THE CHALLENGES POSED TO ACCOUNTING TECHNIQUES BY NEW APPROACHES TO MANUFACTURING.

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1 INTRODUCTION.

This paper sets out to explore, and illustrate using examples from recent research work at Newcastle Polytechnic, some of the challenges posed by current developments in manufacturing technologies to traditional accounting and auditing techniques. The paper will focus on one particular development in manufacturing industry: Computer Integrated Manufacturing (CIM).

CIM is a nascent technology, literally one that is in the process of coming into being. It is generally agreed (1) (2) that the term Computer Integrated Manufacturing was coined in 1973 by Joseph Harrington in his book by that name (3). In the preface to a later book (4), Harrington summarised what he saw as the CIM concept. He described how, in the past, manufacturing organisations were shaped by the unaided muscle power and brainpower of the people who worked in them. As time moved on automation, and then computerisation, began to change the manufacturing milieu. Harrington described what he saw as an underlying "science of manufacturing" which he claimed remained constant in any industry. He claimed that computer technology could provide the basis for a break with the old pattern, and, the development of a new rational pattern based upon this "science of manufacturing". The analogy used by Goldhar (5) is the CIM factory as a computer; for Appleton (6) it is a data driven enterprise. Gondert (7) sees CIM as a way of transforming the dirty, confused and inefficient factory of the industrial era into the clean, focused and efficient factory of the information era.

The CIM concept, as originally formulated, was clearly aimed at providing a universal systems based approach to the organisation of an efficient and competitive "factory of the future". Conceptually CIM might be thought of as an approach to improving the competitive position of a company by the rationalisation and integration of all facets of the enterprise aided by the application of computer technology; in practice a combination of

computer systems and organisational philosophies guided by a strategic business plan.

In recent years, when attempts have been made to develop CIM in actual, rather than conceptual, factories the full complexity and depth of its implications have begun to become apparent. Turning theory into practice has raised a host of new issues, few of which are directly concerned with the technical problems of the integrated computer systems themselves. This paper will concern itself only with those issues of direct relevance to the accounting function.

2 THE RESEARCH.

The approach taken to the research could be broadly described as investigative. As indicated above CIM has proved to be both a novel and complex concept when applied to the business of manufacturing some product. The subject of the application of computer technology is littered with acronyms such as CAD, CAM, OPT, and of course, CIM itself.

CIM was originally intended as a unifying concept but it too has fragmented into HCIM (Human and Computer Integrated Manufacturing), ACIMT (Advanced Computer Integrated Manufacturing Technology) and CIMS (Computer Integrated Manufacturing Systems). Although pleas are still made for CIM to be the "Ultimate Acronym" (8), the prospect looks bleak. Probably the best analogy to draw of the study of CIM is that of understanding what is happening in the Tower of Babel (9).

It was against this background that the research was performed. Much interest was being generated but little was known nationally and almost none locally. The overall objective of the research was to gain a broad picture of CIM development locally, and, to "trawl" through the experience of local manufacturers to identify pertinent issues from the plethora of claims and counter claims.

This was done through examining five themes: "What is CIM?"; "Who is developing it?"; "Why develop it?"; "What problems are encountered?" and "What changes is it expected to bring?". These themes were explored through the ways in which they were developed in the manufacturers of the region. A summary of the findings as a whole can be found elsewhere (10) (11).

60 companies were contacted of which 40 agreed to be interviewed; the majority of the interviews were with senior management. The following comments and conclusions were drawn from the 19 companies that claimed to be actively attempting to implement CIM.

3 THE RESULTS.

There were several issues raised during the interviews concerning the problems of planning for and justifying investment in CIM, which may legitimately be seen as falling within the remit of the accountancy/financial function.

Firstly, at the most general level, there was a clear difficulty in obtaining the information to manage adequately a period of profound change in a new, complex and dynamic environment.

There was a perceived lack of appropriate and accessible information on what might represent a suitable system, how it might contribute to the business as a whole and, in some cases, a lack of knowledge on why such systems should be used at all. Several comments were made on the problems of information overload and the speed of change.

> *"things are happening so quickly and it takes so long for your plans to come to fruition (that) it is very very difficult to co ordinate it into one master plan." (M.D., Plastics Company 2.)*

The constant introduction of new systems and techniques, or modifications to existing systems, only served to compound the difficulties of adequately and effectively planning CIM. It was apparent that in several of these companies there was nobody who had a clear idea of what magnitude of benefits could be achieved or what type benefits should be aimed for. This was due, at least in part, to the perceived shortcomings of the accountancy function.

The second issue raised identifies accountants more directly. Traditional accounting techniques were widely seen as inaccurate or inapplicable. The justification of CIM systems was more often described in terms of a policy decision than a quantified judgement.

> *"the classic payback calculations ... don't give the right answers ... I don't think we have any accounting mechanism to measure the benefits of fast turnaround ... if you can put something in three months earlier, what is that worth to you?" (Operations Director, Engineering Company 4.)*

or

> *"I think the problems are justifying certain aspects of it from the financial point of view ... justifying that a certain package will integrate" (Engineering Manager, Engineering Company 1.)*

Respondents whose companies were part of some larger group, particularly those whose parent company was outside the region or country, found an additional set of problems stemming from the use existing accounting systems to justify an investment in CIM to "external" investors.

In such cases, the approach to accounting techniques appeared to be quite cynical. Corporate policy and accounting systems were seen to be at variance with local needs when large investments were required. The impression was gained that in some cases the decision is made first and, only afterwards, the numbers found to make the investment look

worthwhile.

> *"The benefits of it are difficult to quantify, its' ... a situation where you need to get into it in any case or you will be left way behind" (Engineering Manager, Engineering Company 1.)*

Changes of ownership in such companies can serve to exacerbate the problem. In one case the company had struggled with it's American parent for some time to be allowed to buy a computer system that was different to that dictated by the corporate policy; just as these negotiations were nearing completion the parent company was taken over and the whole process had to begin again.

A further example of such problems was provided by one respondent who claimed that it was only through the government providing a grant, for half of the cost of a Flexible Manufacturing System (FMS), that the initial investment could be justified. The FMS however proved to be crucial in enabling the company to survive the 1984 miners strike and continue to compete in world markets. The strategic benefits were "obvious to everybody" but the accounting systems could not capture them.

Clearly existing accounting systems were seen as inaccurate and a hindrance to strategic investment by these respondents, rather than a valuable aid and rational decision making tool. It is perhaps interesting to note that the two respondents quoted above were from the smaller sites in the "most advanced CIM users" group.

Finally there were a variety of issues raised which related to the expectations of the way in which the nature of work in manufacturing industry would change. These are of both a direct and indirect interest to the accountancy function.

Although not all respondents in "CIM companies" saw radical changes in the way that they and others worked, two particular issues were highlighted.

The first was the widely held view that "computers" would lead to fewer people being employed.

> *"I personally believe that we would still need the technically experienced person ... maybe less of them ... what we will not need necessarily (is) the particularly unskilled people." (Industrial Engineer, Engineering Company 2.)*

The reduction in numbers however was certainly not limited solely to the "shop floor". One director summarised many of the issues surrounding the expected "impact" of CIM at other levels.

> *"Yes I think it's going to have a dramatic change in business, my feeling is that its going to be a bigger change at the senior supervisory /junior management level than elsewhere ... I would look at it and say, Where is the*

job for a middle manager in 5 years time? ... I see the bottom level of the company reducing in numbers, yes, but I then see a very narrow neck where the middle managers used to be ... I see it as an hour glass shape in the future ... pinching in through a neck at the middle with virtually nobody (there) in the future, and opening out at the top to a wider and flatter plateau with a range of decision makers and people involved with the whole business ... I see the whole shape of the company changing." (Operations Director, Engineering Company 4.)

Such a radical re-shaping of the company's structure would have profound implications for many aspects of the calculations of "cost" and "benefit" which are traditionally based upon the concepts of the contributions of "direct" and "indirect" labour.

The second issue highlighted was that those who remain would be qualified and knowledgeable people in a far more powerful position to exercise control over the business as a whole. They would also be required to take greater responsibility and be more flexible than at present. They would be expected to:

"manage rather than react the way they do at the moment ... I would expect much less time spent sorting out problems and more time spent moving things forward" (Director of Planning, Chemical Company.)

They would be:

"a more flexible type of person, I was going to say more intelligent but that might not be the right word, a more complete person who is able to come to terms with the new technology and be computer literate ... and maybe take more responsibility than at the present time" (Engineering Manager, Engineering Company 1.)

Similar changes were seen for shop floor personnel. One respondent explained how previously operators

"weren't interested in how the parts arrived to them, they just arrived, and if they didn't they just sat and waited until they did arrive" (Senior Training Manager, Engineering Company 5.)

But now, through the use of shop floor terminals,

"the operator is controlling ... a whole number of chain reactions ... I would say the amount of control which is exercised now by the operators at each stage of assembly is far greater than it ever was" (Senior Training Manager, Engineering Company 5.)

The numbers employed would continue to reduce and, as they do, the skills and

importance of those who remain increase correspondingly. Employees traditionally, viewed as a cost, might increasingly come to be viewed as an asset.

Such major changes in organisational structure and skill levels would obviously be of direct, perhaps even personal, concern to those accountants in manufacturing industry. However, more important to accountants as a whole, are the indirect implications that such changes have for the calculation of overall cost-benefit equations and the evaluation of assets.

The next section of the paper will explore some of the issues raised by the research as they are expressed in the literature.

4 LITERATURE REVIEW.

The crucial importance of advanced manufacturing technologies, such as CIM, in keeping British manufacturing industry out of the "relegation zone" (12) has been widely accepted e.g. in reports such as those by NEDC (13) and ACARD (14). The willingness of the UK government and the EEC to invest in CIM through the CIMAP and ESPRIT programmes provides further evidence of the perceived importance of such technologies. CIM is claimed by many to be central to obtaining the long term strategic benefits needed to become a "World Class Manufacturer" (15). The potential of CIM is said to be so profound and wide ranging that it is frequently been compared to that of motive power in the first industrial revolution (16).

Given such a widespread acceptance of the importance of technologies such as CIM, it is perhaps surprising that, in Britain at least, the uptake of such technology seems to have been relatively slow (17).

A wide variety of benefits are claimed to flow from the adoption of integrated computer technology and several authors have produced lists of such benefits together with estimates of their magnitude; a summary of these can be found in table 1. This is not exhaustive but does provide a comprehensive summary of the major benefits claimed to flow from the use of CIM.

It can be seen that the benefits claimed for CIM make themselves felt across the whole spectrum of manufacturing. There are clear operational benefits (i.e. those associated with a particular process, operation or machine within the factory); what can be described as tactical benefits (i.e. those associated with the manufacture of the product as a whole rather than a particular process, operation or machine) and strategic benefits (i.e. those associated with achieving some long term corporate goal).

The range and diversity of potential benefits poses the first major challenge to accountants when dealing with developments such as CIM and provide the first clue concerning the apparent failure of accounting procedures to cope with the changes which are taking place. How, for example, is it possible to evaluate adequately the potential

impact of such new and radically different systems when dealing with complex strategic decisions?

Benefit	O	T	S
Improved machine utilisation.	**x**		
Quicker design/manufacture.	**x**		
Reduced WIP.	**x**		
Increased productivity.	**x**	**x**	
Less scrap/rework.	**x**	**x**	
Lower labour costs.	**x**	**x**	
Lower overheads.		**x**	
Reduced overall inventory.		**x**	
Improved lead-time.		**x**	**x**
Improved control.		**x**	**x**
Improved quality.			**x**
Lower Economic Order Quantity (EOQ).			**x**
Improved flexibility.			**x**
Improved customer service.			**x**

O = Operational Benefit; T = Tactical Benefit; S = Strategic Benefit.

Sources: Willis and Sullivan (18), Goldhar and Jelinek (19), Jarvis (20), Bessant et al (21) and Ralston (22)

TABLE 1

One of the key factors governing the success of CIM is the ability to choose and integrate systems in such a way that they meet the strategic business needs of the company. However, how can the impact upon long term strategic goals such as improved quality, flexibility, lead-times and customer service be quantified in a reliable and meaningful way? How is the synergy and close integration brought about by CIM to be dealt with? As Claret (23) points out, in highly integrated systems even small investments that appear only to have a local effect, may, in reality, have a far wider influence.

An example from Hewlett Packard (24) will illustrate the complexity of the problem. Hewlett Packard found that improving the strategic goal of quality, through adopting a holistic "Total Quality Management" (TQM) approach, lead initially to quality related

"costs" jumping from 2%, as implied by the traditional measure of warranty cost as a fraction of sales, to 25%. However they eventually found that improving product quality lead to a reduction in manufacturing costs, that inventory costs were reduced, manufacturing times were reduced and that customers even seemed to pay their bills more promptly. As L. E. Platt of Hewlett Packard explained:

> *"People don't mind paying on time when they get the right product and it works the first time" (24)*

Although "cost" as traditionally measured was increased, overall, a benefit was obtained. Traditional accounting procedures appear to be unable to deal with the complex and interacting effects of company wide, holistic and integrated approaches such as TQM or CIM. They are frequently criticised as providing "optimised sub totals leading to sub optimised totals": uncoordinated, piecemeal and often inappropriate investment.

The difficulty of the task should not however be an excuse for not attempting it. Some attempts have been made to develop software, such as UMIST's InVestment ANalysis program (IVAN) or the Cost-Benefit Analysis Toolkit (C-BAT), to aid accountants and others in evaluating the net effect of the introduction and integration of computer systems. These however tend to rely heavily upon identifying potential benefits, and subsequently requesting a value to be placed upon that benefit. In themselves, they do not provide a means of accurately quantifying individual benefits. Ignoring for the moment any questioning of the underlying economic models of such programs, these will simply calculate the net result of many individual estimates in some way. They will inevitably run the same risk as many computer programs: garbage in - garbage out; inaccuracy to 10 decimal places. If the individual estimates are inaccurate, the net result will also be inaccurate.

Until more holistic and appropriate accounting systems are developed the complexity and uncertainty involved in evaluating the benefits of CIM leads a number of authors to assert that investment in it must remain, essentially, an act of faith and judgement (25).

The second area where accountants are frequently criticised in the literature is in their use of outdated or inappropriate metrics when appraising the benefits of computer based technologies. For example, Claret (23), Gunn (26) and others have argued that traditional accounting procedures fixation with the role of direct labour inevitably underestimates the financial benefits which accrue from an investment in any aspect of Advanced Manufacturing Technology (AMT). Such accounting procedures use "absorption costing" where the cost of overheads, representing the cost of the basic manufacturing facility, are shared between the labour hours, which represent the capacity. As Claret (23) points out, this was acceptable in the past when labour could account for 25% or more of the cost, however, in modern manufacture, labour may represent under 10% of the final cost of the product.

The utility of this form of absorption costing when evaluating modern manufacturing systems is challenged by Gunn (26) who poses the pertinent question

> *"What happens when direct labour cost becomes 0% of the product cost?" (26)*

He comments

> *"If direct labour costs were zero most of today's uncompetitive companies would still be in serious trouble" (26)*

arguing that

> *"if you could find free direct labour there is no way a factory of 200 - 300 people could produce the level of quality needed to be a successful global competitor." (26)*

Claret (27) argues further that an adherence to absorption costing based on direct labour leads to a tendency to under price low volume "special" jobs: exactly the sort of jobs which CIM is supposed to be best at producing. Price Waterhouse are developing a system of costing based on machine hours rather than labour hours, and factory overheads as a whole rather than departmental overheads (28). However, once again, Claret (27) claims that if batch sizes vary widely this leads to under pricing of small special batches.

The criticism that traditional accounting procedures are misdirected and anachronistic can be linked to the previous point and to the issues raised in the research. It was clear from the respondents that they expected quite profound changes to occur: The numbers employed at various levels were expected to drastically while the overall skill level in the company was expected to increase. This calls into question both the logical basis of measures based on direct labour and the utility of measures which fail to take into account the more global changes taking place in the company's structure and functioning.

The final area of criticism concerns the evaluation of CIM for the justification of a case to external investors. It is claimed, once again, that existing techniques are outmoded and also that the criteria used by investors to decide if an investment is "worthwhile", at least in Europe and the United States, are narrow, short term and inappropriate. Accounting systems, originally designed to be management information systems, it is claimed, have simply become narrow and short-term shareholder information systems geared more toward maximising shareholder wealth than the long-term prospects of the company. This, it is argued, exacerbates the piecemeal approach to investment.

Ashford et al (29) criticises existing investment appraisal techniques on four fronts. They argue that traditional methods of calculating payback undervalue long term benefits; that traditional financial models assume a far to static view of industrial activity; that many of the less tangible benefits which flow from AMT are often ignored or neglected and

finally that the accounting systems of large organisations are biased against expensive but long term investments.

These themes have been taken up by other authors. Kaplan (25), for example, has outlined how traditional accounting measures tend to undermine investment in manufacturing technology in general and CIM in particular. He uses the example of Discounted Cash Flow (DCF) to illustrate this. He demonstrates how the problems of estimating interest rates and cash flow over the long term, the adequate quantification of all of the costs and benefits of CIM, and, the relatively high weighting given to the early years of the investment, exaggerate what Olsen (30) and others describe as a "the short term profit mentality".

Kaplan defends DCF as a method of ensuring that "cash flows in the future are equivalent to cash flows received now" arguing simply that it's application is often misguided or inappropriate. Claret (23) on the other hand defends both DCF as a method and also the heavy emphasis that is frequently placed on quick returns in practice. He points out that the model is based on the reality that businesses obtain capital from shareholders and lenders of various kinds, and, that these demand an early repayment and return on their investment. He places the blame on the perspectives of U.K. investors not DCF. He comments:

> *"Unfortunately that appears to be a priority of investors, rather than accountants, in the UK's relatively high interest economy" (23)*

This obviously raises the contentious question of how effective the capital markets are in allocating resources to investors. It may be argued that the apparent myopia of the market is in fact simply the setting of the appropriate criteria to ensure a reasonable return on capital deployed at an acceptable level of risk. However, if the information upon which the market bases it's decisions is fundamentally flawed and inconsistent, is it still reasonable to talk of the market being able to set meaningful parameters by which to judge an investment? Even if it is accepted that the markets do set the right rates, several respondents identified the corporate investment criteria, which they had to meet in order to be allowed to make an investment, as inappropriate and inhibitors in their development of CIM. There was clearly a perception the accounting systems were somehow inherently biased against long term strategic investments in AMT.

5 DISCUSSION.

From the research, it can be seen that managers and directors expressed grave concern about the difficulties of adequately planning and managing CIM, and also, the justification of such investments in the first place. Specifically three themes emerged from the interviews.

Firstly there was a general feeling of "too much data but too little information"; a creeping realisation that the accepted rationality had been displaced while no worthy successor had been found to fill the gap. The responsibility for this conceptual vacuum was, at least in part, placed at the feet of the accountancy profession.

Secondly, existing accounting and investment appraisal techniques were seen as inadequate or inappropriate. Investment was seen as an unquantified or poorly quantified gamble based more on "gut feeling" than reason and logic. The financial procedures of large groups and organisations were singled out as being a particular problem in this respect. There was the feeling that the benefits were somehow "obvious" and a matter of "common sense"; accounting techniques simply failed to recognise them.

Finally, companies that developed CIM expected to undergo profound organisational changes that will have far reaching implications for accounting techniques developed in an era of low skill, labour intensive mass production.

From the literature, it is apparent that although CIM is a nascent technology it has certain generally accepted characteristics. Its aim is to improve the competitive position of a business; it will involve the integration and rationalisation of all facets of the enterprise via the medium of computer technology; it is an enabling technology guided by a strategic business plan. Finally, although it shows that CIM is seen as being crucial for the survival of UK manufacturing as a world class competitor, it also shows that the uptake of such advanced manufacturing technology in the UK is too slow.

A wide and diverse variety of benefits are identified and as many disparate estimates of their magnitude made. The benefits identified range from the operational to the strategic; from the immediate to the long term. Could the complex nature of the interactions in integrated systems be one reason for the problems that faced the managers in the research?

Procedures and tools such as UMIST's IVAN program and the ESPRIT C-BAT have been developed to quantify the net effects of the introduction of integrated systems but the fundamental problem of a universal and comprehensive framework for quantifying individual benefits has remained relatively untouched. Different methods of measurement make comparisons and the development of a database of quantified concrete experience impossible. Without such a framework, the investment in new technologies will always remain more a matter of subjective judgement than logic. Managers are likely to remain confused and the investment appraisal process debased.

The first challenge therefore is the development of new holistic economic concepts, and a common technique for the quantification of the potential benefits applicable to a modern manufacturing enterprise. The use of such a framework, coupled with post implementation audits, could form the basis for the development of a database of concrete experience to allow a more accurate evaluation of future investment.

Existing individual accounting measures are also widely criticised as inappropriate for today's factories. Absorption costing, and the general emphasis on the role of direct labour

or machine utilisation in calculating costs, is singled out as particularly inappropriate for the projected "factory of the future". Could the use of anachronistic measures more suited to a bygone age also go some way to explaining the issues raised in the research?

Attempts have been made to develop more appropriate measures that will provide managers with the sort of information they need to manage their businesses. There is however little agreement on their validity or use. Consequently, the second challenge for accountants is to develop new techniques for the evaluation of integrated systems that take account of the changes in the manufacturing milieu. In particular there is a need for techniques which recognise direct labours reduced role in the ultimate manufacturing cost, and can incorporate measures of overall strategic objectives, in a broader overall cost-benefit equation.

Finally, if it is accepted that CIM is crucial to the survival of UK manufacturing, and that UK investors take an inherently short term view, the remaining challenge is to find new methods of presenting a case for strategic investments in CIM. Here the problem here appears to be one of the collation and presentation of the appropriate information rather than the development of new concepts, techniques or metrics.

6 CONCLUSIONS.

New and radical approaches to manufacturing such as Computer Integrated Manufacturing (CIM), Total Quality Management (TQM) and Just In Time (JIT) will not go away. The changes in the markets for manufactured goods in the 1960's and 1970's, the demand for greater customisation and quality, the growth of East Asian competition and the relentlessly competitive nature of international commerce, have made such approaches an integral part of modern world class manufacturing. Profound and far reaching changes are expected to take place in almost every aspect of the business of designing, producing and marketing manufactured goods. The challenge to accountants is to react and adapt to these changes.

From the research, aimed at simply identifying the most pertinent issues to local manufacturers, and from a review of the literature, presumably aimed at a much wider audience, three clear challenges emerge.

1. The first is to develop a conceptual framework to describe and understand the economics of an Integrated Manufacturer.
2. The second is to develop techniques and metrics with which to quantify the impact of such techniques upon the business as a whole.
3. The third, to be able to use these new concepts, techniques and metrics to provide a rational basis for the selection of, investment in and management of the components which will go up to make the "factories of the future".

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