage of an industry (Porter 1990). The size, consumer sophistication and the growth of domestic demand shape the characteristics of an industry's products that are essential to competitive success in foreign markets. India has a large market that can provide domestic industries the scale economy that is essential for cost leadership. But the quality of domestic' demand rather than its quantity is more important in shaping the competitive advantage of domestic industries. Quality of domestic demand has never been nurtured by Indian manufacturers To successfully compete with World-Class manufacturers in the domestic as well as the global market, Indian firms will have to offer high quality product choices to domestic customers in order to create a sustainable base for national manufacturing excellence.

1.7. WCM and Competition

In the changed globalize business environment, it is no longer feasible to compete only on the basis of costs without paying attention to real customer preferences represented by other product dimensions. Consequently, many new manufacturing approaches have emerged, mostly as a reaction to the dynamically changing situation in the market place, where increased competition and market globalization have greatly affected the distribution of market share and profit margins. These new approaches to manufacturing are based on a pragmatic philosophy distilled from worldwide experience in manufacturing. The major concepts are independent of tech- nology, though they may be applied differently with technical advances. Taken independently, none of these concepts are new; in fact, they all have antecedents dating to the early twentieth century, if not before. In spite of this, they have a novelty of thinking in that they combine the best and simplest practices into an elegant whole for a given approach. Manufacturing excellence, which is the aim of these approaches, refers to an improvement in its broadest context. This excellence can be attained by a combination of several approaches to manufacturing such as the following (Hall 1987):

- ✓ Value-added manufacturing, which means do nothing that does not add value to the product or to the customer
- ✓ Continuous improvement manufacturing, which suggests that every aspect of manufacturing is dedicated to making it better in ways, great and small.
- ✓ Just-in-time (JIT)/Total quality control.

World-Class manufacturing was the term introduced for referring to the goal of achieving and/or sustaining World-Class competitiveness through manufacturing excellence, attained through best practices. In this context, different experts have expressed the goal and necessary practices for World Class manufacturing differently, but always with the implicit goal of sus- tained

competitiveness in the global, market place. For example, Schonberg, who introduced the term 'World-Class manufacturing' (1986), states that it has the goal of continual improvement in quality, cost, lead time and customer service, as also the flexibility. Gunn (1987) suggests a number of criteria for evaluating a company's World-Class manufacturer status, such as inventory turnover, quality defects and lead times. According to Gunn, a company needs inventory turnovers in raw materials and work-in-process (WIP) of some 25 to 30 per year to be a Class C World Class manufacturer, about 50 to 60 turns per year for a Class B status, and of 13 the order of 80 to 100 turns or more per year to be a Class A World Class manufacturer. As a measure of world-class quality, a Class A manufacturer should have fewer than 200 defective parts per million of any product it manufactures. As for lead times, the ratio of value-added lead time to cumulative manufacturing lead time must be greater than 0.5 for a company to be a World-Class manufacturer.

Maskell (1991) states that World-Class manufacturing is a very broad term which generally includes focus on product quality, just-in-time (JIT) production techniques, workforce management and flexibility in meeting customer requirements Kinni (1996) characterizes World-Class manufacturing by three core strategies of customer focus, quality and agility, (i.e. the ability to quickly, efficiently and effectively respond to change) and six supporting competencies-employee involvement, supply management, technology, product development, environmental responsibility and employee safety, and corporate citizenship.

The information age has affected not only the industrialized countries but also the developing countries. Consequently, the environment facing developing countries has become increasingly more turbulent, dynamic and complex. A combination of external and internal factors, including population growth, weak infrastructure, foreign indebtedness, and asymmetric world relations and increasing inequalities between individuals, groups and regions, has prevented many developing countries from achieving significant socio-economic improvements. Some developing countries such as India have, therefore, made economic management their prime agenda. They are going through a process of restructuring their economy to emphasize competition, integration with global markets and increasing level of privatization. Thus, the Indian manufacturing industry has been thrust from the protected environment of the 'license- permit-quota' raj to an uncertain environment of global competition and global markets.

Global competitors operating in global markets almost always tend to have world-class status. Therefore, to be globally competitive, Indian manufacturers necessarily need to achieve world-class performance. Oddly enough, as stated earlier, developing countries such as India, China and Brazil themselves constitute a huge market that attracts many world-class companies from other countries to sell their products. Thus, even domestic companies in these countries, who are not targeting global markets, are forced to compete with these world-class companies by virtue of their entry into the domestic market. This is facilitated by the liberalization policy of the governments of these countries, often somewhat at a pace that does not give time to domestic companies to be really ready for world-class performance. Thus, as is clear from Figure 1.2, Indian manufacturers need to acquire World-Class status, irrespective of the fact that they operate only in the domestic market or are exporters. Achieving world-class performance is a great opportunity for those who can make it, and for others a serious threat. Though to some extent, Indian manufacturers have realized this and are trying to rise to the challenge, their battle for survival and growth has just

begun. Their success will depend on their readiness to move from a protected domestic to world-class global manufacturing status quickly and confidently.

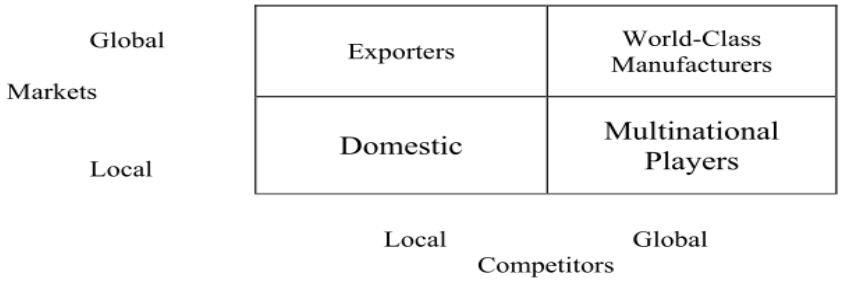

Figure 1.2: World-Class Manufacturing

1.8. Manufacturing Challenges

Time will be the primary competitive motive of business in the twenty first century. It does not mean, however, that other motives, such as cost, quality and services, can be ignored. In fact, these are prerequisites to sustain competitiveness. But the winning factor is provided by time (Stalk 1988) and enhancement to basic products. Reducing time is not critical in itself-it is the benefits achieved through time reduction, in the form of greater cash flow, less inventory, quicker customer response and ultimately, greater profits, that make time-based competition worthwhile (Hadfield 95). Moreover, time-based competition does not just refer to manufacturing but to the entire product/value supply chain, which includes product development, order processing, supplier delivery, pre-production, manufacturing, final assembly and distribution. Thus, in the manufacturing environment, time-based competition becomes the highest priority to gain responsiveness and flexibility (Figure 1.3) (Meyer 1990).

Responsiveness and flexibility have several important dimensions (Table 1.1). One is product- mix, the need to support maximum variety in end products with minimal disruption to the manufacturing operations. Others relate to upgrading of plant and equipment in order to start production quickly. The driving force behind this priority setting is the need and the wish to respond to virtually any customer request just-in-time.

Flexibility, on the contrary, is the response of a system to environmental uncertainties ('the unknown customer'). Thus, the 1990s will need an information culture to manage uncertainties, which will no longer be pushed Exporters World-Class Manufacturers Domestic Multinational Players 15 S t r a t e g i c G o a l s 1 960 1970 1980 1990 2000 Year Figure 1.3 Changing Business Goals in a Changing Environment Table 1.1 Flexible Manufacturing for Meeting Business Objectives Business Objectives Flexibility Product Innovation Product Technology Product Diversity Product Mix Customer requirement Design Market share Volume Meeting delivery dates Routing, Sequencing

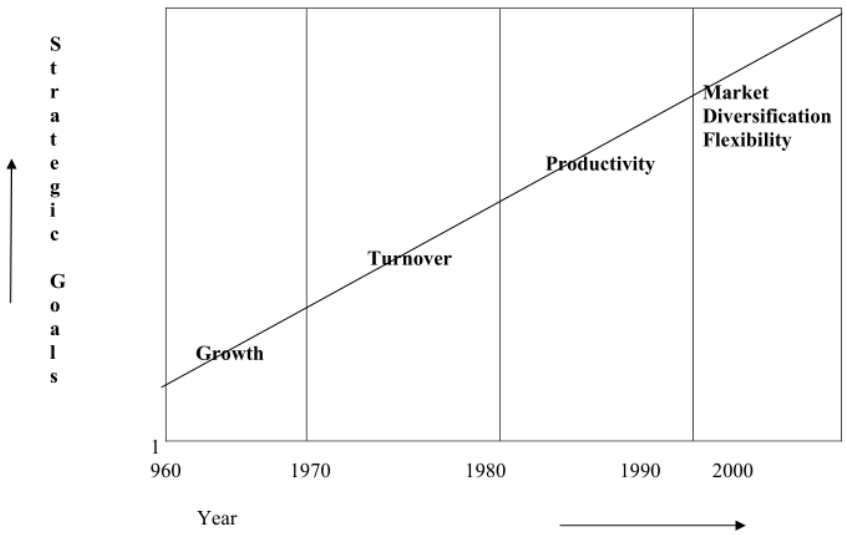

Figure 1.3 Changing Business Goals in a Changing Environment

Table 1.1 Flexible Manufacturing for Meeting Business Objectives

Business Objectives	Flexibility
Product Innovation	Product Technology
Product Diversity	Product Mix
Customer requirement	Design
Market share	Volume
Meeting delivery dates	Routing, Sequencing

Forward by technology but will be controlled by information feedback. This leads us to the second challenge industries are facing today: how to manage knowledge?

Managing Knowledge: In the twenty-first century, the productivity and, even more important, the effectiveness managers and white-collar workers will become critical to long-term survival. The effectiveness of these experts depends on their smooth integration In to the organization. Therefore, in the era of advanced specialization, integration of dispersed knowledge will become progressively more difficult and more costly to achieve. Knowledge will become scarce and the most crucial and expensive economic resource. Of late, the dependence of organizations on Growth Turnover Productivity Market Diversification Flexibility 16 experts, mainly through the increase of informal power generated by expert knowledge, has been analyzed in detail.

Managing knowledge would, therefore, be a big challenge in the twenty first century due to its strategic potential.

1.9. Problems in The Manufacturing Industry- Problem of Coordination

Once a company has defined its manufacturing strategy, it has to initiate mechanisms for managing product complexity as well those for managing demand uncertainty in the form of uncertain orders, both perhaps at the same time. The challenge of managing product complexity is to

improve productivity (goal of 'mass production' strategy) whereas the challenge of market uncertainty is to improve flexibility (goal of 'mass customization' strategy) (Meyer 1990).

Product complexity is managed by breaking down a manufacturing task into a number of subtasks and operations. Executing these subtasks and operations in parallel improves productivity. But if different subtasks are performed by different workers ('division of labour'), then the productivity improvement is restricted by coordination costs, which may otherwise exceed productivity gains. This is also true for expert knowledge, the other resource required to execute operations. Thus, a basic problem in manufacturing is the problem of coordination, which could be stated as:

- ✓ After exploding a manufacturing task into thousands of subtasks, how difficult and costly is it to ensure their proper sequencing, scheduling and interaction over a period of time?
- ✓ After dividing the task expertise among hundreds of 'incomplete expert' workers, how difficult and costly is it to maintain their coordination, motivation and performance?
- ✓ As we divide information into millions of tiny bits, hoe difficult and expensive is it to achieve integration, record and update?

That answer to the sequential is that it gets progressively more difficult and more costly. Therefore, as the complexity and cost of integration and coordination becomes too large, we tend to focus on the question of reintegration. In this context, just-in-time (JIT) efforts aim at the reintegration of physical labour (via flow lines) whereas computer-integrated manufacturing (CIM) anticipates the reintegration of special expertise organized in functional departments through integrated information process.

Need for Control: For managing task complexity, coordination is required. Likewise to manage market uncertainty, planning and control is required. Management by hierarchical planning and control copes with uncertainties by adaptation to environment and optimization of controller parameters. For instance, a production schedule should be optimized to increase system responsiveness to demand, i.e.

- ✓ To keep due dates,
- ✓ To reduce total flow-time, and
- ✓ To balance factory loads.

This is the planning problem. Against this, the control problem deals with machine-sharing policy, lot is splitting and job sequencing. That is, with (i) exploiting resources efficiently, and (ii) respecting due dates in the face of uncertainty. In general, the breakdown of long- to short- term planning decisions indicates levels in the complexity of decisions. This is managed by defining a family of decision problems and generating solutions in a sequential top-down manner.

Fragmented Information infrastructure: Today, the manufacturing industry is still striving for stability of its production system as a major organizational goal. Therefore, in most manu- facturing firms, management of change is not yet considered a permanent objective. Whether JIT or CIM, whichever way task coordination is managed, a seamlessly integrated information infrastructure is a must. However, information processing is still very fragmented even in computerized applications (Sahay et al. 1997). Therefore, in many companies, the decision-making process is still based on traditional information processing information gathering with 'paper and pencil' on request and

from inconsistent sources. This process is at its least very time consuming and may yield only insufficient or even unreliable information.

Insufficient Process ability of Available Information: In addition to having a fragmented information infrastructure, most companies are still not organized for fast decision-making processes. Departments are still managed according to their own sub-goals rather than to real enterprise goals. The responsibilities are still structured in one-dimension hierarchies, which mix responsibilities for enterprise assets with those for enterprise operations.