Journal of New Business Ideas and Trends 2004 2(1), pp.66-74

Company Size and the Adoption of Manufacturing Technology

by Paul Hyland, Jessica Kennedy, Central Queensland University, and Robert Mellor, University of Western Sydney

Increasing competition from globalisation, rapid improvements in technology and environmental requirements have led many manufacturing firms to adopt advanced manufacturing technologies to remain competitive. Smaller enterprises can compete successfully with large companies through operations capabilities embedded in people and operating systems. They face various constraints including lack of resources and experience, but their small size can bestow advantages in implementing changes because they have fewer layers of bureaucracy and are more flexible. To explore how well SMEs are adopting manufacturing technologies, this paper compares the past use, payoffs and expected future use by large firms and SMEs of a range of advanced manufacturing technologies and improvement programs as reported by manufacturing managers in a global survey. The analysis of data from 632 firms from both OECD and non-OECD countries indicates that in general, SMEs have used advanced technologies less than larger firms in the past and received a lower payoff. They also expect to use such these technologies less in the future.

Competition within the manufacturing sectors in both developing and developed economies is increasingly focused on areas other than price. It has been argued that in the developed world we can no longer hope to compete on price alone, and must now be faster and better as well as cheaper. In order to compete, manufacturers have invested substantial resources in advanced manufacturing technologies (AMT), improvement programs such as kaizen and total quality management (TQM), and process improvements such as just-in-time (JIT). With different cost structures and environmental conditions in developed and developing nations, it is expected that there would be substantial difference in the adoptions of these technologies and in their payoff.

The adoption of AMT is also expected to be influenced by the size of the company. There is a considerable body of literature that reports on differences between the manufacturing operations of large and small to medium enterprises (SMEs). This research maintains that there are fewer resources available to SMEs compared to larger firms. As small firms have fewer resources and often less access to capital, this research will examine if SMEs invest in low cost programs and techniques rather than expensive AMT, and if they achieve a similar payoff to large firms. While manufacturers in developed economies such as OECD nations have been investing in technology and improvement programs for a substantial period of time, it is only in recent times that firms in developing economies have invested in these innovations. Hence differences in past and future use and payoffs are likely. This paper therefore compares the use of AMT and improvement programs across large firms and SMEs and across developed and developing economies.

Literature Review

To maintain or achieve competitiveness and profitability, a manufacturing firm or enterprise must respond to a range of challenges, including rapid improvements in technology, declining industry employment and output, globalisation of markets and environmental requirements.

In addition, substantial changes in government policy have had important impacts in many countries as has the increasing levels of global trade. Manufacturing enterprises need to a clear understanding of what their customers want and why customers purchase their products rather than purchase from their competitors. They need to fully understand the aims of the business in terms of its customers, market segments, product attributes and geographical markets.

In selecting or investing in an improvement program or quality accreditation such as ISO9000 or in an AMT such as computer-aided design (CAD) or computer-aided engineering (CAE) it is important that the manufacturer regardless of its size achieves a benefit or payoff and this is part of its strategic positioning. For example a manufacturer who needs to ensure quality of design in the aerospace industry may have to invest in a particular CAD technology rather than in a work place health and safety program. Similarly a manufacturer in a developed economy may have to invest in an environmental safety program to meet local government regulations rather than in invest in an ungraded CAE system.

According to (Davies, 2000), business strategy is a design or plan for achieving a company's policy goals and objectives. So strategy provides the frame in which decisions are reached about how the company's goals and objectives will be achieved, what operational units will be used to achieve the company's goals and objectives, and how those operational units will be structured. Importantly (Davies, 2000) argues that strategy should determine the resources that will be needed to achieve any goals and objectives and how these resources will be acquired and used. (Campbell and Alexander, 1997) argue that many managers believe there is a structure and order to strategy development that should be followed. Often many strategists begin by choosing a mission -- a long term purpose for the organization, then they define short-term and mid-term objectives that sets the organization on a path toward the mission. A strategy can then be developed to achieve the objectives using short-term operating decisions, or tactics, to implement the strategy. However they (Campbell and Alexander, 1997) argue that tactics need to be worked out before the strategy can be determined, and the strategy needs to be clear in order to define the objectives. As (Mintzberg, 1994) argued strategy making does not occur in isolation. It does not occur because a meeting is held with that label. Rather, strategy making is a process interwoven with all that it takes to manage an organization. A critical part of strategy formulation is understanding what tactics, technologies and programs are available and which of these will provide the most benefit for the enterprise.

Operations capabilities can allow small firms to compete successfully with much larger competitors even in situations where they lack size and experience, do not have radical new technology, and are not entering an emerging market (Hayes and Upton, 1998). Because this competitive advantage is embedded in people and operating systems, it is less apparent to competitors and difficult to imitate (Hayes and Upton, 1998). Hence operations capabilities can form the basis of sustainable competitive advantage. It is argued that SMEs who adopt AMT can benefit by improving competitiveness through faster innovation and production, increasing flexibility and reducing costs (Meredith, 1987). There is some evidence to support these claims. For example, use of advanced management practices has been linked to higher performance in SMEs in developed countries (Cagliano, Blackmon, and Chris, 2001; Garsombke and Garsombke, 1989).

Adoption of management technologies by SMEs may be the result of pressure from government or associated companies or customers. Many SMEs feel forced to adopt ISO9000 standards but then do not move to adopt other quality management systems (van der Wiele and Brown, 1998). Pressure from customers forces small

firms to adopt JIT philosophy (Stamm and Golhar, 1991). Adoption patterns may also be influenced by the characteristics and preferred abilities of SMEs (Cagliano, Blackmon, and Chris, 2001). Smaller firms may lack sufficient financial and human resources required for the implementation of some AMT, resulting in lower levels of adoption of more costly technologies. Lack of resources is identified as a problem in implementing statistical process control (Krumwiede and Sheu, 1996) and just-in-time manufacturing (Lee, 1997). Another problem in small businesses may be the lack of business experience and knowledge of the business owner (Haksever, 1996). Business owners need to be convinced to introduce technology (Haksever, 1996). Lack of upper management support is cited as a significant problem in introducing statistical process control in small businesses (Krumwiede and Sheu, 1996). Small business managers may also distrust consultants who could provide assistance (Ghobadian and Gallear, 1997). SMEs because of their size may also lack bargaining power with suppliers and customers (Stamm and Golhar, 1991). This can make it difficult to get the cooperation needed for adoption of total quality management (Sun and Cheng, 2002) and just-in-time manufacturing (Lee, 1997), particularly just-in-time delivery (Manoochehri, 1988).

Once they decide to introduce new technology, small business managers can often bring about change more quickly in small firms than is generally possible in larger firms because they have fewer layers of bureaucracy, tend to be less geographically dispersed, have shorter communication lines, and are less bound by tradition (Haksever, 1996). They are also noted as having more flexibility because of low labor specialisation and their small lot size production, and having more participatory decision making (Manoochehri, 1988). The informal nature of smaller businesses and leadership of owner/managers can make implementation of TQM, for example, easier in small firms than in large (Haksever, 1996).

Studies of different AMTs suggests that they can be successfully introduced into SMEs, but that they will be implemented in ways that differ from large businesses. For example, in implementing TQM, small companies put more emphasis on leadership, employee involvement and quality information whereas larger firms emphasize training, feedback, quality assurance, and supplier cooperation (Sun and Cheng, 2002). In implementing kaizen, (Chapman and Sloan, 1999) reported significant differences in the mechanisms used.

Previous studies suggest that the payoff from various AMTs is also likely to differ between large and small companies. For example, ISO certification has been related to higher performance in small companies but not in large companies (Sun and Cheng, 2002). Because of shortages of capital, changes in processes that free up capital from inventory such as just-in-time manufacturing can have a higher pay-off for small businesss than for large (Manoochehri, 1988). It is suggested that benchmarking is also likely to benefit small companies more than large because of their reliance on intangible assets (Monkhouse, 1995).

This research on ATM suggests that the type of ADM adopted by small enterprises would be expected to differ from that adopted by large businesses. Moreover, the implementation process is likely to differ which may also contribute to different payoffs for small enterprises. To determine the extent to which small and large enterprises differ, this study compares the use, future use and payoff of AMT in large and small enterprises in both OECD and non-OECD countries.

Method

The second International Manufacturing Strategy Survey (IMSS) was conducted in the period 1996-98 in 23 countries in the Americas, Europe and the Asia Pacific, with over 700 responding firms. It was almost entirely a mail survey, utilising a common questionnaire in all countries, except for minor modifications for local

differences in terminology. The survey questionnaire was divided into four sections: a) strategies, goals, and costs, b) current manufacturing and integration practices, c) past and planned activities in manufacturing, and d) manufacturing performance. The respondent was generally the manufacturing or production manager, or the general manager. This paper reports on data collected in section c) past and planned activities in manufacturing.

The IMSS comprised a random or representative sample of firms in International Standard Industrial Classification (ISIC) 38 – Manufacture of Metal Products, Machinery and Equipment, concentrated on medium to large companies. There was participation from 703 leading assembly manufacturers in the IMSS, including 87 from Australasia (Australia and New Zealand), and 307 from the ten European countries, Denmark, Finland, Germany, Hungary, Italy, Netherlands, Norway, Spain, Sweden and United Kingdom. The remaining firms comprised 81 from North America (USA and Canada), 105 from Central and South America (Argentina, Brazil, Chile, Mexico, Peru) and 123 from the following Asian countries, China, Hong Kong, Japan, South Korea. The 17 OECD countries provided 583 of the responding firms, whilst the remaining 120 firms came from the six Non-OECD countries.

Results

In this analysis firms are classified according to number of employees. Small to medium firms (SME) are firms with less than 100 employees and large firms are firms with more than 100 employees. In determining size category, the number of employees locally is used to classify a company. If the question on local employees was left blank on the questionnaire, the number of employees across the country was used to classify the firm. There were 632 usable returns after deleting those who provided insufficient information for analysis. The number of firms in each category is summarized in table 1.

Table 1: Number of firms by size

	Small-medium firms	Large firms
OECD:	72	459
NON-OECD	23	78

The data presented in tables 2 and 3 presents the firms use, payoff and expected future use of quality related programs. In comparing large firms and SMEs in OECD countries, more large firms maintain that they are involved in the quality activities and are achieving a significant payoff and intend to use them in the future, except for a higher future use of zero defect programs by SMEs. The overall pattern is the same in non-OECD countries where SMEs indicate lower past usage and lower payoffs, but intend to use Statistical Process Control and Quality Policy Deployment more in the future than large firms. Comparing SMEs in OECD and non-OECD countries, non-OECD firms report higher use of KAIZEN, Quality Policy Deployment, Statistical Process Control, and Quality Function Deployment, record similar or higher payoffs on these, and expect higher future use.

Table 2: Quality Variables - Past Use, Payoff and Future Use in SME

Small Firms	OECD				NON-OECD			
	High Past Use		Pay Off	High Future Use	High Past Use		Pay Off	High Future Use
	Count	%	%	%	Count	%	%	%
ISO 9000 Certification	38	52.78	25.00	59.72	10	43.48	39.13	47.83
TQM Program	18	25.00	29.17	51.39	4	17.39	13.04	47.83
KAIZEN	18	25.00	18.06	41.67	6	26.09	17.39	52.17
Quality Policy Deployment	15	20.83	19.44	23.61	8	34.78	30.43	65.22
Statistical Process Control	11	15.28	13.89	22.22	8	34.78	21.74	52.17
Quality Function Deployment	11	15.28	12.50	18.06	4	17.39	21.74	30.43
Zero Defect Program	17	23.61	12.50	43.06	5	21.74	21.74	43.48

Table 3: Quality Variables - Past Use, Payoff and Future Use in Large Firms

Large Firms	OECD				NON-OECD			
	High Past Use		Pay Off	High Future Use	High Past Use		Pay Off	High Future Use
	Count	%	%	%	Count	%	%	%
ISO 9000 Certification	317	69.06	46.19	64.92	48	61.54	64.10	70.51
TQM Program	179	39.00	35.29	49.24	40	51.28	52.56	56.41
KAIZEN	172	37.47	37.91	49.67	44	56.41	53.85	53.85
Quality Policy Deployment	162	35.29	26.14	36.17	27	34.62	47.44	50.00
Statistical Process Control	129	28.10	26.58	40.74	42	53.85	47.44	47.44
Quality Function Deployment	117	25.49	23.97	31.59	36	46.15	47.44	47.44
Zero Defect Program	100	21.79	21.57	31.37	28	35.90	41.03	58.97

As shown in Tables 4 and 5, a similar pattern emerges with technologies as occurs with quality activities. Regardless of the location, large firms use, benefit and intend to use quality activities more in the future than small firms. Again, however, there is higher use of some technologies in non-OECD countries as well as higher intended use of most technologies. It is interesting to note that small non-OECD firms intend to use Material Requirement Planning, Shared Databases, Manufacturing Requirement Planning (MRP) and Computer-Aided Inspection in the future more than small OECD firms. Given the hype that has been attached to the internet and intranets it is surprising to note that even when it comes to future use only 48% of large firms indicate a significant large usage.

The analysis of activities other than quality and new technologies presents a slightly different picture. Comparing large firms and SMEs in OECD and non-OECD countries, cost activities are performed more by large firms than smaller firms, the exceptions being Health and Safety programs and Just-In-Time deliveries in OECD countries, and Implementing a Team Approach and Defining a Manufacturing Strategy in non-OECD countries. It would appear that small OECD firms are focusing on improvements in their supply chain when it comes to Just-In-Time Deliveries. In the case of Just-In-Time Deliveries small OECD firms score the highest on future use(55.6%) and past payoff(50%) with a second highest score of 43% for past use compared to large non-OECD firms at 55%. As with the previous analyses, non-OECD countries indicate higher future use in many of the activities than similar size companies in OECD countries.

Table 4: Technology Variables - Past Use, Payoff and Future Use in SMEs

Small Firms	OECD				NON-OECD			
	High Past Use		Pay Off	High Future Use	High Past Use		Pay Off	High Future Use
	Count	%	%	%	Count	%	%	%
Computer-Aided Design	26	36.11	37.50	51.39	7	30.43	26.09	47.83
Local Area Network	20	27.78	27.78	47.22	5	21.74	26.09	26.09
Material Requirement Planning	14	19.44	20.83	38.89	4	17.39	21.74	47.83
Numerical Control, Computer, Direct	15	20.83	22.22	23.61	2	8.70	17.39	26.09
Shared Databases	9	12.50	12.50	19.44	3	13.04	21.74	34.78
Computer-Aided Engineering	10	13.89	18.06	25.00	0	0.00	4.35	13.04
Manufacturing Requirement Planning	11	15.28	16.67	26.39	1	4.35	8.70	34.78
Computer-Aided Inspection	5	6.94	5.56	19.44	3	13.04	13.04	30.43

Table 5: Technology Variables - Past Use, Payoff and Future Use in Large Firms

Large Firms	OECD				NON-OECD			
	High Past Use		Pay Off	High Future Use	High Past Use		Pay Off	High Future Use
	Count	%	%	%	Count	%	%	%
Computer-Aided Design	270	58.82	54.90	59.91	51	65.38	48.72	56.41
Local Area Network	197	42.92	41.61	48.37	23	29.49	34.62	29.49
Material Requirement Planning	196	42.70	39.65	40.74	45	57.69	53.85	64.10
Numerical Control, Computer, Direct	164	35.73	40.09	35.73	32	41.03	26.92	46.15
Shared Databases	155	33.77	36.60	47.93	17	21.79	28.21	48.72
Computer-Aided Engineering	149	32.46	32.03	38.13	22	28.21	33.33	37.18
Manufacturing Requirement Planning	142	30.94	29.41	40.31	37	47.44	51.28	55.13
Computer-Aided Inspection	113	24.62	27.45	34.42	34	43.59	43.59	47.44

In the work organisation and job design literature much has been made of the benefits of team based approaches. This would not be supported by the payoffs indicated in tables 6 and 7. While 41% of large OECD firms indicate a significant payoff, 30% small non-OECD firms indicate a better payoff than large non-OECD firms or small OECD firms.

There should be a real concern about the level of usage and pay off from Defining a Manufacturing Strategy, particularly in small firms with less than 30% of small firms indicating they have defined a manufacturing strategy in the past and only 40% intending to do so in the future. There has also been a focus in recent years on Activity Based Costing yet the highest score (25.64%) for past use is in large non-OECD firms.

Table 6: Other Variables - Past Use, Payoff and Future Use in SMEs

Small Firms	OECD				NON-OECD			
	High Past Use		Pay Off	High Future Use	High Past Use		Pay Off	High Future Use
	Count	%	%	%	Count	%	%	%
Health and Safety Programs	38	52.78	47.22	63.89	6	26.09	26.09	47.83
Implementing Team Approach	13	18.06	18.06	40.28	7	30.43	30.43	56.52
Just-In-Time Deliveries	31	43.06	50.00	55.56	9	39.13	39.13	52.17
Defining a Manufacturing Strategy	19	26.39	31.94	40.28	6	26.09	30.43	39.13
Environmental Protection Programs	12	16.67	15.28	37.50	2	8.70	21.74	26.09
Just-In-Time Manufacturing	15	20.83	19.44	51.39	6	26.09	26.09	43.48
Benchmarking	15	20.83	13.89	33.33	5	21.74	30.43	39.13
Pull Scheduling	7	9.72	11.11	12.50	3	13.04	13.04	17.39
Activity Based Costing	10	13.89	19.44	30.56	2	8.70	13.04	52.17
Energy Conservation Program	5	6.94	6.94	9.72	2	8.70	13.04	17.39

Table 7: Other Variables - Past Use, Payoff and Future Use

Large Firms	OECD				NON-OECD			
	High Past Use		Pay Off	High Future Use	High Past Use		Pay Off	High Future Use
	Count	%	%	%	Count	%	%	%
Health and Safety Programs	234	50.98	48.58	54.25	44	56.41	52.56	65.38
Implementing Team Approach	190	41.39	41.39	54.68	11	14.10	19.23	29.49
Just-In-Time Deliveries	159	34.64	35.29	48.15	43	55.13	47.44	53.85
Defining a Manufacturing Strategy	157	34.20	32.03	47.28	17	21.79	23.08	33.33
Environmental Protection Programs	161	35.08	33.77	50.54	32	41.03	38.46	57.69
Just-In-Time Manufacturing	138	30.07	30.50	45.97	31	39.74	38.46	39.74
Benchmarking	110	23.97	23.97	43.57	24	30.77	37.18	51.28
Pull Scheduling	115	25.05	27.45	33.12	34	43.59	30.77	41.03
Activity Based Costing	98	21.35	22.66	33.12	20	25.64	14.10	24.36
Energy Conservation Program	103	22.44	25.71	35.29	11	14.10	10.26	21.79

Conclusions

The strategic use of improvement activities such as quality programs and Kaizen is much higher in large firms than in small firms regardless of whether they are based in developed economies or developing economies. This may be related to the knowledge and capacities of SMEs or it may be that they have neither the financial resources nor people to invest in improving their processes and systems. Nonetheless ISO 9000

Certification which for most firms is an expensive investment is widely used and there appears to be little if any decline in its importance to the firms in this study. Large firms in both non-OECD and OECD economies are investing in and using technologies such as CAD , MRP and CNC machinery and are achieving significant payoffs while small firms appear to be slower to invest in these technologies and do not achieve the same payoffs as large firms. When other activities and programs are considered small firms appears to be benefiting from supply chain strategies such as JIT deliveries and they may have to focus on these to satisfy customers' needs. A significant concern is the lack of activity in defining manufacturing strategies in all firms responding to this survey. It may be the case that the firms in this sample International Standard Industrial Classification (ISIC) 38 – Manufacture of Metal Products, Machinery and Equipment, see little or no need for a strategy as they tend to be component manufacturers and often manufacture to order rather than supply final consumer products.

Small firms will continue to struggle to compete while they are either unwilling or unable to invest in improvement programs and activities and new technologies. To remain competitive regardless of their location, in developing or developed economies, large manufacturers need to continually seek out ways to reduce cost, improve quality and conformance to customers' specifications as well as deliver goods faster and on time. If large firms are to achieve these goals they will continue to invest in improving their processes, systems and technologies. While small agile business may survive for short periods of time, to remain competitive they must also seek to improve their processes, systems and technologies. Some of the small firms in this study have recognised this and invested in low-cost people-centred activities such as team based approaches and Kaizen. In the short to medium term this can sustain them; in the longer term they will have to find ways to invest in more expensive activities and advanced manufacturing technologies.

References

Cagliano, R., K. Blackmon, et al. (2001). "Small firms under Microscope: international differences in production/operations management practices and performance", Integrated Manufacturing Systems, Vol 12 No 4, pp. 469-482.

Campbell, A. and Alexander M. (1997). "What's wrong with strategy?" Harvard Business Review, Vol 75 No 6, pp. 45-50.

Chapman, R. L. and Sloan T. R. (1999). "Large firms versus small firms - do they implement CI the same way?" The TQM Magazine, Vol 11 No 1, pp. 105-.

Davies, W. (2000). "Understanding strategy." Strategy & Leadership, Vol 28 No 5, pp. 25-30.

Garsombke, T. W. and Garsombke D. J. (1989). "Strategic implications facing small manufacturers: The linkage between robotization, computerization, automation and performance." Journal of Small Business Management, Vol 27 No 4, pp 34-44.

Ghobadian, A. and Gallear D. (1997). "TQM and organization size." International Journal of Operations & Production Management, Vol 17 No 2, pp. 121-163.

Haksever, C. (1996). "Total quality management in the small business environment." Business Horizons, Vol 39 No2, pp. 33-40.

Hayes, R. H. and Upton D. M. (1998). "Operations-based Strategy." California Management Review, Vol 40 No 4, pp. 8-25.

Krumwiede, D. and Sheu C. (1996). "Implementing SPC in a small organisation: a TQM approach." Integrated Manufacturing Systems, Vol 7 No1, pp. 45-51.

Lee, C. Y. (1997). "JIT adoption in small manufacturers in Korea." Journal of Small Business Management, Vol 35 No 3, pp. 98-107.

Manoochehri, G. H. (1988). "JIT for small manufacturers." Journal of Small Business Management, Vol 26 No 4, pp. 22-30.

Meredith, J. (1987). "The strategic advantages of new manufacturing technologies for small firms." Strategic Manufacturing Journal, Vol 8, pp. 249-258.

Mintzberg, H. (1994). "The fall and rise of strategic planning." Harvard Business Review(Jan-Feb), pp. 107-114.

Monkhouse, E. (1995). "The role of competitive benchmarking in small- to medium-sized enterprises." Benchmarking for Quality Management & Technology, Vol 2 No 4, pp. 41-.

Stamm, C. L. and Golhar D. Y. (1991). "Customer and supplier linkages for small JIT manufacturing firms." Journal of Small Business Management, Vol 29 No 3, pp. 43-49.

Sun, H. and Cheng T.-K. (2002). "Comparing reasons, practices and effects of ISO9000 certification and TQM implementation in Norwegian SMEs and large firms." International Small Business Journal, Vol 20 No 4, pp. 421-442.

van der Wiele, T. and Brown A. (1998). "Venturing down the TQM path for SMEs." International Small Business Journal, Vol 16 No 2, pp. 50-68.