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Environmental management accounting and innovation: an exploratory analysis

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Abstract

Purpose – Increased awareness regarding environmental issues has encouraged organisations to use environmental management accounting (EMA), which has been said to deliver many benefits to users, including an increase in innovation. There is, however, little evidence to consubstantiate this claim and thus this paper aims to investigate the issue. It also seeks to examine the role of strategy with EMA use and innovation.

Design/methodology/approach – The paper uses a survey designed and administered to management accountants and financial controllers in large Australian businesses.

Findings – The analysis suggests that EMA use has a positive association with process innovation, but not with product innovation. It also finds that the effect of strategy on innovation was driven by the level of commitment to research and development. However, no statistically significant relationship between strategy and EMA use was found. The key driver of EMA use was industry.

Research limitations/implications – The small sample size is the most important limitation of this study and affected the statistical power of the analysis conducted. The results need to be interpreted with caution.

Practical implications – The study suggests that EMA use is associated with process innovation, implying that economic benefits may be realised by using this technique, while simultaneously enhancing environmental performance.

Originality/value – This is the first study to provide cross-sectional evidence of the relationship between strategy, EMA use and innovation. It is also the first to propose a research instrument to measure EMA use as a multi-item construct.

Keywords Environmental management, Innovation, Australia, Management accounting, Corportate strategy

Paper type Research paper

1. Introduction

As a growing area of research, environmental management accounting (EMA) has received relatively little attention from accounting researchers. There has been some

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case-based research that discusses the relevance and benefits from implementing EMA systems in a specific country or industry (Burritt and Saka, 2006; Deegan, 2003; Masanet-Llodra, 2006; Staniskis and Stasiskiene, 2006) and on designing a general environmental management framework that can be used by businesses (Burritt *et al.*, 2002). However, there is limited academic research that attempts to either explore EMA empirically or focus on its potential effects on internal processes and outcomes within organisations, such as the development of innovations. With a growing awareness of environmental issues, mainly as a product of the now generally accepted global warming phenomenon, there is a need for this type of research to assist businesses in relation to resource allocation and decision-making.

It is generally accepted that innovation is important to most organisations. While the benefits arising from innovations may be well documented, the role of sustainability-related accounting systems (such as EMA), as a driver for innovations within organisations remains largely unexplored. In this study both product and process innovations are considered. The organisational forces behind EMA use represents another gap in accounting research, in particular the role of organisational strategy. Therefore, two research questions are addressed: first, "Does EMA use lead to innovations within organisations?" and, second, "What is the role of strategy in relation to EMA use and innovation?"

To examine the relationships of interest to this study a survey of large Australian businesses is drawn on. The survey yielded 40 usable responses (response rate of 14 per cent). Statistical analysis suggests that while it is likely that EMA use has a positive effect on process innovation, the same is not found for product innovation. A prospector-type strategy is also found to have an effect on process innovation through the commitment of resources to research and development (R&D). However, no such effect is found for product innovation. Analysis also shows that strategy is not an antecedent of EMA use, which is found to be primarily driven by industry. This study adds to the literature by providing cross-sectional evidence of the relationships between strategy, EMA use and innovation. It also contributes by developing a research instrument to capture EMA use with adequate measurement properties that are available to future researchers. An additional contribution of the current study is to measure empirically which benefits of EMA use are perceived to be the most significant in organisations, thus validating the perceived contributions of EMA towards various organisational outcomes.

The structure is as follows. Section 2 presents a literature review and precedes the development of the theoretical framework presented in section 3. Section 4 sets out how the survey is designed and data gathered and analysed. Section 5 outlines issues related to construct measurement and presents the empirical findings. Section 6 provides a discussion of the main findings and their implications. Section 7 provides a summary of the study, identifies limitations, and suggests areas for future research.

2. The literature

Sustainability accounting can be manifested in organisations through the development of conventional accounting systems, including management accounting systems (Schaltegger *et al.*, 2006). EMA is a prime example of a recent innovation in management accounting that represents this development. Sustainable development has increasingly become part of the objectives of many organisations, leading to greater adoption and use of EMA systems (Figge *et al.*, 2002). EMA constitutes an important part of sustainability accounting (Schaltegger *et al.*, 2006) and is an important instrument for organisations that aim "to minimize the total costs or environmental costs and mitigate the environmental impact of their activities, products and services" (Hyršlová and Hájek, 2006 p. 455). Previous studies have defined EMA as a technique that generates, analyses, and uses both financial, and non-financial information, to improve the environmental, and economic performance of a company, and contributes towards a sustainable business (Bennett *et al.*, 2003; Deegan, 2003). EMA can help organisations face their environmental responsibilities and can lead to the identification of joint environmental and economic benefits from corporate activities (Burritt *et al.*, 2002; Schaltegger and Burritt, 2000). Furthermore, EMA aims to provide physical information on the use of materials and energy and monetary information on environment-related costs, earnings and savings (Bartolomeo *et al.*, 2000; Bennett *et al.*, 2003; Hansen and Mowen, 2005; IFAC, 2005; United Nations, 2001). Other physical aspects of EMA include product life-cycle assessment, product improvement analysis, product inventory analysis and ascertaining the carbon footprint of an organisation. IFAC (2005) reports that organisations using EMA are likely to conduct more extensive research and design activities in producing environmentally friendly products and developing techniques that are less harmful to the environment. It is also likely that those organisations will utilise product life-cycle systems, which promote the identification of opportunities, to obtain environmental improvements (Hansen and Mowen, 2005).

In seeking to achieve sustainable practices and eco-efficiency, organisations are led to develop new products and to improve existing processes in order to reduce their use of resources and the environmental damage caused by their activities. In other words, organisations are required to innovate. Innovation is generally considered to be an important aspect of most businesses as it can lead to a competitive advantage (Porter, 1985a, b). Evidence shows that companies with greater emphasis on a business model based on innovation have faster operating margin growth and higher sales growth (Ferrari and Parker, 2006; Klomp and Van Leeuwen, 2001). Ferrari and Parker (2006) also find that, for manufacturing organisations, process innovation plays an important role in maintaining competitive advantage, as it is generally a key factor in securing long-term profitable growth. Innovations can be conceptualised in various ways, and both product and process innovations are considered. While product innovation can incorporate significant changes to existing products or the creation of new products, process innovation considers significant changes to the internal production processes.

The extent to which organisations pursue innovation is likely to be related to their business strategies (Miles and Snow, 1978). Miles and Snow (1978) propose a four-prong taxonomy for organisational strategy, which includes prospector, analyser, defender, and reactor strategy types. A prospector attempts to be the first in the market and stresses innovation and flexibility to respond quickly to changing market conditions. Firms following a prospector strategy are frequently first to launch new products in the market, even if there is uncertainty about the likelihood of success. In contrast, defender strategies focus heavily on the efficiency of existing operations achieved by maintaining a stable portfolio of products and committing to tried products. Firms pursuing this strategy are rarely the first to market with new products and are unlikely to offer new products until there is assurance of cost effectiveness.

Firms that pursue an analyser strategy are less aggressive than those pursing a prospector strategy but are more aggressive than those pursing a defender strategy with regards to product innovation. They maintain a stable base of products and services and move selectively into new areas of the market with demonstrated promise. Finally, firms pursuing a reactor strategy lack a consistent strategy-structure relationship, adjusting their operations and strategies when there is pressure from the external environment and are considered to be an unstable form of organisation (Miles and Snow, 1978; Shortell and Zajac, 1990).

There are other typologies of strategy, such as those developed by Miller and Friesen (1982), who categorise firms as conservative or entrepreneurial, using the extent of product innovation. Conservative firms, reluctantly engage in innovation, while innovation, is aggressively pursued by entrepreneurs (Langfield-Smith, 1997; Miller and Friesen, 1982). Miles and Snow's typology (1978) is deemed to be appropriate to this study, given that the scope of innovation is not confined to product innovation and there is evidence that successful firms emphasise both product and process innovation (Athey and Schmutzler, 1995). Furthermore, the Miles and Snow (1978) framework is consistent with other typologies (Kober *et al.*, 2007; Langfield-Smith, 1997; Shortell and Zajac, 1990) and has benefited from ample psychometric assessment (Abernethy and Guthrie, 1994; Kober *et al.*, 2007).

2.1 Benefits of EMA use

There are several potential benefits associated with EMA use. These include cost reductions, improved product pricing, attraction of human resources, and reputational improvements (Bennett *et al.*, 2003; Burritt *et al.*, 2002; de Beer and Friend, 2006; Gibson and Martin, 2004; Hansen and Mowen, 2005). Studies also note that the use of EMA typically benefits organisations by providing them with different information for decision-making (Adams and Zutshi, 2004; Bennett *et al.*, 2003; Burritt *et al.*, 2002). Such information may reveal hidden opportunities, such as better waste management processes, reduced energy and material consumption or opportunities for material recycling. From an environmental perspective this information may also be used in the development of more efficient processes and thus lead to innovation. For instance, Hansen and Mowen (2005) report the economic benefits enjoyed by organisations, such as Baxter International and Interface Inc., from EMA use generated savings of approximately $14 million and $12 million per year, respectively.

There is evidence that environmental costs can be 20 per cent or more of an organisation's total operating costs (Ditz *et al.*, 1995; Hansen and Mowen, 2005). In conventional accounting systems, environmental costs are usually hidden in manufacturing overhead costs (Burritt *et al.*, 2002), which makes it difficult for managers to observe the actual environmental costs related to their particular activities. Under EMA systems, these costs are identified, classified and allocated, allowing for advanced cost analysis and possible cost reductions to occur (Bennett *et al.*, 2003; Gibson and Martin, 2004). Hence, economic benefits are likely to flow from better-informed decision-making. Adams (2002), finds that organisations, which produce social, and environmental reports (i.e. sustainability reports), are able to develop better internal control systems, and lead to better decision making. She also suggests that cost-savings are likely to occur in these organisations, resulting in continuous improvements.

Improved corporate image and better relations with stakeholders are also among the benefits that can be experienced by organisations using EMA (Adams and Zutshi, 2004). The improvement in organisational reputation can arise from good citizenship behaviour and from offering environmentally friendly products. Organisations may also reduce the risks of consumer boycotts by providing information on social and environmental issues (Adams, 2002). Environmental information enables stakeholders to assess the environmental performance of organisations providing them with opportunities to understand the way organisations conduct their activities. Considering few organisations provide such information, those that do tend to experience improvements in their reputation, which is likely to translate into improved competitive advantage (Adams, 2002; King, 2002).

3. Hypothesis development

3.1 Strategy and EMA use

EMA use in an organisation is likely to be influenced by its business strategy. Management control systems (MCS) ensure that managers use the available resources effectively and efficiently in the pursuit of the objectives of the organisation (Anthony, 1965). Thus, MCS that are designed to meet the needs of the organisation contribute towards achieving superior performance (Dent, 1991; Samson *et al.*, 1991; Simons, 1987, 1990, 1995b). Business strategies, which identify the means by which the organisation intends to achieve organisational goals, are key determinants in the configuration of the MCS (Ferreira and Otley, 2009; Otley, 1999; Simons, 1995b). On the other hand, EMA is a technique that emphasises efficiency and effectiveness in the use of resources and is part of the broader MCS. The corollary is that if strategy is a determinant of MCS, then it is likely to have an effect on the extent of EMA use.

Gosselin (1997) finds that a prospector strategy is associated with the adoption of activity management. He concludes that the type of strategy followed by an organisation determines the need for innovation with regards to activity management and observes that organisations that pursue a prospector strategy tend to adopt accounting innovations. The relatively early stage of adoption and implementation of EMA and the fact that it is a fairly recent phenomenon, supports the view of EMA as an example of an accounting innovation. Thus, the use of EMA is likely to be greater in organisations pursuing a prospector strategy as it may assist them with their aim of being innovative (Gosselin, 1997). Hence, the following hypothesis is proposed:

H1. There is a positive association between prospector strategy and EMA use.

3.2 EMA use and innovation

Because of the perceived benefits of EMA use, organisations are likely to pursue this technique, as a part of the MCS, as a means of maintaining or enhancing their competitive advantage. One way in which this can be achieved is through innovation. Innovation can be defined as the adoption of new systems, policies, programs, processes, products or services, which can be internally or externally generated (Daft, 1982; Damanpour and Evan, 1984; Zaltman *et al.*, 1973). Of particular interest is the distinction between product and process innovation. Utterback and Abernathy (1975), suggest that, the rates of adoption of product, and process innovations, is different, during various stages of business development. Product and process innovation often complement each other in helping organisations to increase profitability (Athey and

Schmutzler, 1995). Additionally, product and process flexibility determine how changes in product designs and production processes influence organisational costs. As a consequence of limited access to finance, there is often a trade-off between process and product flexibility that rebuts the assumption, investments in both product and process flexibility are independent (Hayes and Wheelwright, 1984; Hayes *et al.*, 1988).

Research highlights that organisations producing social and environmental information develop better internal control systems thereby resulting in better decision-making processes (Adams and Zutshi, 2004). The new information encourages development of new products, more advanced technological processes, and improved cost structures. In other words, EMA use is likely to be associated with both product and process innovation, and may consequently improve the competitive position of organisations. The result is similar to that noted for activity-based costing, a technique providing management with additional and more accurate cost information (Cooper, 1988) that can lead to an increase in the number of process improvements (Drake *et al.*, 1999). On the basis of the previous argument, the following hypotheses are proposed:

H2a. There is a positive association between EMA use and product innovation.

H2b. There is a positive association between EMA use and process innovation.

3.3 Strategy and innovation

Organisational strategy typically determines the different emphasis that organisations place on product and process innovations in achieving their competitive advantage (Etlie, 1983; Hull *et al.*, 1985). Cozzarin and Percival (2006) find that innovation complements many organisational strategies, while others note that strategy is an antecedent of the emphasis that organisations place on product and process innovation (Etlie, 1983; Hull *et al.*, 1985). Some studies find a relationship between key elements of strategy and business environment (Chong and Chong, 1997; Fuschs *et al.*, 2000). Miller (1988) finds a relationship between an unpredictable and dynamic environment and an innovation strategy. When the environment is largely driven by changing customer demands and level of market concentration there is greater pressure for firms to develop a strategy that places customer interests first, such as the provision of innovative products (Perera *et al.*, 1997; Sim and Killough, 1998).

Organisations that follow a prospector strategy aim to be first in the market, even though not all efforts are ultimately successful (Miles and Snow, 1978). These organisations also aim to respond rapidly to early signals of market needs or opportunities. Therefore, the greater the emphasis on being first in the market, the higher the level of product innovation expected. Thus the following hypothesis is proposed:

H3a. There is a positive association between prospector strategy and product innovation.

Although the primary concern of prospectors is with being first in the market, once products gain acceptance companies will seek to improve efficiency in product production and delivery. In this process of seeking greater efficiency, it appears likely that resources will be committed to the development and improvement of processes. Otherwise, prospector companies may find it hard to achieve and maintain a profitable position, particularly in the face of firms pursing an analyser strategy that benefits from a second mover advantage. Hence, the following hypothesis is proposed:

H3b. There is a positive association between prospector strategy and process innovation.

3.4 Control variables

There are other variables, which may affect the level and type of innovation that occurs within organisations and EMA use. The R&D effort of organisations is also likely to have an effect on the level of process and product innovation. When there is a greater financial commitment from organisations to encourage innovation, the levels of product and process innovation are expected to be higher. This decision, however, is also likely to be influenced by the organisation's strategy.

Larger organisations are likely to have a higher level of innovation given the availability of resources such as finance, high quality staff, benefits from economies of scale and better work organisations (Mairesse and Mohnen, 2002). Organisational size is also likely to affect EMA use. Larger organisations are generally considered to have greater base of human, technical, and financial resources (Ferreira, 2002) and this is likely to facilitate the adoption and use of EMA systems. Previous research has found that the size of an organisation influences its control arrangements (Otley, 1995) and that larger firms are more likely to adopt sophisticated management accounting techniques (Abdel-Kader and Luther, 2008; Haldma and Laats, 2002).

In addition, organisations that operate in industries, which have a greater and direct impact on the environment, are likely to use EMA since they will be able to enjoy the benefits. Further, Mairesse and Mohnen (2002) suggest that organisations, as members of a particular group, are likely to have a higher level of innovation given their internal transfer of knowledge and access to finance. However, this aspect is not a major focus and will not be tested.

Figure 1 indicates the hypotheses that are tested, as well as the control variables.

4. Research methods

4.1 Survey design and administration

To examine the relationships between strategy, EMA use and innovation, a survey was conducted. This method was selected for several reasons. First, it allows researchers to survey a large random sample at a relatively low cost and the collection of data enables the examination of patterns and relationships (Dillman, 2000; Salant and Dillman, 1994). Second, surveys place less pressure on immediate responses and provide respondents with a feeling of anonymity (Dillman, 2000; Salant and Dillman, 1994). However, surveys present the potential issues of low response rates and non-response bias. To mitigate these issues and enhance benefits from the use of the survey, Dillman's total design method was implemented (Dillman, 2000; Salant and Dillman, 1994).

The survey consisted of four main multi-item questions that were designed to be clear and concise. Salant and Dillman (1994) propose that multi-item questions increase the likelihood of survey participants completing the survey and reduce ambiguity, thus enhancing the validity of the research instruments. The survey was pilot tested among academic staff prior to its implementation.

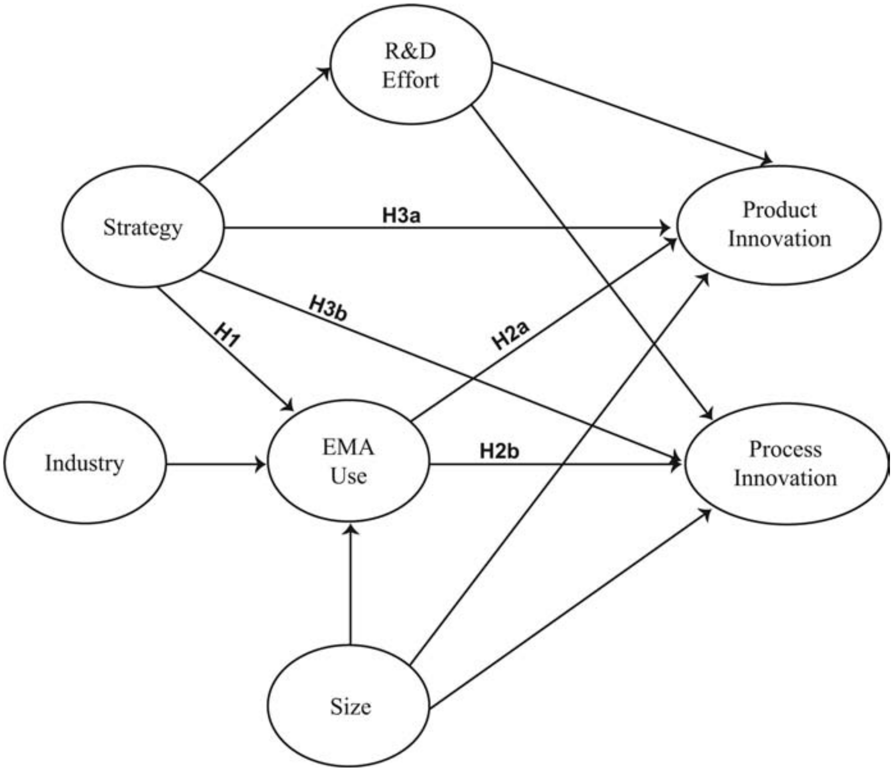


Figure 1.
Research framework with control variables

The survey was sent to 298 management accountants and financial controllers in large Australian companies. The data for the companies were obtained from a Listbank database, which included the largest 1,000 firms in Australia[1]. Management accountants and financial controllers were deemed appropriate participants given their involvement in the day-to-day financial and operating activities of companies, in addition to their likely involvement in activities related to the environment, organisational strategy and their understanding of decision making processes (Chenhall and Morris, 1986; Shortell and Zajac, 1990). The companies were contacted by phone to ascertain the name of targeted respondents and these names were later used to personalise correspondence.

The organisations subject to this survey operated in four industries: manufacturing, transport, hospitality and construction. These industries were chosen for two reasons. First, it was anticipated that their operational activities would have a negative impact on the environment and, second, companies in these industries are typically high users of natural resources. On this basis, it is likely that these companies enjoy greater benefits from EMA use compared with other industries.

The survey administration procedure began with the mailing of surveys to participants. Two weeks later, follow up phone calls to all participants were made to ensure they had received the survey and to encourage participation in the study. Additional copies of the survey were forwarded to those who had misplaced the original survey along with a personalised hand-written reminder. A personalised letter was posted to all other participants. One week after the first reminder, a final, hand-written postcard reminder was sent out to encourage the participants to take part in the survey. Salant and Dillman (1994) propose that this approach is effective in emphasising to respondents that the selection of the participants is not computer generated. Follow-up telephone conversations with non-respondents revealed that some participants did not have time to complete the survey, that company policy restricted completion of some postal surveys, and that some companies considered environmental issues to be a sensitive matter.

4.2 Measurement of constructs

EMA use. This construct consisted of 12 items, which aimed to reflect EMA activities. The selection of EMA activities was derived from various sources (e.g. Hansen and Mowen, 2005; IFAC, 2005) and these activities were distinct from other general management accounting activities. Some of the items focused on monetary aspects of EMA, while others on the physical aspects, as proposed by Burritt *et al.* (2002). It asked respondents "Please indicate the extent to which your company has done each of the following in the past three years:" on a seven-point Likert scale with three anchors: "Has not done at all", "Has done to some extent", and "Has done to a great extent" (see the Appendix (Figure A1)). The 12 items were:

(1) Identification of environment-related costs.
(2) Estimation of environment-related contingent liabilities.
(3) Classification of environment-related costs.
(4) Allocation of environment-related costs to production processes.
(5) Allocation of environment-related costs to products.
(6) Introduction or improvement to environment-related cost management.
(7) Creation and use of environment-related cost accounts.
(8) Development and use of environment-related key performance indicators (KPIs).
(9) Product life cycle cost assessments.
(10) Product inventory analyses.
(11) Product impact analyses.
(12) Product improvement analysis.

To the best of our knowledge, this is the first published study to develop a comprehensive measure of EMA use within organisations.

Business strategy. This construct asked respondents to indicate the business strategy pursued by their organisation (see the Appendix). Four different approaches to operationalising strategy have been proposed in the literature: typologies, textual description, partial measurement and multivariate measurement. Research suggests that it is appropriate to use typologies to provide brief profiles of various strategic types and emphasize the important or distinctive components of each strategy type (Langfield-Smith, 1997; Shortell and Zajac, 1990). The Miles and Snow (1978) typology was used in this study. Measures of organisational strategy were adapted from

Ferreira (2002), and are based on instruments used by Abernethy and Brownell (1999) and Shortell and Zajac (1990) (see the Appendix). This typology is consistent with other typologies (Kober *et al.*, 2007; Langfield-Smith, 1997; Shortell and Zajac, 1990) and has been used by many prior studies (e.g. Abernethy and Guthrie, 1994; Kober *et al.*, 2007).

Product innovation and *process innovation*. To capture the level of product innovation we used the four-item instrument by Bisbe and Otley (2004) and adapted this instrument to also measure the level of process innovation[2]. Participants were required to indicate the position of their organisation in comparison to their industry average along a continuum, an approach that has also been used in other studies (Bisbe and Otley, 2004; Capon *et al.*, 1992; Scott and Tiessen, 1999; Thomson and Abernethy, 1998) (see the Appendix).

The control variables were:

- *R&D effort*. This construct asked respondents to indicate the amount of their organisation's R&D expenses and sales turnover. The ratio between the former and the latter is a measure of R&D effort. Market-based accounting research uses this ratio as a proxy for innovation, but given that it is an input measure, it effectively captures the organisation's effort or commitment towards innovation.
- *Industry (CMS)*. Participants were asked to write in an open-end question the industry of their company's main products. Considering that EMA may not be an innovation in high environmental risk industries, but rather an already established practice, the companies that identified chemical, mining, and smelting (CMS) as their main products have been coded as the industry control variable. The sample contained three chemical companies, two mining companies and two smelting companies (17.5 per cent of the total number of cases); all of these were coded "1" in the dummy used.
- *Size*. The survey collected information regarding size by asking respondents the number of employees in their companies as well as sales turnover.

The survey also elicited information on a number of other items. For example, respondents were asked about the benefits gained from EMA use. This question listed 15 benefits of using EMA practices commonly experienced by organisations according to the literature previously reviewed. The question asked respondents to "Please indicate the extent to which your company experienced, in the past three years, each of the following as a consequence of its environmental management accounting practices": in a seven-point Likert scale with two anchors: "Experienced to a small extent" and "Experienced to a great extent" (see Appendix). The remaining part of the survey asked general information about the participant's background, such as job title and the length of time the participant had worked in the company and in their current position. This information aims to provide insights into the demographic characteristics of survey participants and helps to ensure the reliability and quality of the responses.

4.3 Response rate and non-response bias

In total, 41 responses to the survey were received, of which 40 were usable[3]. Of the initial sample of 298 companies, six were eliminated because of duplication or incorrect addresses leading to a response rate of 14 per cent. As shown in Table I, the majority of respondents worked in manufacturing companies[4].

To test for non-response bias, responses were compared from the first 15 respondents and the last 15 respondents (using late respondents as a proxy for non-respondents) on key variables of interest. The results show that non-response bias was unlikely to be a problem.

4.4 Data analysis – Partial Least Squares (PLS)

Data were analysed using a structural equation modelling (SEM) technique. Partial Least Squares (PLS) method was chosen because of its ability to cope with the small sample size, the lack of assumptions regarding the distribution of regression residuals and the minimal demands it places on measurement scales (Chin, 1998; Smith, 2003). However, PLS does not resolve the problem of poor statistical power and the difficulty of reaching statistical significance that is associated with a small sample. Also, the lack of distributional assumptions requires the use of jack-knife or bootstrap procedures to determine the statistical significance of items and path coefficients (Chin, 1998). Hence, bootstrapping with 1,000 subsamples was carried out.

PLS is a technique that can also be used to suggest where relationships might or might not exist and to suggest propositions for later testing, as well as a tool for theory confirmation (Smith, 2003). It has also been argued that PLS can be used in situations where there is limited theoretical background to support hypotheses as in exploratory studies (Chin, 1998; Joreskog and Wold, 1982). Additionally, PLS is able to estimate the measurement and structural model simultaneously (Barclay *et al.*, 1995; Vandenbosch, 1999) and has the further advantage of avoiding both inadmissible solutions and factor indeterminacy (Fornell and Bookstein, 1982; Wold, 1982).

5. Empirical analysis

5.1 Construct measurement – the measurement model analysis

Prior to the evaluation of the structural model, it is necessary to perform measurement model analysis to ensure that each variable is valid and reliable (Barclay *et al.*, 1995). Through the examination of individual item loadings, it is possible to determine which items may be included in the final model and which items may need to be considered for removal. Items may be removed to avoid bias in parameter estimates in performing the structural model analysis (Hulland, 1999; Nunnally, 1978). The minimum acceptable loading is generally 0.50 (Hair *et al.*, 1998), however this criterion did not result in the removal of any items since all displayed loading above 0.60. In addition, items that were not statistically significant at the 10 per cent level were removed, regardless of their loadings (bootstrapping was conducted to determine the level of significance for each item). This resulted in the removal of one item from the EMA use construct and one item from product innovation. Construct items are presented in Table II, which indicates those that were retained and those removed.

Table I.
Response rate

Industry	Sample	Response	(%)
Manufacturing	176	31	18
Hospitality	45	4	9
Transport	41	2	5
Construction	30	3	10
	292	40	14

	Loading	*p*-values
EMA use (composite reliability: 0.963, AVE: 0.701)		
Identification of environment-related costs	0.892	0.000
Estimation of environment-related contingent liabilities (e.g. EPA fines)	0.865	0.000
Classification of environment-related costs	0.878	0.001
Allocation of environment-related costs to production processes	0.888	0.001
Allocation of environment-related costs to products	0.801	0.000
Introduction or improvement to environment-related cost management	0.901	0.001
Creation and use of environment-related cost accounts	0.850	0.001
Development and use of environment-related key performance indicators (KPIs)	0.843	0.000
Product life cycle cost assessments[a]	–	–
Product inventory analyses (i.e. the specification of the types and quantities of materials and energy required and the amount of residues released to the environment)	0.744	0.097
Product impact analyses (i.e. assessment of the environmental effect of competing product designs)	0.761	0.010
Product improvement analysis (i.e. identification of opportunities for reduction of environmental impact)	0.769	0.030
Product innovation (composite reliability: 0.875, AVE: 0.699)		
During the last three years we have launched few/many new products	0.851	0.014
During the last three years we have launched few/many modifications to already existing products	0.847	0.071
Regarding new products, we are very rarely/very often first-to-market	0.810	0.051
The percentage of new products in our product portfolio is much lower/much higher than the industry average[a]	–	–
Process innovation (composite reliability: 0.907, AVE: 0.710)		
During the last three years we have introduced few/many new production processes	0.815	0.001
During the last three years we have introduced few/many modifications to production processes	0.884	0.000
Regarding new production processes, we are very rarely/very often the first to introduce them	0.774	0.009
The frequency of production process improvements in our company is much lower/much higher than the industry average	0.892	0.000
Size (composite reliability: 0.888, AVE: 0.799)		
Sales turnover (Ln)	0.949	0.001
No. of employees (Ln)	0.835	0.058

Note: [a] Items removed because of the lack of statistical significance at the 10 per cent level

Table II. The PLS measurement model

In addition to the factor loadings, this study also examined how well the items explained the latent variable by examining the average variance extracted (AVE) statistic. The AVE is used to determine the validity of a variable or to measure convergent validity (Chin, 1998; Hulland, 1999; Vandenbosch, 1999). An AVE above 0.50 indicates that the latent variables explain over half of the variance in the observed variable, hence 0.50 is considered to be the minimum threshold (Fornell and Bookstein, 1982). Table II indicates that the AVE for all variables is above the general rule of thumb of 0.50 (the minimum AVE equals 0.699). The statistical properties of the constructs suggest that they are appropriate for use in examining the structural model.

The discriminant validity of constructs has also been assessed, as presented in Table III. The table indicates that the square root of AVE for each variable is greater than their correlations with all other variables. The figures demonstrate that although there may be a correlation between variables, for example the correlation between process and product innovation, the variables are independent from each other. This suggests that the discriminant validity of EMA use, size, product innovation, and process innovation is not an issue (Chin, 1998; Hulland, 1999; Mahama, 2006).

5.2 Descriptive statistics

Descriptive statistics regarding demographic data from respondents and organisations are presented in Table IV[5]. The descriptive statistics for other variables such as EMA Benefits, R&D expenses and sales turnover, are also provided[6].

The statistics show that, on average, EMA use within organisations was 2.33 (theoretical range of 0-6). The range includes organisations that do not adopt EMA at all (0 out of 6) to organisations that implement EMA to a great extent (6 out of 6). The level of product innovation is 4.16 on average, while the level of process innovation has an average of 4.3 (theoretical range of 1-7).

Figure 2 exhibits the level of benefits experienced by organisations as a consequence of their EMA practices. Among the 15 benefits surveyed, participants identified that through EMA use, they enjoyed the benefit of identifying new opportunities at a relatively high level (3.78 out of 7). This is the highest level compared with other benefits and is closely followed by both improvements in reputation and in decision-making. These findings are consistent with other studies (Adams, 2002; Anand, 2002; Bernhut, 2002; Marx, 1992/1993). Porter and van der Linde (1995) and Reinhardt (1999) find that pollution reduction is likely to produce future cost savings and minimise future environmental liabilities. The participants also identify that, on average, they experience process innovations, operating cost reductions, and product innovations at a level that is relatively higher than the remaining benefits (approximately 3 out of 7).

On the other hand, participants placed the cost of capital and insurance cost reductions at the lowest level of the benefits surveyed. This finding suggests that EMA use may result in little reduction in the organisation's perceived risk, whereas prior research in this area is inconclusive. Several studies suggest that there is a relationship between the share price (or market value) of the organisation and social and environmental activities (Dowell *et al.*, 2000; Feldman *et al.*, 1997; Klassen and McLaughlin, 1996; Shane and Spicer, 1983). However, other research does not support the relationship between economic performance and environmental disclosures (Freedman and Jaggi, 1986).

5.3 Results – PLS structural model analysis

This section presents the PLS results of testing the research propositions involved in the structural model and discusses the explanatory power of the model. Table III shows the correlation between variables and their *p*-values. The PLS results of the structural model analysis are presented in Table V, which also displays *p*-values for each path coefficient. The results of the PLS structural model analysis are also depicted in Figure 3. Both analyses – i.e. correlations and PLS path coefficients – are used collaboratively to explain the relationships among variables.

	Strategy (prospector)	p-value	EMA use	p-value	Product innovation	p-value	Process innovation	p-value	R&D effort	p-value	Industry (CMS)	p-value	Size	p-value
Strategy (prospector)	1.000													
EMA use	−0.147	0.183	0.837											
Product innovation	0.181	0.132	0.043	0.396	0.836									
Process innovation	0.199	0.109	0.230	0.077	0.672	0.000	0.843							
R&D efforts	0.154	0.171	−0.06	0.356	0.166	0.153	0.305	1.000	0.028					
Industry (CMS)	−0.232	0.075	0.402	0.005	−0.07	0.334	0.067	0.341	0.364	1.000	0.010			
Size	0.021	0.449	0.184	0.128	0.340	0.016	0.320	0.022	0.068	0.338	0.225	0.081	0.894	

Table III.
Correlation of variables from PLS model and square root of AVE (diagonal)

Table IV.
Descriptive statistics

	Minimum	Maximum	Mean	SD
Time in current position	0.2	25	5.26	5.58
Time in the company	0.2	38	8.99	7.51
Number of employees	70	28,000	1,711	4,371
Benefits of EMA	1	5.73	2.56	1.49
R&d expenses (in millions)	0	100	8.54	16.9
Sales turnover (in millions)	15	2,000	490	545
Level of EMA use	0	5.56	2.33	1.67
Product innovation	1	6.33	4.16	1.32
Process innovation	1	7	4.30	1.30

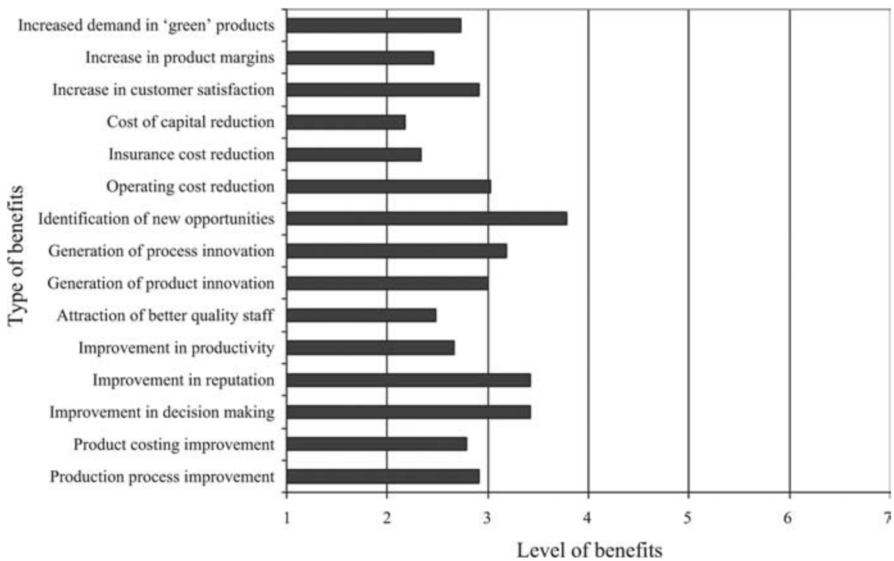


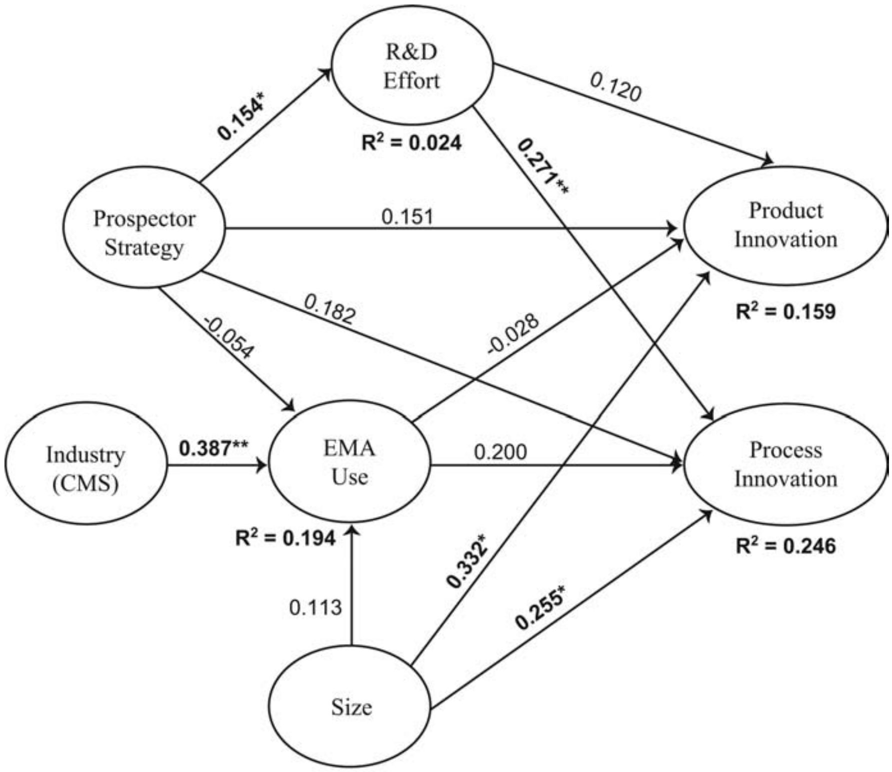
Figure 2.
Benefits from the use of EMA

H1 predicted a positive association between a prospector strategy and EMA use. EMA is believed to provide information that would contribute positively towards product innovation. Hence, organisations that aim to be first in the market were predicted to show greater proclivity to use EMA. The correlation analysis (see Table III) and the structural analysis (see Table V) show that the relationship between the two variables is not statistically significant. Consequently, *H1* is not supported.

As mentioned, EMA arguably provides information, which is useful to encourage product innovation and predicted that EMA use would be positively associated to product innovation (*H2a*). Table V indicates that there is no significant relationship between EMA use and product innovation, a finding that is consistent with the non-statistically significant correction shown in Table III. Therefore, H2a is not supported. This is an unexpected result since the literature suggests that product innovation is a reported benefit from EMA use (Hansen and Mowen, 2005). The result also contrasts with benefits shown in Figure 2, indicating that product innovation is among the most commonly cited. These apparent conflicting findings may be

Table V.
Path coefficients and significance (p-values)

	Independent variables									
	Strategy (prospector)	p-value	EMA use	p-value	R&D effort	p-value	Industry (CMS)	p-value	Size	p-value
EMA use	−0.064	0.364					0.364	0.024	0.103	0.281
Product innovation	0.157	0.212	0.014	0.476	0.121	0.206			0.326	0.05
Process innovation	0.185	0.179	0.226	0.159	0.273	0.018			0.256	0.052
R&D effort	0.154	0.053								



Note: *Significant at 0.10 (one-tail); **significant at 0.05 (one-tail)

Figure 3.
Estimated PLS path model

explained by the way respondents interpret product innovation. The question relating to Figure 2 did not provide a definition of product innovation and consequently is prone to subjective interpretation and social desirability bias. On the other hand, the measure of product innovation used in the analysis was based on a multi-item construct, which arguably enhances the reliability of the constructs' measurement. Furthermore, the items focused on product innovation in general, not on product innovation specifically derived from EMA use (as in Figure 2).

H2b predicted that there is a positive association between EMA use and process innovation. Table III shows a statistically significant correlation between EMA use and process innovation. Hence, on a one-to-one basis, the relationship between EMA use and process innovation is supported. Figure 2 shows that "identification of new opportunities" and "generation of process innovation" is among the most cited benefits from EMA use, which is consistent with the correlation analysis. However, PLS results (see Table V) show that this relationship is not statistically significant ($p = 0.159$), which means that *H2b* is not supported at a multivariate level of analysis. We attribute this finding partially to the low number of observations, which reduce the statistical power of the analysis[7].

H3a proposed a positive association between a prospector strategy and product innovation. Organisations pursing a prospector-type strategy understand and emphasize the importance of developing innovative products (Miles and Snow, 1978). The analysis, however, provides no support for this relationship. The correlation between prospector strategy and product innovation is not statistically significant (*p*-value = 0.132; see Table III), while the p-value for the path coefficient between the two variables stands at 0.212 (see Table V), therefore, *H3a* is not supported.

A positive association between a prospector strategy and process innovation (H3b) was also predicted. Prospectors are expected to emphasise improvements in production processes as successful product launches make their way to the development stage and maturity stage of their life cycles. Also, R&D towards new product development may branch into improvements in existing processes. The correlation between prospector strategy and process innovation is positive and just misses the 10 per cent significance threshold (*p*-value = 0.109). Table V shows that in PLS analysis, prospector strategy is not significantly associated with process innovation (*p*-value = 0.179). However, Figure 3 shows a significant indirect effect of prospector-type strategy on process innovation, through the commitment of resources to R&D activities. Taken in its entirety and considering the number of observations, there is weak support for *H3b*.

The study controlled for the effects of both size and industry (CMS) on EMA use and innovation. Table III indicates that, although positive, the correlation between EMA use and size is not statistically significant. However, companies operating in the chemical, mining, or smelting (CMS) industries do display greater levels of EMA use. The correlation between Industry (CMS) and EMA use is statistically significant ($p < 0.1$), as well as the path coefficient between the two variables ($p < 0.05$).

Based on the results (see Table V), it is apparent that R&D effort and size are factors that significantly affect process innovation, indicating that, on average, larger companies and companies committing more resources to R&D are the ones that experience more process innovations. The only statistically significant variable that affects product innovation is size, implying that larger organisations outperform smaller organisation in regards to product innovations.

The indirect associations between strategy and innovation through R&D effort were also controlled. A significant relationship between strategy and R&D effort and between R&D effort and process innovation was found, hence indicating an indirect effect of strategy on process innovation.

The R^2 of each dependent variable is presented in Figure 3[8]. Figure 3 shows that 19.4 per cent of variance in the EMA use construct can be explained by the model (i.e. by strategy, size, and industry (CMS)). It also shows that the explanatory power of the model for product and process innovation (i.e. the combined effect of prospector strategy, EMA use, size and R&D effort) is, respectively, 15.9 and 24.6 per cent.

6. Discussion

This study sought to answer two research questions. The first research question asked whether EMA use leads to innovation within organisations. To address this question a set of hypotheses linking EMA with both product and process innovation was developed. The findings indicate that EMA use does not affect product innovation. This result is contrary to the suggestion by Hansen and Mowen (2005) that EMA use may lead to product innovation. Previous studies have found inconclusive evidence as to the relationship between the use of MCS and product innovation, as noted by Bisbe and Otley (2004). Some researchers argue that innovative firms are intensive users of MCS (Simons, 1990, 1991, 1995a, b) while others do not support the view that MCS have the potential role of encouraging successful product innovation (Dougherty and Hardy, 1996; Gerwin and Kolodny, 1992; Leonard-Barton, 1995; Tidd *et al.*, 1997). As an element of the MCS, EMA use does not affect product innovation; product innovation appears to be primarily driven by organisational size.

In addition, the study found that EMA use has an effect on process innovation, although these results are not entirely convincing since the PLS structural model does not indicate a significant path. The result could be attributed to the limited number of observations (which is supported by the additional analysis conducted; see footnote #6). The correlation analysis result is consistent with accounts that suggest EMA use is likely to result in the identification of opportunities, such as improvements in production processes (Bartolomeo *et al.*, 2000; Ditz *et al.*, 1995; Hansen and Mowen, 2005) and cost reductions (Adams and Kuasirikun, 2000).

The second research question asked about the role of strategy in relation to EMA use and innovation. It was proposed that organisations that followed a prospector strategy would be likely to use EMA as a tool to achieve their strategic objectives. The findings suggest that strategy does not affect EMA use and are not consistent with the study by Gosselin (1997), which finds that prospector organisations are likely to adopt management accounting innovations. By controlling for companies that operated in the chemical, mining or smelting industries we used a variable as a proxy for industries where EMA was likely to be regarded to be routine and less of an innovation. The analysis shows a strong and significant effect for industry (CMS) in EMA use[9], but no significant effect for the size control variable. The amount of variance unexplained for EMA use means that there are other factors, not captured, that affect the construct. These may include the organisation's environmental commitment or regulation environment. Another possible explanation is that despite the similar characteristics shared by EMA and other accounting innovations such as activity based costing, there are differences in the perceived costs and benefits between these innovations that contribute to different research findings. These differences may be caused by the lack of awareness of participants of EMA or variations in how respondents interpret EMA.

Also no significant direct relationship was found between strategy, as defined by Miles and Snow (1978), and both product and process innovation, although strategy has an indirect effect on process innovation through commitment to R&D activities. The lack of direct relationship is at odds with the studies by Miller and Friesen (1982) and Hull and Hage (1982), which suggest that innovation levels may vary among different types of organisations. Miller and Friesen (1982) find that the impact of organisational variables on product innovation may be different between "conservative" and "entrepreneurial" firms, while Hull and Hage (1982) find that innovation is different among "traditional", "mechanical", "organic" and "mixed" organisations. In comparing these results, it is paramount to understand that these other studies use different typologies in measuring the effects of strategy on innovation. However, previous research has cons istently found a relationship between strategy, similar to that conceptualised by Miles and Snow (1978), and innovation. Similar to the relationship between EMA use and process innovation, this result is primarily attributed to sample size issues.

It was previously mentioned that studies in management accounting and management literature found inconclusive evidence as to what drives innovation and the relationship between MCS and level of innovation (Bisbe and Otley, 2004). It was found here that R&D effort and size have a positive relationship with process innovation, while product innovation is positively associated with size. The result for size is consistent with the suggestion that the larger the company the higher the level of product and process innovation. Griliches (1990) notes in his study that the relationship between R&D spending and innovation has been repeatedly demonstrated, but this study only observes the effect for process innovation. Herold *et al.* (2006) also mention that people are among the resources that support innovation within an organisation. Hence, the results for R&D effort and size are consistent with those studies.

7. Conclusion

EMA use helps organisations to recognise the environmental effects of their operational activities. Several case studies outline the benefits related to EMA use (Bennett *et al.*, 2003; Burritt *et al.*, 2002; de Beer and Friend, 2006; Gibson and Martin, 2004; Hansen and Mowen, 2005). This research uses cross-sectional data to investigate the effect of EMA use on both product and process innovation. The role of strategy is also explored, and includes the direct effects of strategy on EMA use and direct and indirect effects of strategy on innovation.

Results are not as strong as expected. The correlation analysis suggests that it is likely that EMA use has a positive effect on process innovation. However, some doubt is placed on this finding in the PLS structural analysis. The correlation between EMA use and product innovation is found not to be significant, which is likely to be driven by the small magnitude of the effect. Therefore the results suggest that innovation is a potential outcome arising from EMA use in that it can impact on the extent to which an organisation engages in process innovation. The results also suggest that EMA use is not driven by organisational size, and show that companies from chemical, mining and smelting industries are more likely to be users of EMA than all other companies considered in the study. Finally, the PLS analysis indicates that product and process innovation are significantly associated with size, while R&D effort is only positively associated with process innovation.

In relation to the association between a prospector-type strategy and EMA use, no support is found. Instead, an effect of strategy on process innovation is revealed through the commitment to R&D activities, but no direct effects are found between a prospector strategy and both product and process innovation.

It is acknowledged that the response rate and small sample size are limitations of this research and that the latter affects the statistical power of the analysis conducted. However, the response rate is considered acceptable given the exploratory nature of the research conducted and given that it is commensurate with published studies that generated modest sample size and response rate equal to less than 20 per cent (e.g. Baines and Langfield-Smith, 2003; Lee *et al.*, 2001; Spanos and Lioukas, 2001). The R^2 in the PLS structural model suggests omitted variables, which could exert upward bias in the estimated coefficient of the variables included (if these variables are correlated with the omitted variables). In addition, some issues with the measurement of constructs used in this study may exist.

This is the first study that has attempted to develop a multi-item research instrument to measure "EMA use". The possibility that this instrument contains measurement error is acknowledged. In particular, one item was excluded from the construct because of its inability to meet significance levels. The construct used, however, still retained a range of items that captured both the physical and monetary aspects of EMA. Despite this, more physical aspects of EMA could have been added to this construct in order to create a better balance between the physical and monetary aspects covered. The inclusion of an item to provide a long-term dimension of EMA (e.g. capital investment-related decisions) could be considered in future research. Also in relation to the EMA use construct, considering the study's participants – management accountants and CFOs – it is possible that there was some bias towards the monetary aspects of EMA in the responses of participants. In relation to the approach taken for business strategy, there are alternative conceptualisations, which if used may have yielded different results.

Despite the limitations, the literature is enhanced by providing cross-sectional evidence of the relationship between organisational strategy, EMA use, and both product and process innovation, and of the benefits derived from EMA use. The study also develops and proposes a multi-item research instrument to measure EMA use, and tests and validates the properties of this construct, as well as adding to the academic debate on sustainability accounting.

Sustainability accounting techniques, such as EMA, are in a process of evolution and include methods and techniques aimed at providing quality information to support organisations as they move towards sustainability (Schaltegger *et al.*, 2006). The lack of, or weak support for the predictions regarding EMA use may reflect the fact that organisations are at the start of this evolutionary process towards sustainability accounting. The study's response rate and the level of EMA use by companies surveyed are indicative of the slow rate of adoption of EMA in Australian businesses and consistent with an early stage of development of EMA.

Implications for businesses indicate that even though the results suggest that EMA use does not affect product innovation and provide weak support for the effect on process innovation, there are still other worthwhile benefits that an organisation may experience from EMA use. These benefits include identification of new opportunities, and improvements in reputation and decision making (see Figure 2).

Future research may aim to refine the "EMA use" construct or use this instrument to investigate the relationship between EMA use and other said benefits empirically. In addition, there is an opportunity to investigate other determinants of EMA use such as legal requirements, stakeholder pressure and the organisation's attitude towards environmental issues. These factors were not included. Finally, future research may use a case study approach to obtain insights into the factors that determine the adoption of sustainability accounting practices, to investigate how these techniques are perceived and operationalised at different organisational levels and to explore further the innovative effects of EMA use.

Notes

1. Listbank is a commercial provider of mailing lists in Australia (see www.listbank.com.au/ for details).

2. Effectively, the adaptation meant to replace "products" in the item descriptions to "production processes".
3. Maximum likelihood estimates (MLE) were used to replace the few missing data points.
4. The survey administration process enabled the tracing of responses to the four broad industry classifications that were provided in the database.
5. The statistical distribution of size, as measured by the number of employees, is clearly skewed to the left. Linear transformation of the variable is used to reduce this problem.
6. These descriptive statistics were calculated using simple averages of the relevant items.
7. The structural equation model was estimated using twice as many observations (effectively duplicating the observations available) and testing the significance of the path coefficient. Under this scenario, the path coefficient remains unchanged (as expected), but the p-value becomes 0.051. This is clear evidence of the statistical power issues raised.
8. PLS Graph reports unadjusted $R2$.
9. Strong effect as measured by the magnitude of the standardised path coefficient.

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Appendix

Q. Please indicate the extent to which your company has done each of the following in the past three years:

	Has not done at all			Has done to some extent			Has done to a great extent
Identification of environment-related costs	0	1	2	3	4	5	6
Estimation of environment-related contingent liabilities (e.g. EPA fines)	0	1	2	3	4	5	6
Classification of environment-related costs	0	1	2	3	4	5	6
Allocation of environment-related costs to production processes	0	1	2	3	4	5	6
Allocation of environment-related costs to products	0	1	2	3	4	5	6
Introduction or improvement to environment-related cost management	0	1	2	3	4	5	6
Creation and use of environment-related cost accounts	0	1	2	3	4	5	6
Development and use of environment-related key performance indicators (KPIs)	0	1	2	3	4	5	6
Product life cycle cost assessments	0	1	2	3	4	5	6
Product inventory analyses (i.e. the specification of the types and quantities of materials and energy required and the amount of residues released to the environment)	0	1	2	3	4	5	6
Product impact analyses (i.e. assessment of the environmental effect of competing product designs)	0	1	2	3	4	5	6
Product improvement analysis (i.e. identification of opportunities for reduction of environmental impact)	0	1	2	3	4	5	6

[Strategy]

Q. The following four statements describe different types of businesses. Please read each one carefully.

1. Firm A maintains a "niche" in the market by offering a relatively stable set of products/services. Generally, Firm A is not at the forefront of new services or product market developments in its field. It tends to ignore changes that have no direct impact on current areas of operation and it concentrates instead on doing the best job in its existing arena.

2. Firm B maintains a relatively stable set of products/services while at the same time moving to meet selected, promising new product/service-market developments. The firm is seldom "first in" with new products or services. However, by carefully monitoring the actions of institutions like Firm C (below), Firm B attempts to follow with a more cost-efficient or well-conceived service/product.

3. Firm C makes relatively frequent changes in (especially additions to) its set of products/services. It consistently attempts to pioneer by being "first in" in new areas of market activity, even if not all these efforts ultimately prove to be highly successful. Firm C responds rapidly to early signals of market needs or opportunities.

4. Firm D cannot be clearly characterised in terms of its approach to changing its products/services or markets. It doesn't have a consistent pattern on this dimension. Sometimes the firm will be an early entrant into new fields of opportunity, sometimes it will move into new fields only after considerable evidence of potential success, sometimes it will not make service/product/market changes unless forced to by external changes.

(*Continued*)

Figure A1.

Considering your company as a whole and thinking of its typical pattern of behaviour, please place your company on the continuum below for the periods indicated or tick the box if your company's typical pattern of behaviour resembles Firm D:

	Firm A			Firm B			Firm C	Firm D
Three years ago	1	2	3	4	5	6	7	☐
Now	1	2	3	4	5	6	7	☐
In three years' time	1	2	3	4	5	6	7	☐

[Product/Process Innovation]

Q. Please indicate how you would position your company, compared to the industry average, in the following continuums:

During the last three years we have launched **few** new *products*	1	2	3	4	5	6	7	During the last three years we have launched **many** new *products*
During the last three years we have launched **few** modifications to already existing *products*	1	2	3	4	5	6	7	During the last three years we have launched **many** modifications to already existing *products*
Regarding new *products*, we are **very rarely** first-to-market	1	2	3	4	5	6	7	Regarding new *products*, we are **very often** first-to-market
The percentage of new *products* in our product portfolio is **much lower** than the industry average	1	2	3	4	5	6	7	The percentage of new *products* in our product portfolio is **much higher** than the industry average
During the last three years we have introduced **few** new *production processes*	1	2	3	4	5	6	7	During the last three years we have introduced **many** new *production processes*
During the last three years we have introduced **few** modifications to *production processes*	1	2	3	4	5	6	7	During the last three years we have introduced **many** modifications to *production processes*
Regarding new *production processes,* we are **very rarely** the first to introduce them	1	2	3	4	5	6	7	Regarding new *production processes*, we are **very often** the first to introduce them
The frequency of *production process* improvements in our company is **much lower** than the industry average	1	2	3	4	5	6	7	The frequency of *production process* improvements in our company is **much higher** than the industry average

Figure A1.

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