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An Investigation into the Implementation of Computer Integrated Manufacturing in Small and Medium Enterprises

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Small and medium enterprises (SMEs) play an increasingly important role in all aspects of competitiveness e.g. for both products and production techniques, but also management methods, the organisation of the firm and human resource training. Obtaining and, just as importantly, mastering scientific and technological information is therefore essential to competitiveness of all SMEs. During the last two decades, several factors have forced global manufacturers to make dramatic changes in their products, markets, and manufacturing strategies. One of the ways by which SMEs can achieve a competitive advantage in manufacturing is through the implementation of computer integrated manufacturing (CIM). Realising the importance of SMEs, an attempt has been made in this paper to study the implementation of CIM in SMEs. First, the characteristics of CIM have been studied with reference to the application and infrastructure of SMEs. Secondly, a framework has been presented for the implementation of CIM in SMEs with the help of a conceptual model. Finally, future research directions on CIM in SMEs are indicated.

Keywords: CIM; Framework; Implementation; SMEs

1. Introduction

Small and medium-sized enterprises (SMEs) across the world are implementing computer integrated manufacturing (CIM). They face growing international competitive pressures combined with the need to interface and integrate their computer-aided design (CAD) systems, numerically controlled (NC) machine tools, robots, and their control systems [1]. In a world in which competition is more and more unrelenting, the harnessing of technological resources has become a major strategic challenge for SMEs. The globalisation of markets, growing interpenetration of economics and increased interdependence between players, change the conditions of competition and oblige enterprises to alter the foundations of their competitiveness and economic performance. Many SMEs have to respond to these challenges and supply competitive goods and services by adapting the mix and quality of their production factors to the nature and acceleration of the change now in progress. In other words, improving their competitiveness is absolutely imperative to SMEs, as it is to large enterprises.

Cromie [2] identified lack of capital as a common problem in start-up failure of both young firms and SMEs. Kellock [3] found that 23% of the SMEs examined suffered from insufficient working capital. The associated report also indicates that up to 60% of all SMEs in the United Kingdom were financed by overdraft, suggesting a general lack of long-term investment in this sector. Thomson and Thomson [4] and Balic et al. [5] proposed that the implementation of an effective policy is an essential element in the successful management of SMEs. They define an effective policy as one that provides a common set of rules to govern the decision-making process within the organisation and is also communicated to all the organisation's employees.

Williams [6] has identified some important failure-avoiding cum success-generating elements of SMEs strategy. From the preceding analysis, he has concluded that primary success factors for the implementation of CIM in SMEs are related to their capability of creating quality products and services, controlling capital intensity and controlling debt levels. Another important capability is the ability to create and implement an effective policy. Thus, any organisational process that reduces the cash outflows for a smaller or medium enterprise is likely to have a positive impact in terms of a reduction of debt, and the consequential savings can be made into profits or into improved market competitiveness through investment into differentiating features of the business or into the charging of lower prices [7]. Further, the effective control of cash flow may reduce long-term capital requirements and alleviate the common SME problem of under-capitalisation.

The purpose of CIM is to improve the ability to manufacture and sell products through the utilisation of people, land, equipment, raw materials and facilities. CIM is a generic term for a group of manufacturing technologies which combines both scope and scale capabilities in a manufacturing environment [8]. Manufacturing strategy has become more sophisticated. As a result, CIM can play a crucial role in helping SMEs to

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compete and achieve traditionally contradictory competitive priorities. When trying to design a CIM strategy, the initial problem which management faces is the lack of reliable knowledge of CIM. It is always easy to report, read and tour successful CIM installations, but it is a rather different task when one's own organisation must be converted to this new technology. Clearly management education is vital at the appropriate level and at the appropriate time. Having done all the important learning and preparation for CIM, the next step is to form a team that can create a CIM proposal and a plan, manage the implementation, measure the results and move the company to the next phase of the CIM project.

Companies undertake projects in automation and CIM for a variety of reasons. One of the ways by which SMEs can achieve a competitive advantage in manufacturing is through the implementation of CIM. This article presents a brief background of CIM and SMEs along with past experiences of CIM in SMEs. Also, a framework for the implementation of CIM in SMEs is offered. Finally, future research directions and conclusions are presented.

2. Computer-Integrated Manufacturing

Computer-integrated manufacturing (CIM) is a multi-disciplinary subject and is a complex, multilayered system designed for the purpose of minimising waste and creating wealth in the broadest sense. According to Lefebvre et al. [9], CIM is concerned with providing computer assistance, control and high-level integrated automation at all levels in manufacturing (and other) industries, by linking islands of automation into a distributed processing system. These isolated automated production islands include NC machines, distributed numerical control (DNC), computerised numerical control (CNC), material requirement planning (MRP), manufacturing resource planning (MRP II), CAD, computer-aided process planning (CAPP), computer-aided manufacturing (CAM), automated storage, computer controlled material handling equipment, and robotics.

In CIM, the output of one activity serves as the input to the next activity, through a chain of events that starts with the sales order and culminates with shipment of the product. Customer orders are entered by the company's sales force into a computerised order-entry system. The orders contain the specifications describing the product. The specifications serve as the input to the product design department. New products are designed on a CAD system. The components that comprise the product are designed, the bill of materials is compiled, and assembly drawings are prepared. The output of the design department serves as the input to manufacturing engineering, where process planning, tool design, and similar activities are accomplished to prepare for production [10]. Many of these manufacturing engineering activities are supported by the CIM computer system: process planning is performed using CAPP, and tool design is carried out on a CAD system, making use of the product model generated during product design. The output from manufacturing engineering provides the input to production planning and control, where material requirements planning and scheduling is performed using the computer system.

CIM promises many benefits including increased machine use, reduced work-in-process inventory, increased productivity of working capital, reduced number of machine tools, reduced labour costs, reduced lead times, more consistent product quality, less floor space, and reduced set-up costs [11]. To gain such benefits, the first and most important task is to convince the top management to become dedicated to the implementation of CIM and to lead the programme as active initiators and participants at the same time.

3. Small and Medium Enterprises

A unique definition of SMEs is not possible, the concept varies from country to country and from sector to sector. However, in terms of the structural funds and leading instruments of the EU, it has always been accepted that the SME should not have a workforce exceeding 500, or net fixed assets of more than a third of the capital held by a large firm. In particular, it has been recognised for some 20 years that their dynamism, related in part to the technological and economic changes which have occurred over this period, has made an important contribution to the creation of new jobs, to the economic revival of certain regions and also to technological progress. These factors explain the interest shown by the governments of all countries in the competitiveness of their SMEs which, along with and interrelated to that of large firms, constitutes the basis of national competitiveness. The following are some of the characteristics of SMEs:

- In SMEs, shop floor tasks which are closely related to production usually involve a high degree of human decision-making and execution.
- Personal relationships in SMEs are very important.
- SMEs have a higher inherent innovatory potential than large enterprises.
- They have the ability to react quickly to keep abreast of fast changing market requirements.
- There is a lack of bureaucracy. Dynamic, entrepreneurial managers react quickly to take advantage of new opportunities and are willing to accept risk.
- There are efficient and informal internal communication networks. This affords a fast response to internal problem solving: provides the ability to reorganise rapidly to adapt to change in the external environment.
- A large number of SMEs have some sort of external linkage which is of importance to the development of their business.
- Small enterprises tend to concentrate on traditional industries where entry barriers are low, minimum production scales are low, and labour intensity relatively high.

SMEs are therefore more dependent than other companies on external sources of scientific and technological information.

These sources are numerous and diverse, e.g. universities, public laboratories, contract research companies, industrial research organisations, suppliers (especially of equipment), customers and other clients [12]. Information reaches SMEs either directly or through diverse channels, e.g. the general system of scientific and technological information (libraries, media), fairs and exhibitions, consultancy firms, and personal business contacts.

In the last two decades, several factors have forced global manufacturers to make dramatic changes in their products, markets, and manufacturing strategies. The market place of the twenty-first century is evolving into one of merging national markets, fragmented consumer markets, and rapidly changing product technologies. To stay in the market place, it is necessary for SMEs to adopt automation in general and implement CIM in particular for various reasons. For instance, automated operations not only produce parts at faster rates than do their manual counterparts, but they also produce parts with greater consistency and conformity to quality specifications. Automation also allows manufacturers to reduce the time between customer order and product delivery, this gives the manufacturer a competitive advantage in promoting good customer service. The past experience of SMEs in adopting CIM systems and other automated manufacturing systems is described in the next section.

4. Experiences of SMEs with Automation

From the mid 1970s onwards many European governments increasingly supported SMEs. This support was based on a growing belief in the inherently superior innovatory potential of SMEs, on their employment creating potential, and on their potential as an endogenous vehicle for regional economic renewal. By the early 1980s many instruments were in place to support innovation by SMEs [13]. From the 1980s, while public support for SMEs in general has continued, growing emphasis has been placed on a special subclass of SMEs, that is, the new technology-based firm. SMEs in particular often require complementary inputs such as assistance with business planning, quality control, project assessment, and so on. Recent SMEs support initiatives are directed mainly towards technology development and transfer [14].

A recent survey indicates that almost 87% of SMEs in the USA are actively engaged in CIM or have plans to do so. Many of the SMEs that are currently using CIM, have reported a number of improvements in their performance [15]. Much of the recent research literature on CIM and FMS systems suggests that SMEs implementing these systems have often gained a considerable increase in productivity, reductions in lead time and unit cost, as well as better machine utilisation [16,17]. Yet these same studies also suggest that while productivity benefits accrue to SMEs, CIM and FMS systems appear not to have generated many benefits in enhanced business flexibility in SMEs. Many SMEs experimenting with or implementing CIM technologies seem to have considerable organisational problems, resulting in disappointment for managers.

The importance of creating a suitable internal organisational structure to implement CIM and FMS in SMEs becomes apparent when one considers the inherent skill and data demands of the system. Although CIM greatly reduces the organisational work and FMS greatly reduces the amount of physical work needed to manage and operate production processes, the skills and knowledge required for implementing CIM in SMEs on a continuous basis are likely to become more sophisticated over time [18]. Early studies on CIM technologies had focused on the adoption of NC machine tools in 140 SMEs. They found that larger size, higher profitability, and younger and better educated managers would increase the likelihood of the SME adopting CIM.

The literature identifies a variety of strategic, tactical and operational factors that induce CIM adoption, e.g. reduced product development time, labour cost savings, material cost savings, a need to remain competitive, a need for product change flexibility, environmental, safety or health concerns, increased profitability or plant performance, and customer requirements [19]. These factors have strategic impacts on the performance of SMEs and affect virtually every major aspect of the operating environment of SMEs. The characteristics of SMEs and CIM are compared in Table 1.

A review of literature available on the implementation of CIM in SMEs reveals that there is a lack of capital, government and top management support, and skilled workers to implement advanced manufacturing technologies. Also, there is a lack of networking, joint ventures, frequent transfer of technological know-how with large counterparts, and there are problems with the structural characteristics of SMEs. To address these deficiencies, an attempt has been made to develop a conceptual model which is discussed in the next section.

5. A Framework for the Implementation of CIM in SMEs

Implementing a new technology is a greater burden for SMEs than it is for large companies, which have better resources because of a large number of employees and a broader knowledge base. Solutions for shop floor control have been worked out already by research institutes. One special problem is the necessity to adapt these solutions to the needs of SMEs. A conceptual model for the implementation of CIM in SMEs is shown in Fig. 1. The issues of implementation of CIM in SMEs are discussed with respect to four dimensions that include business structure, structural characteristics, strategic alliances and top management support, and system integration. Each of these issues is discussed from the view of implementation of CIM in SMEs. The details follow hereunder.

5.1 Business Structure

The business environment is the total pattern of the decisions and actions which position the organisation in its environment and aim to to achieve its long-term goals. If the organisation is a large diversified corporation, its strategy will position it in its global, economic, political and social environment and

Table 1. Comparison of the characteristics of SMEs and CIM.

Decision-making level	SMEs	CIM
Strategic	High degree of human decision making and execution, ability of customer satisfaction, reduced lead time, improved quality of products, large portion of market share.	Reduce manpower costs, increase capacity, ability of customer service strategy and demand forecasting, reduce product development time, higher product quality, analysing markets and generating forecasts.
Tactical	Efficient and informal internal communication networks, afford a fast response to internal problem solving, ability of project control and technological forecasting, quality control co-ordination.	Greater production control and faster internal communication responsiveness, ability of stand-alone systems for design and engineering technologies, ability of intermediate systems for automated material handling and inspection, higher quality control co-ordination.
Operational	Delivery schedule performance, increase productivity; inventory maintainability; flexibility and quality control.	Ability of customer service, ability to increase productivity within limited resources and improve quality of the product, raw material analysis and control, safety preventive and environmental monitoring, higher quality control ability.

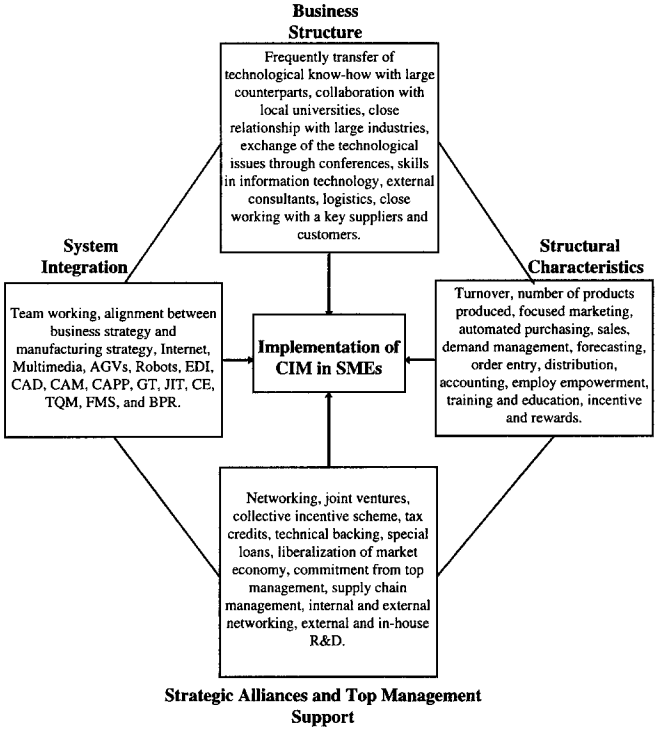

Fig. 1. A conceptual model for the implementation of CIM in SMEs.

will consist of decisions about what type of business the group wants to be in, in what parts of the world it wants to operate, what businesses to acquire and what to divest, and how to allocate its cash between its various businesses and so on [20]. Each business unit within a corporate group must assemble its own business strategy which sets out its individual mission and objectives as well as defining how it intends to compete in its markets. This business strategy guides the business in an environment which consists of its customers, markets and competitors. Similarly, within the business each function will need to consider what part it should play in contributing to the strategic and/or competitive objectives of the business.

Industrial economics revolves around the relative roles played by large and small firms in industrial innovation. One area in which SMEs can be disadvantaged in comparison to their larger counterparts is in establishing communication with external sources of scientific and technological expertise. The SMEs' disadvantages relate to their relatively low levels of in-house employment of technical specialists and to the managerial opportunity costs associated with seeking out appropriate external sources of technical advice. SMEs external technological needs vary from sector to sector and even within sectors, depending on the nature of the innovations under development [21]. Data collected by Rothwell from the UK show that, in general, innovative SMEs have dense external networks involving other firms in a variety of technical, marketing and manufacturing relationships and involving infrastructural institutions such as universities and private sector research institutes. A growing pattern of relationships between SMEs and larger enterprises offers mutual benefits in enabling both to overcome their relative innovatory disadvantages [22]. Some modes of large company SME interactions are manufacturing subcontracting relationships, producer–customer relationships, licensing agreements, contract-out R&D, collaborative development, large company SME joint ventures, and personnel secondment.

The successful business structure for the implementation of CIM in SMEs depends upon the following: frequent transfer of technological know-how with large counterparts; collaboration with local universities; close relationship with large industries; exchange of the technological issues through conferences; skills in information technology; external consultants; logistics; and close working relationships with key suppliers and customers. Affiliation with large firms usually results in greater financial success for SMEs. Firms with some affiliation tend to have higher profits and greater sales. The financial and technical support that flows through these channels of affiliation is apparently the reason for the discrepancy of success among SMEs.

Close linkages with suppliers and customers, high information content, long-term relationships with numerous external entities, and customer participation in the design of the product

or service offer opportunities for the double-loop learning business to acquire even more knowledge, information and other insights vital to the building and refining of new skills for the future [17]. One role of the operations part of the business is to support the achievement of strategic goals. That is, it must develop its resources to provide the capabilities which are needed to allow the organisation to achieve its strategic objectives [20]. SMEs must organise and train its staff to understand the way products are changing and put in place the necessary changes to the operation. It must develop relationships with its suppliers which help them to respond quickly when supplying new parts.

5.2 Structural Characteristics

Structural characteristics can be defined by reference to the overall performance of SMEs such as turnover, number of products produced, automated purchasing, employee empowerment, training and education, marketing, and demand forecasting. All organisations must decide what transformation processes they are going to perform and which they are going to purchase. These make-or-buy decisions are also known as process positioning. The process technology of a supplier may be different from that of the purchaser, the scale of operations required for efficiency may be considerably different, or competitors of the supplier may develop processes or products that make their products more attractive, causing capital requirements or the span of general management to increase [23]. Additionally, many organisations develop computerised information systems. However, most SMEs purchase technical expertise in product and process information system design from specialists, even though they themselves may possess considerable technical ability. Downstream integration begins with the establishment of a marketing organisation, including distribution, warehousing, and retail outlets. This guarantees access to the market, permits greater flexibility in pricing, and gains the profits of retailing. However, downstream integration requires higher operating costs such as warehouses, finished goods, and retail outlets. The span of top management is increased as additional personnel and facilities are needed.

SMEs adopting CIM systems have a greater number of growth options for entering new markets and creating new products than SMEs relying on traditional manufacturing technologies and generic strategies. In effect, CIM changes the external risk-propensity of the SMEs from risk-averse to risk-prone [17]. SMEs using CIM in effect create a series of call options to enter new markets and industries in the future. Growing market heterogeneity complicates product and process planning, since segment and niche stability is diminishing over time. Customers are increasingly aware of new alternatives, while their growing sophistication makes it more difficult to employ classical differentiation strategies based on quality or image. With numerous alternatives available, consumers can demand fresh ideas, increased variety, better functionality and multiple relationships with vendors that create niches within niches. The information related area in which SMEs often require assistance are:

- Market information, especially for overseas markets.
- Export market start-up advice and assistance.
- Management education, especially in the area of technology management.
- Information on general economic trends that might influence future market developments and requirements.

Automated purchasing is one of the structural characteristics desirable in SMEs for adopting CIM. Most operations buy in a wide variety of materials and services and typically the volume and the value of these purchases are increasing as organisations concentrate on their core tasks. The successful structural characteristics for the implementation of CIM in SMEs depends upon the following factors: turnover, number of products produced, focused marketing, automated purchasing, sales, demand management, forecasting, order entry, distribution, accounting, employed empowerment, training and education, incentive and rewards.

Human factors should be considered at the earliest stages of the planning and implementation of CIM in SMEs. If not, a CIM project may fail as workers struggle to operate and maintain a system superficially designed to thwart their efforts. Human factors are important in areas such as installation, operation and maintenance, and safety. Installation requires workers well trained in automation principles. Operation and maintenance requirements include workstation and computer interfaces, designed according to established human factor principles, and work environments that provide human interaction during the job performance and during scheduled breaks in order to prevent feelings of isolation. It is frequently argued that since humans are error prone, it is necessary to limit their influence in manufacturing by using CIM technology to automate physical tasks [24].

5.3 Strategic Alliances and Top Management Support

Strategic alliances are concerned with projecting a good image of the company to the outside world. A business depends for its long term existence upon public goodwill. It is essential, therefore, for the business to establish an alliance with the public which includes many groups, such as consumers, government, trade association, etc. The full understanding, support and leadership of an organisation's top management emerges as a crucial factor in almost all the studies of CIM implementation. The importance of top management support goes far beyond the allocation of resources to the programme, it sets the priorities for the whole organisation. If the organisation's senior managers do not understand and show commitment to the programme, it is understandable that the rest of the organisation will ask why they should do so. Top management support usually means that senior personnel must put in much more effort at an operational level.

Government policies play an important role in the adoption and implementation of CIM in SMEs. Any change in government policy may affect the cost of raw materials, supply of power and transportation facilities. Industrial growth is encouraged by favourable government budgetary and fiscal policies. Government support, either financial or technical, will certainly help the implementation process by minimising the risk of loss

while implementing CIM in manufacturing firms [24]. The issues include: networking, joint ventures, collective incentive scheme, tax credits, technical backing, special loans, liberalisation of market economy, commitment from top management, supply chain management, internal and external networking, external and in-house R&D, and the probable influence of government fiscal policy on the profitability of the industry.

The economic and social importance of SMEs, justifies the special assistance given to them by governments in order to help them to adapt to technological changes and prepare their competition strategies. It should not be forgotten that the importance attached to the development of SMEs increased over the 1980s, and many countries now regard satisfactory performance in this sector as a major aspect of economic growth and adjustment [21]. This trend is indicated by the relative increase in support given to SMEs in Organisation for Economic Cooperation and Development countries (against a relatively low total expenditure), and also by the diversity and complexity of the measures implemented. In this context, programmes designed to improve, in one way or another, the multiple aspects of scientific and technological information transfer to SMEs, are of primary importance. It should be noted that government support for technology information transfer to SMEs takes a wide variety of forms, e.g. direct or indirect; short-term, occasional or sustained; and focused on SMEs or embracing large companies and research institutes.

Supply chain management plays an important role in SMEs during the adoption of CIM. While logicians have devoted relatively little attention to managing the chain of supply upstream of the purchasing function into suppliers operations, and materials managers have more or less ignored the management of the flow of finished goods and service downstream through distribution channels, supply chain management views the entire chain as a system to be managed [20].

5.4 System Integration

System integration means the linking together of previously separated activities within a single technology or system. Advanced manufacturing systems play an important role in the manufacturing environment. There is some evidence to suggest that AMT systems can produce dramatic improvements, such as direct labour cost reduction by 50–90% through downsizing the work force, productivity improvement by 30–90%, scrap level reduction by 90–95% and improvement of quality and reliability, and floor space saving by 30–80%, etc. and provide comparative market based advantage [25]. CIM technology may enhance competitive advantage, but, it must be recognised that the integration of various computerised systems produced by different companies often leads to technological difficulties. In addition, the capital investments needed for the development and implementation of CIM in SMEs are substantial. Hence, it is very important to provide a system, after the necessary changes, in order to facilitate computer integration.

A suitable CIM configuration should be decided before the implementation process that generally centres around the identification of tasks to computerise, the selection of feasible software packages, and software compatibility. In order to include flexibility in CIM, manual policies, procedures, and practices should be established. The integration and adaptability of CIM for system integration can be made considerably easier with flexible manufacturing systems (FMS), cellular manufacturing systems, total quality management (TQM), and just-in-time (JIT) production systems. Technologies such as internet, and multimedia can be used to improve the integration of various business areas of manufacturing organisations. Automated guided vehicle systems (AGVs) using computers can play an important role in improving the integration of material flow within the production system. Integration of operational activities with suppliers can be improved by on-line computer information systems such as electronic data interchange (EDI). These also can play a vital role in an unmanned factory [24].

Sarkis et al. [26] presented an enterprise engineering methodology for the strategic management of technologies in CIM for system integration. This methodology is based on preparing the manufacturing system that will accept the CIM effectively. Boubekri et al. [27] argue that the design of automated equipment such as robots, computers and CNC machines should conform to high-level standards of communication protocols to develop an intelligent manufacturing cell. The companies that are able to exploit the hidden capabilities of a new technology most effectively are generally those that adopt it early, continually experiment with it, and keep upgrading their skills and equipment as the technology evolves [28]. The issues regarding system integration includes team working, alignment between business strategy and manufacturing strategy, internet, multimedia, AGVs, robots, EDI, CAD/CAM, CAPP, GT, JIT, CE, TQM, FMS, and business process re-engineering (BPR).

A framework for the implementation of CIM in SMEs is characterised by the following managerial actions:

- Examine and investigate the strategic and operational needs for adopting CIM. This requires an ongoing investigation of the performance of existing systems in relation to the SMEs ability to remain competitive in the external business environment.
- SMEs need to ensure that their strategic focus is in tune with their requirements to succeed in the evolving business environment. Organisational goals and performance benchmarks that reflect this strategic focus should be developed. Additionally, SMEs should consider a wide variety of technological and procedural innovations that can assist in meeting their objectives.
- Modify organisational infrastructure and processes in preparation for the adoption of CIM, such as the ability to change production lot sizes, variety of part-types produced, average number of tasks per worker, operator output rates, revenues from manufacturing operations, delivery lead times, overhead costs, product quality, inventory turnover rates, production changeover times, time needed for a major design change in an existing product, and time-to-market for a new product.
- The appropriateness of CIM systems should be based on their ability to meet SMEs goals such as profitability, compatibility, adaptability and flexibility in a cost-effective manner with due consideration being given to required

infrastructural changes. This is achieved through a systematic investment justification process.

6. Suggestions for Future Research

The following are some of the future research directions on the implementation of CIM in SMEs:

1. SMEs fall short of achieving those benefits that were perceived as being important in CIM implementation. The reasons for the failure of CIM in SMEs include lack of technology initiatives, lack of top management's continued support, poor commitment to shop-floor employees and inadequate managerial training for CIM projects. Further research is required on setting goals and objectives stipulated by the adoption strategy of CIM in SMEs.
2. Human factors should be given due consideration while designing CIM for SMEs. There is a need to establish the level of skill and training required in order to implement CIM in SMEs.
3. The reasons for the failure in the implementation of CIM in SMEs are the lack of developing effective support systems, lack of planning for a higher level of system integration, lack of experience with modern technologies, inadequate understanding of new technologies, and lack of top-management knowledge and support of CIM. It is suggested that further research is needed, for total system integration, rather than stand-alone technologies, should be the key requirement for the implementation of CIM in SMEs.
4. Most SMEs are small in size, therefore increasing modularity and low-cost solutions are a more feasible approach for the implementation of CIM in SMEs.
5. Overall, the exploratory work has found a lack of awareness of the concept of joint technology and organisational design and its benefits in terms of improved design and implementation processes, better system designs, more appropriate organisational structures and motivated and engaged employees at all levels in SMEs. Much work clearly needs to be undertaken in the area, both in terms of increasing awareness and developing easy to use supporting methods and tools to help minimise the risks associated with the implementation of computer-aided technologies in SMEs.
6. For the successful implementation of CIM in SMEs, employees must have a clear understanding of its principles, capabilities, goals and objectives. The literacy factors pertain to those educational efforts which make the employees become more familiar with the implementation of CIM in SMEs and their goals and objectives. This understanding will make it possible for the goals of CIM in SMEs to be communicated appropriately to all the employees.
7. A suitable architecture for CIM in SMEs should be decided before the implementation process which generally centres around the identification of tasks to computerise, the selection of feasible software packages, and improving software compatibility. In order to include flexibility in CIM, manual policies, procedures, and practices should be established.
8. A framework for integrating productivity improvement strategy within the CIM strategy, and the groundwork required to facilitate the process of easy implementation of CIM in SMEs is required such as just-in time (JIT), optimised production technology (OPT), and business process re-engineering (BPR) for simplifying the material flow, and simplifying the logistics and decision-making and information-processing factors.

7. Conclusions

In this paper, some of the literature available on the experiences of SMEs with CIM have been reviewed. Based on this review, a conceptual model for the implementation of CIM in SMEs has been developed and discussed. Also, a comparison of the characteristics of SMEs and CIM, and future research directions are presented. It has been found that SMEs frequently lack strategies, expertise, capital, and time to upgrade their manufacturing operations. Also, SMEs face problems in introducing new technologies and methods, implementing better quality control, and improving workforce training. This is due to lack of:

1. Top management support and skills available, and training in CIM.
2. Effective support systems for system integration.
3. Strategic alliances and networking between government, universities, and SMEs.
4. A long-term relationship between SMEs and large scale industries.
5. A framework on the size, modularity and low-cost solution for a successful implementation of CIM in SMEs.

To address these issues, a comprehensive empirical research programme on the implementation of CIM in SMEs is needed. Currently, the authors are carrying out research in this direction.

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