The Relationship between Technological Innovation, Activity Based Costing and Business Size

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Abstract

Size is one of the most controversial influencing factors in the diffusion literature. Some authors argue that large firms have several advantages over smaller firms in the adoption of an innovation (Brown 1981), while others argue that diffusion of innovation in small firms is quicker than in large firms because of the advantages associated with small size (Acs & Audretsh, 1988; Julien, 1993; Lefebvre & Lefebvre, 1993; Riding, 1993). However, the controversy on the impact of size on diffusion of innovation has been further complicated by the mixed results of the studies investigating the relationship between size as an influential factor and diffusion of innovation (Aiken, et al., 1980; Blau & McKinley, 1979; Booth & Giacobbe, 1998; Damanpour, 1992; Dewar & Dutton, 1986; Hage, 1980; Krumwiede, 1998; Libby & Waterhouse, 1996). Shedding light on this controversy, this paper examines the relationship between business size and the diffusion of both technological innovation and activity based costing (ABC) through a longitudinal study in a single industry.

Keywords: management accounting; diffusion; innovation; activity-based costing and business size

Introduction

There are a variety of factors such as annual sales, total assets, total revenue, net worth of firms and number of employees, which could be used to define firm size. Considering these factors, Forsaith and Fuller (1995: 1), state that "enterprises are most frequently classified by size according to the number of people they employ". They suggest that as changes in factors such as annual sales, total revenue, total assets, and net worth of firms occur more frequently than changes in the number of employees each year, defining firms based on such volatile factors may result in a change in the classification of firms each year.

Given these different parameters, Forsaith and Fuller (1995: 5) use two measures to specify business size: 1) public negotiability of share ownership, and 2) personal guarantee of any existing or planned financing. According to these measures, publicly held companies are by nature, subject to financial markets and the consequent discipline and requirement, which determine the market value of these shares. But in private firms, owners are required to submit personal guarantees on any debt to the lenders who have no direct control in these firms. As in large firms the investors' investments are the maximum guarantees of investors; difference in guarantees is one of the main differences between small and large firms (Forsaith & Fuller, 1995). Following this statement, Forsaith and Fuller (1995) point out that many firms are neither small nor large. Such firms are not publicly listed, yet financial markets do not require personal guarantees for firm financing. These firms are defined as *medium sized firms* (Osteryoung & Newman, 1992).

Watson and Everett (1993: 40) also recognise that numerous definitions of small business have been suggested. They refer to a Congressional Committee in the U.S., which was presented with 700 definitions. The definition of small business that Watson and Everett (1993: 40) have used in their study is: “a business in which one or two persons are required to make all the critical management decisions such as finance, marketing, selling without the aid of internal specialists and with specific knowledge in only one or two functional areas”. Berryman (1993: 7) states that these conditions have been found to exist in the majority of enterprises with less than 100 employees.

Nooteboom (1994: 328) points out that in Europe usually 'small enterprises' engage between 5 to 50 persons (in the Netherlands 10), and 'medium-sized enterprises' engage between 50 to 500 persons (in the Netherlands 100). Indeed, small businesses have different definitions in different countries. For example in the Netherlands, firms with more than 100 persons are considered large, while in the United Kingdom firms with less than 200 employees are considered as small, between 200 to 500 medium-sized and more than 500 large (McMahon, et al. 1993; 11).

Furthermore, in addition to the difference between the number of employees in different countries, there is also a difference between the number of employees in different industries. This means that, while in consumer services a firm may be considered 'large' when it exceeds 50 or 100 employees, in manufacturing it may not be considered 'large' until it exceeds 200 or 500 employees. For example, in New Zealand a small business is "one employing less than 50 persons in the manufacturing sector, less than 25 in wholesaling and retailing, and less than 10 in the service sector" (McMahon, Forsaith et al. 1993: 11). Watson and Everett (1993: 40) note that a quantitative definition based on attributes such as number of employees, annual sales or total worth is generally preferred, but the difficulties with using any of the above factors includes the need for different measures in different types of industries. Therefore, it should be remembered that the *ideal* definition of business size depends on the purpose of the study, and it could vary in different countries and in different types of industries.

McMahon, *et al*, (1993: 11) state that businesses which “have independent ownership, are not dominant in their field, and meet specific size guidelines which may include the number of employees,..., or the net worth of the company" can be classified as small size business. They also report that a manufacturing firm in Australia with less than 100 employees is considered to be small while for a non-manufacturing firm this figure is 20. As the definition of firms based on the number of employees is one the most widely used definitions in the world, the above definition as confirmed by the Australian Bureau of Statistics (ABS) will be used in this study. However, according to Berryman (1993: 6), about 90 percent of small businesses in Australia employ 20 or fewer persons and the majority consist of fewer than 10 persons. Given these explanations, this paper clarifies the sizes of firms based on the above parameters and examines the relationship between the size of the firms and the diffusion of both technological innovation and administrative/accounting innovation, with activity based costing being used as an example of the latter.

Background

Size has remained one of the most controversial influencing factors in the diffusion literature since most practical investigations of the influence of size on diffusion of innovation have produced mixed results (Aiken, et al., 1980; Blau & McKinley, 1979; Damanpour, 1992; Dewar and Dutton, 1986; Hage 1980). Some authors claim that large firms have several advantages over smaller firms in the adoption of an innovation. For example, Brown (1981) argued that one of the advantages of large firms is their greater ability to afford capital, to put up with the costs of innovation and bear the risk of failure. He further added that larger firms are also capable of better affording managerial and technical specialists.

Other authors argue that small firms have several advantages over larger firms in the adoption of an innovation. Nooteboom (1994: 339) lists some of these advantages as: less bureaucracy, greater motivation, better survey of the entirety of the project, and greater proximity to the market. According to Nooteboom, these factors are likely to facilitate the diffusion of innovations in small firms. Given these advantages, Nooteboom further claims that small firms bring technological change to the market more quickly than large businesses.

Some authors also argue that small firms are more innovative than large firms. For example, Segers (1993) states that a significant number of basic technological changes have originated in small firms. He further emphasises that small firms often play an important role in industries characterised by a particularly high rate of growth and technological changes. Supporting this argument, Feldman (1994: 363) suggests that in certain industries, small businesses are the prime source of technological change.

It has also been suggested that small firms have historically made an important contribution to technological change and the diffusion of innovation. Lefebvre and Lefebvre (1993: 298) argue that in terms of product innovation, it would appear that historically small firms may have contributed greatly to the improvement of existing products and even to the creation of new ones. They emphasise that clearly more empirical research is required to fully understand the underlying dimensions of technological change and the diffusion of innovation in smaller manufacturing firms.

Julien (1993: 160) argues that, despite a time lag in the use of technological change and diffusion of innovation in small and large firms, it nevertheless seems that such changes and innovations are currently diffused more quickly in small firms than in larger ones. He notes that many recent studies show that small firms are more innovative than large firms and concludes that small firms are characterised by a relatively rapid rate of technological change and diffusion of innovation.

Justifying the advantage of small size in facilitating the diffusion of innovation, Julien (1993: 162) claims that a key factor in the continued existence of small firms lies in the behaviour of entrepreneurs and their propensity to innovate. This means that facilitating diffusion of innovation in small business helps them to compete, otherwise large firms may capture the markets and this could be an important threat to the survival of small firms. In other words, in addition to the other factors such as capital, and financial management, the facilitation of diffusion of innovations has an important role in the survival and of small businesses. Supporting this argument, Shields and Young (1994: 175) state that, increasingly, small firms are gaining competitive advantage through innovative activity. As small firms are expected to compete with large firms in the market, they always need to have better ability in diffusion of innovations in order to bring improvement in their products and services and to consider the introduction and production of new products, otherwise they could fail.

Extending this debate, Johne and Rowntree (1991: 247) state that there is an accumulated body of evidence on the organisation and management of successful diffusion of innovation in relation to product development in manufacturing small firms. They emphasise that product developments are of critical importance to small firms because they can present the opportunity for taking the first independent steps for further product development and competition in the market. Product improvement could include improvement in the existing products and services of small firms, introduction and use of an entirely new material or equipment in the production processes, and production of a whole range of new product groups.

Supporting this argument, Dana, *et al*, (1994: 71) characterise small firms as entrepreneurial and innovative, defining entrepreneurial activity in terms of the process of doing something new (creative) and something different (innovative) for the purposes of creating wealth. Ham and Lischeron (1991: 50) confirm that the key ingredient of entrepreneurship lies in innovativeness and they also refer to innovation, creation, or discovery as the key factors for the survival of small enterprises. Ham and Lischeron point out that the term "entrepreneur" has often been applied by some authors to the founder of a new business or to a person who started a new business where there was none before. Others, however, reserve the term to apply only to the innovator of a creative activity. Yet others refer to the identification and exploitation of any opportunity as entrepreneurial. Ham and Lischeron note that much of the entrepreneurial literature has included risk-taking as a major characteristic of the entrepreneur. In this view they refer to the definition of 'entrepreneur' in Webster's dictionary as "a person who organises or manages a business undertaking, assuming the risk for the sake of profit". This argument is consistent with small businesses having advantages in the diffusion of innovation and by their nature these firms are always expected to be innovative.

Considering the influence of small size as a facilitating factor in the diffusion of innovation, Acs and Audretsh (1988: 200) state that one study of 635 technological changes in the U.S. between 1970 and 1978 found that small firms produce 2.5 times as many technological changes per employee as did larger firms. They also mention that the greater propensity of small firms to innovate is true regardless of the type and the scope of the technological change. Confirming this argument, Riding (1993: 14) introduces R&D expenditure as an index for measuring innovation and technological change, and states that the average per cent of the revenue which small businesses (employing less than 50 people) spend on research and development expenditures (R&D) is much more than those in larger firms. According to Riding (1993: 14) two thirds of the firms performing R&D in Canada are small; such firms spend an average of 12.4 per cent of their revenue on R&D, while by comparison, larger firms spend an average of 1.6 per cent of their revenue on R&D.

However, both the Acs and Audretsh (1988) and Ridings (1993) findings use scale weightings: per employee and per $ revenue respectively. In absolute terms we can expect larger firms both to spend more on R&D and to make more technological changes. Given the above argument, this paper empirically examines the relationship between size and the diffusion of both manufacturing innovation and activity based costing.

Research Method

A two stage longitudinal (1985-2001) survey was designed to gather information for this study. In both stages (first stage in 1997 and the second stage in 2001), the survey was administered to all 200 manufacturing firms registered with the Australian plastics industry (PACIA). The selection of the plastics industry for this investigation was due to the fact that organisations in this industry are known to have undergone considerable innovation and change to their manufacturing procedures during the last two decades.

Two different questionnaires were designed in two separate stages of this longitudinal study to capture the necessary information on the diffusion of technological changes and cost and management accounting innovations. The first stage of the survey (relating to the period 1985 to 1996) aimed to investigate whether there was any change, or perceived need for change in the management accounting techniques employed in response to the diffusion of technology in manufacturing processes. It also aimed to examine the relationship between business size, the diffusion of manufacturing innovation and activity based costing. Besides business size, the first stage survey further also explored other influencing factors (from the users' point of view) and provided a framework for the second stage survey in order to investigate their impact on the diffusion of cost and management accounting innovation.

PACIA agreed to distribute the questionnaires to the firms registered with them in both stages, but did not divulge the name of the firms concerned to the researcher. This restriction resulted in lack of opportunities both for follow-up enquiries and for interview.

Survey Findings

Responses to the survey were provided by 51 firms in the first stage and 31 firms in the second stage, representing disappointing response rates of 25% and 15% respectively. Non-response bias was examined in both stages using the aggregate details provided by PACIA including: number of employees, year of establishment, and the activities of the firms. A comparison between the early responses and late responses (in both stages) showed there was no perceived difference between these responses, suggesting that non-response bias would not influence the outcomes. Using the results of the first stage of the study, this paper first examines the relationship between business size, manufacturing innovation and activity based costing.

Business Size

The research literature on 'the diffusion process and influencing factors' indicates that there are some significant differences in the emphasis regarding the impact of influential factors on the diffusion of innovations. Some researchers tend to give more attention to the characteristics of the innovation and those of the adopting firms, including size; whereas, other researchers give relatively more emphasis to the society, economy, and communication or information flow process. However, it is difficult to generalise such preferences. Depending on the type of societies, innovations, and the interaction between the influencing factors, the importance and the influence of factors responsible for the diffusion of an innovation might change. Social concerns in some societies might give added importance to some innovations that might have otherwise not been diffused, and reduce the importance of other innovations; an innovation might be associated with a specific social, economic, geographical and institutional situation within which diffusion is likely. Furthermore, there are also some important variations in the way that these influencing factors are seen to hinder or facilitate the diffusion process. However, as mentioned earlier, there are a number of parameters which are suggested to measure the size of firms. The current study examines the size of targeted firms based on three alternative parameters as follows:

Number of employees:

Number of employees is one criterion for determining size of firms and categorizing firms to small, medium and large firms. The Australian Bureau of Statistics (1993: 24) defines large manufacturing establishments as those, which employ over 600 persons. According to this definition, manufacturing establishments, which employ less than 100 persons are considered small establishments, and non-manufacturing establishments, which employ less than 20 persons, are considered to be small. Medium establishments are those which are neither classifiable as large or small. In other words, those establishments, which employ 100 to 600 persons in manufacturing establishments and 20 to 600 persons in non-manufacturing establishments, are medium-sized. As Table 1 shows, more than 82 percent of plastics industry establishments have fewer than 100 employees. This information is consistent with the Status and Outlook Study Report on the Australian Plastics Industry, published in February 1997. Also, the proportion of establishments, which have more than 600 employees, is less than 6 per cent. In other words, 94 percent of establishments in PACIA are small and medium-sized and only 6 percent of establishments can be considered to be large.

Table 1: Number of employees in organisations

Number of employees	Percentage	Accumulated
Less than 20	35.3	35.3
20 to 49	39.2	74.5
50 to 99	7.8	82.3
100 to 199	2.0	84.3
200 to 499	9.8	94.1
Over 500	5.9	100

Annual Gross Operating Revenue

Annual gross operating revenue is a second measure for determining the size of establishments. As Table 2 shows, more than 94 percent of establishments have a total annual gross revenue of less than $100 million. McKinsey & Company (1993) considered small and medium-sized establishments to be those with under $100 million annually in total sales or fewer than 500 employees. Using this definition, more than 94 percent of establishments in the Australian plastics industry are small and medium-sized, and only about 6 percent of establishments are large. This classification is consistent with the classification of establishments based on the number of employees. In other words, using either the number of employees or the annual gross revenue as an index of size, the percentage of large establishments in PACIA is about 6 per cent. There thus appears to be a strong relationship between the number of employees and the total annual gross revenue of the establishments.

Table 2: Categorising establishments based on their annual gross operating revenue

Annual gross revenue	Valid percent	Cumulative percent
Less than $1 million	23.4	23.4
$1m to less than $5m	41.2	64.6
$5m to less than $10	15.6	80.2
$15m to less than $20	2.0	82.2
$20m to less than $50	2.0	84.2
$50m to less than $100	9.8	94.0
$100m to less than $200	2.0	96.0
$500m to less than $1000	2.0	98.0
$1000m and over	2.0	100.0

Total assets of the organisation

Similar to the annual gross operating revenue and the number of employees, the total assets of the establishment is a further index for size classification of establishments. As Table 3 shows, more than 95 percent of the establishments have total assets of less than $200,000,000. According to the definition of establishments by their total assets presented by the Australian Bureau of Statistics (1995), large establishments are those, which have assets of more than $200 million, and small and medium establishments are those, which have assets of less than $200 million. If we use this definition and classify the establishments based on their total assets, 95.9 percent of the establishments are small and medium sized.

This figure is very close to the previous classifications based on both annual gross revenue and the number of employees.

Table 3: Categorising of establishments based on their total assets

Total assets	Valid percent	Cumulative percent
Less than $1 million	40.9	40.9
$1m to less than $5m	32.8	73.7
$5m to less than $10	8.2	81.9
$10m to less than $15	2.0	83.9
$15m to less than $20	2.0	85.9
$20m to less than $50	6.1	92.0
$50m to less than $100	2.0	94.0
$100m to less than $200	2.0	96.0
$500m to less than $ 1000	2.0	98.0
$1000m and over	2.0	100.0

As Table 4 shows, the three alternative measures of business size including: number of employees; total assets employed; and gross revenue are very closely related to each other.

Table 4: Correlation Coefficient Matrix for Size Measures

	Employees	Assets	Revenue
Employees	1.000		
Assets	0.942 sig (.001)	1.000	
Revenue	0.953 sig (.001)	0.968 sig (.001)	1.000

The Pearson correlation coefficient reveals measures in excess of 0.94 for each of the inter-correlations, all statistically significant at the 1% level. Accordingly, a single measure of size (number of employees) is used for all further size-related tests of the 51 respondents to the first stage of the study.

Using the above parameters for determining the size of firms, the findings indicate that the majority of establishments in this study should be considered as small.

Diffusion of Manufacturing Innovation

Technological changes in manufacturing practices addressed in the current study have included the following techniques:

- computer aided design (CAD)
- computer aided engineering (CAE)

- computer aided machining
- computer aided manufacturing (CAM)
- computer aided process planning (CAPP)
- computer-integrated manufacturing (CIM)
- direct numerical control (DNC)
- flexible manufacturing system (FMS)
- just in time (JIT)
- numerical control (NC)
- robot
- testing machine

As Table 5 shows, advanced manufacturing techniques have been widely used by the Australian plastics industry. According to the information provided by respondents, more than 92 per cent of respondents have experienced one or more types of advanced manufacturing technique up to the time of the investigation. Also, the proportion of establishments, which have used more than one type of advanced technology, was more than 76 percent. In other words, although the benefits associated with use of each technique might not be considered as very high, the percentage of the establishments which have used any one kind of advanced technology is high.

Table 5: The frequency of application of advanced manufacturing techniques by Australian Plastics industry during 1985-1996

Manufacturing technique	Percentage of use in 1995-6	Percentage of use before 1985	Percentage of change
Automation	26	2	24
Computer-aided design	49	4	45
Computer-aided engineering	32	4	28
Computer-aided manufacturing	39	4	35
Computer-integrated manufacturing	22	2	20
Computer-driven requirements plan	31	4	27
Direct numerically controlled machines	22	6	16
Expert-based systems	10	2	8
Flexible manufacturing systems	24	8	16
Just in time technique	32	6	24
Numerically controlled machines	37	10	27
Robotics	23	2	21
Testing and inspection machines	57	22	35

Automation

As Table 5 shows, 4 percent of the respondents did not use automated techniques in their manufacturing processes in the last decade. About 4 percent of those establishments, which have not used automation, are likely to use it in the next two years. Only 26 per cent of the respondents have been using automated techniques in their manufacturing processes up to the time of data collection.

Computer-aided design

The prevalence of the usage of Computer-aided design by the population under study has been more than the usage of automation techniques. According to the information gathered in this study, 49 percent of the respondents have used Computer-aided design techniques in their manufacturing processes in the last decade.

Computer-aided engineering

Computer-aided engineering is another advanced manufacturing technique employed by some establishments in the Australian plastics industry. As Table 5 shows, 32 percent of the respondents are using this technique.

Computer-aided manufacturing

Table 5 shows the implementation year and the percentage of use of Computer aided manufacturing technique by the establishments. This technique has been used by nearly 39 percent of the respondents and only 2 percent of establishments are likely to use that technique in the next four years. The rest of the respondents, more than 58 percent of the respondents, did not use computer-aided manufacturing techniques in their manufacturing processes at all.

Computer-integrated manufacturing

The use of computer-integrated manufacturing techniques by respondents has been less prevalent in comparison with the other advanced manufacturing techniques discussed so far. About 78 percent of the respondents stated that they did not use this technique. Only 2 percent of the establishments are likely to use Computer-integrated manufacturing technique in the next two years and about 22 percent of the establishments have been using this technique up to the time of the investigation.

Computer-driven requirements plan

Compared with those advanced manufacturing techniques which have been discussed so far, the percentage of those establishments which are likely to use the computer-driven requirements plan technique in the future is higher than the percentage of those establishments which are likely to use other advanced manufacturing techniques. The percentage of those establishments which did not use a computer-driven requirements plan technique is 69 per cent but 9.8 percent of the establishments are likely to use this technique in the next two years.

Direct numerically controlled machines

As Table 5 shows, the use of a Direct Numerically Controlled machines technique by respondents has been even less prevalent than the Computer-integrated manufacturing technique. About 78 percent of respondents stated that they did not use this technique at any time in the past. Also, 2 percent of establishments stated that they were using a Direct Numerically Controlled machines technique up to the year 1995-96 but that they were not using that technique at the time of the investigation.

Expert-based system

Among those advanced manufacturing techniques, which have been addressed in the questionnaire, expert-based systems were the least prevalent technique employed by the establishments. About 90 percent of the respondents stated that they did not use this technique at any time in the past.

Flexible manufacturing systems

The prevalence of use of Flexible Manufacturing Systems by respondents was similar to the extent of use of Computer-integrated manufacturing technique. About 76 percent of the respondents stated that they did not use this technique.

Just in time technique

As Table 5 shows, the percentage of the establishments, which did not use the "Just in time" technique, was the same as the percentage of establishments, which had not used Computer-aided engineering technique. About 68 percent of respondents had not used the "Just in time" technique at any time up to the time of the investigation. Only 2 percent of establishments were using that technique up to the year 1995-96 but did not use it at the time of the investigation.

Numerically controlled machines

The Numerically Controlled Machines technique, as another advanced manufacturing technique, was being used by 37 percent of the respondents at the time of the study. As Table 5 shows, 63 percent of the respondents stated that they did not use a Numerically Controlled Machines technique in their establishments.

Robotics

The percentage of the establishments, which were using Robotics at the time of the study, was not high. As table 5 shows, about 77 percent of the respondents stated that they did not use a robotics technique in their establishments. Two percent of the establishment are likely to use Robotics techniques in the next four years. Only 23 percent of establishments were using Robotics at the time of the investigation.

Testing and inspection machines

Testing and inspection machines were among the more prevalent techniques, which have been used by the establishments. As Table 5 shows, about 57 percent of the respondents have been using this technique at the time of the study. Besides the above mentioned techniques, 4 percent of the establishments stated that they have been using DCS technique, which is a multi-plant multi-located business.

Even though the prevalence of use of each individual technique is not particularly high, the percentage of establishments, which have used any kind of advanced technology, is high. According to Tables 5 more than 93 per cent of establishments have used at least one type of advanced manufacturing technology.

More than 35 percent of the respondents specified that they commenced implementation of their first advanced manufacturing technique more than ten years ago (before 1985). Less than 6 percent of the establishments did not specify the commencement year of employing their advanced manufacturing techniques. The majority of the respondents (between 70 and 76.5 percent) commenced the implementation of such techniques in the 1980s or before. In other words, the majority of the population have more than a decade of experience in observing technological change in their manufacturing practices. It can therefore be concluded that the Australian plastics industry has been an appropriate population for the study of technological change in manufacturing processes

Table 6: Commencing year of first using advanced manufacturing techniques

Commencing year of use AMT	**Valid percent**	**Cumulative percent**
First started before 1985	35.3	35.3
First started in 1985-86	21.6	56.9
First started in 1987-88	5.9	62.8
First started in 1989-90	13.7	76.5
First started in 1991-92	2.0	78.5
First started in 1993-94	7.8	86.3
First started in 1995-96	5.9	92.2
First started in 1995-96	5.9	92.2
Not used	7.8	100.0

The percentage of establishments, which have used more than one type of advanced technology, is more than 76 percent, and only 15.7 percent of establishments have used a single type of technology.

Table 7: Quantity of employed advanced technologies

Number of employed AMT	Valid percent	Cumulative percent
Twelve techniques and more	2.0	2.0
Eleven techniques	2.0	4.0
Ten techniques	2.0	6.0
Nine techniques	2.0	8.0
Eight techniques	3.9	11.9
Seven techniques	7.8	19.7
Six techniques	11.7	31.4
Five techniques	7.8	39.2
Four techniques	15.7	54.9
Three techniques	11.8	66.7
Two techniques	9.8	76.5
One technique	15.7	92.2
No technique	7.8	100.0

Activity based costing

Activity based costing is an approach to costing that focuses on activities as the fundamental cost objects. It uses the cost of these activities as the basis for assigning costs to other cost objects such as products, services, or customers. One of the expectations of the application of technological innovations in manufacturing processes is to increase the demand for the adoption of activity based costing by changing the cost structure of products through increasing overhead costs, but decreasing labour costs. The survey results of the plastics industry do not show a noticeable change in cost structure for the products of firms within this industry for the investigated period of ten years (1986-1996). The average proportions of direct material costs, labour costs and overhead cost of products in the plastic industry have not changed by more than two percent in ten years. The average proportion of direct material costs have remained at 50 to 51 per cent, direct labour costs at 25 to 26 percent and manufacturing overhead costs at 22 to 23 per cent of total costs of products during the period of investigation. Allocation of costs based on each activity was less prevalent than the other overhead allocation methods in the establishments under investigation. Indeed, allocation of overhead costs based on each activity had the lowest prevalence among the establishments. About 75 percent of the establishments have not used such a method, and only 14 percent of establishments were allocating overhead costs based on each activity up to the time of the survey. Another 11 per cent of establishments identified that they would like to use ABC in the near future. Among those establishments which did not use ABC, 54 per cent stated that no discussions had taken place regarding the introduction of ABC, 4 percent reported that a decision had been taken not to introduce ABC, while 17 per cent confirmed that some consideration had been given to introducing ABC.

Business size and diffusion of manufacturing innovation

This section examines the relationship between business size and the diffusion of cost and management accounting innovations, and attempts to provide new evidence in an area which exhibits mixed results.

As Tables 8 and 9 show, over 93 per cent of establishments have experienced one or more types of advanced manufacturing technique up to the time of the investigation of which 74 percent have fewer than 100 employees (which can be classified as small businesses based on the definition adopted in this study) and 18 percent large firms with more than 100 employees. The proportion of establishments, which did not use any advanced manufacturing techniques, as addressed in the previous table, was 8 percent, all being small firms with less than 100 employees.

Table 8: The frequency of small and large organisations within Australian Plastics industry using advanced manufacturing techniques during 1985-1996.

Business size	Using advanced manufacturing techniques		Total
	Yes	No	
Small	38	4	42
Large	9	0	9
Total	47	4	51

The commitment of each of the firms to innovation in their productive process is indicated by the number of advanced manufacturing technology (AMT) innovations that had been made over the period.

These ranged from 0 to 12 in number for the companies surveyed. Table 9 details the correspondence of the number of AMTs with the size of the company, based on number of employees.

Table 9: AMT innovations and Number of employees

Number of employees	**Number of AMT innovations**													**Total**
	0	1	2	3	4	5	6	7	8	9	10	11	12	
< 20	2	6	3	3	3	1								18
20 < 100	2	2	2	1	2	2	5	3	1					20
100 < 200				2	1			1						4
200 < 300							1							1
300 < 400					2	1						1	1	5
400 < 600														0
> 600									1	1	1			3
Total	4	8	5	6	8	4	6	4	2	1	1	1	1	51

These 51 companies make a total of 210 AMT innovations over the period, though as the table reveals, these are far from randomly distributed. The correlation coefficient between number of employees and number of AMT innovations is 0.651 (significant at the .001 level) demonstrating a clear positive relationship between the two: bigger companies make more technological innovations.

Aggregating some of the categories above to increase the cell-size sufficiently to perform a contingency table test, gives Table 10.

Table 10: Contingency Matrix for Size/AMT Innovation

Size	AMT Innovations			Total
	0	1-5	6-12	
Small	2	16	0	18
Medium	2	9	9	20
Large	0	6	7	13
Total	4	31	16	51

For the 3*3 matrix the critical value of the chi-squared statistic at the one per cent level of significance is $\chi_{2,4,\,0.01}$=13.28. The test statistic for a null hypothesis of no relationship between the categories is $\Sigma\,(O-E)^2/E = 13.94$. Since the test statistic exceeds the critical value of the chi-squared distribution we can reject the null hypothesis and conclude that there is a relationship between size and technological innovation.

Technological Innovation and Activity Based Costing

A comparison between the scope and the speed of changes in manufacturing processes and cost and management accounting techniques suggests that diffusion of cost and management accounting changes lag behind not only traditional accounting techniques but also those of manufacturing techniques. This implies that the facilitation of cost and management accounting changes need more attention.

The findings indicate that only 14 per cent of establishments had implemented ABC by the time of investigation. However, as the following tables show, 92 per cent of establishments have experienced one or more types of advanced manufacturing technique up to the time of the investigation of which 14 percent had adopted activity based costing. The proportion of establishments, which had not used any advanced manufacturing techniques was 8 percent, none of these had used activity based costing.

Table 11: The frequency of firms using advanced manufacturing techniques and ABC during 1985-1996.

Using activity based costing	Using advanced manufacturing techniques		Total
	Yes	No	
Yes	7	0	7
No	40	4	44
Total	47	4	51

Only 14 per cent of establishments had implemented ABC at the time of investigation, of which 8 percent were small businesses and 6 percent large firms. Of the 86 per cent of establishments, which had not implemented activity based costing, 14 percent were large firms with more than 100 employees and 72 percent small firms with less than 100 employees.

Table 12: The frequency of small and large organisations within Australian Plastics industry using activity based costing.

Business size	Using activity based costing		Total
	Yes	No	
Small	4	37	41
Large	3	7	10
Total	7	44	51

Of greater concern to us in this study is the link between the level of technological innovation (and size) and the level of administrative innovation, illustrated by the introduction of new management accounting innovations. The adoption of Activity Based Costing (ABC) method is used at this stage of the study to measure the firm's commitment to accounting innovation. For testing purposes the adoption of activity based costing is used as an example of the diffusion of a 'new' management accounting technique. Table 12 details the relationship between size and ABC adoption.

Correlation coefficients again reveal positive relationships between the variables in question:

Number of Employees/ ABC adoption: r =0.331 (significant at 0.05 level)

Number of AMT innovations/ ABC adoption: r = 0.600 (significant at 0.01 level)

Statistically significant positive relationships are observed, though the link between administrative and technological innovations appears stronger than with size directly.

Table 13 details the correspondence of ABC adoption with the level of commitment to AMT innovation.

Table 13: ABC Adoption and AMT innovation

ABC Adoption	Number of AMT innovations													Total
	0	1	2	3	4	5	6	7	8	9	10	11	12	
No	4	6	3	6	6	1	2	0	0	0	0	0	0	28
Yes	0	2	2	0	2	3	4	4	2	1	1	1	1	23
Total	4	8	5	6	8	4	6	4	2	1	1	1	1	51

Again the table reveals a preponderance of items at the top-left and bottom right sufficient to suggest that the distribution is not random. Aggregating categories to increase cell-sizes produces the 2*2 contingency table of Table 14.

Table 14: Contingency table for ABC/AMT innovations

ABC Adoption	**AMT Innovation**		**Total**
	Low 0-2	High 3-12	
No	13	15	28
Yes	4	19	23
Total	17	34	

For the 2x2 matrix the critical level value of the chi-squared statistic at the one percent level of significance is $\chi_{2,1,\,0.01}$ = 6.63 and at the five per cent level of significant is $\chi_{2,1,\,0.05}$ = 3.89. The test statistic for a null hypothesis of no relationship between the categories is $\Sigma\ (O\text{-}E)^2/E = 4.79$. Since the test statistic exceeds the 5% level critical value of the chi-squared distribution we can reject the null hypothesis and conclude that there is a relationship between ABC adoption and technological innovation.

The Second Stage Study

As with the results of the first stage study, the results of the second stage study indicate a significant relationship between business size and the diffusion of activity based costing.

Table 15: The diffusion of activity based costing and business size

Implementation stage	less than 20	20 to 49	50 to 99	100 to 199	200 to 499	Over 500	Total per-centage
Not implemented	6	4	10	12	10	36	78
Implemented		2		3	3	14	22
	6	6	10	15	13	50	100

Considering the nature of data and the number of responses received in the second stage survey and as a result of discussion with statistical professionals, Kendall's tau-b is thought to be the most appropriate statistical test to examine the relationship between activity based costing and business size.

Kendall's tau-b has a value of 0.153 (standard error 0.082), which is statistically significant only the 0.069 level. So, we can reject a null hypothesis of no relationship between the diffusion of activity based costing and the size of organisations. However, the findings provide no significant evidence of a strong relationship between diffusion stages of activity based costing and business size.

Table 16: The diffusion stages of activity based costing and number of employee in organisation

Stages of diffusion	Number of employee in organisation						Total
	less than 20	20 to 49	50 to 99	100 to 199	200 to 499	Over 500	
No discussion	4	3	5	3			15
Decided not to introduce			2		1		3
Some consideration is given	2	1	3		1	1	8
Introduced on trial basis						1	1
Implemented and accepted		2			1	1	4
Total	6	6	10	3	3	3	31

Kendall's tau-b has a value of 0.231 (standard error 0.151), which is statistically significant only the 0.132 level. So, we have no strong evidence to reject a null hypothesis of no relationship between the diffusion of activity based costing and the size of organisations.

Conclusions and Reflections

The results of the first stage of the investigation of the plastics industry revealed that cost and management accounting changes lag behind technological changes in manufacturing practices. The results also suggest the existence of a significant relationship between technological changes in manufacturing practices and changes in cost and management accounting techniques, and a significant relationship between size of the organisations and the diffusion of manufacturing innovation. Confirming the results of the first stage study, the results of the second stage of the investigation provide strong evidence suggesting a significant relationship between business size and implementation of activity based costing.

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