The British Accounting Review 43 (2011) 120–134

Contents lists available at ScienceDirect

The British Accounting Review

journal homepage: www.elsevier.com/locate/bar

The relationship between product diversity, usage of advanced manufacturing technologies and activity-based costing adoption

Martijn Schoute*

VU University Amsterdam, Faculty of Economics and Business Administration, Department of Accounting, De Boelelaan 1105, Room 2E-59, 1081 HV Amsterdam, The Netherlands

ARTICLE INFO

Article history:
Received 14 June 2010
Received in revised form 3 November 2010
Accepted 4 November 2010

Keywords:
Cost system design
Activity-based costing (ABC)
Product diversity
Advanced manufacturing technologies (AMT)

ABSTRACT

This paper examines the associations between product diversity, usage of advanced manufacturing technologies (AMT) and activity-based costing (ABC) adoption. Theory strongly suggests that product diversity is a major determinant of the demand for ABC systems. To date, the results of empirical research on the relationship between product diversity and ABC adoption have generally been inconclusive, however, suggesting that there either may be no strong relationship, or that methodological issues may have prevented researchers from consistently finding it. Using a dataset of survey responses from 191 Dutch, medium-sized manufacturing firms, this paper re-examines the relationship between product diversity and ABC adoption. Improving upon the measurement of product diversity and distinguishing between ABC adoption and use, it examines whether the relationship is curvilinear (inverted U-shaped) and/or moderated by usage of AMT. The paper contributes to the literature by showing that, consistent with the underlying theory, product diversity, on average, is positively related to both ABC adoption and ABC use, but also that these relationships are indeed inverted U-shaped and that the relationship with ABC use is negatively moderated by usage of AMT.

1. Introduction

It is widely recognized that in order to be optimal, costing practices should be closely related to the fundamental work processes in a firm. That is, more complex work processes require more complex cost systems (in terms of the applied overhead absorption procedures) to capture them. Accordingly, from a rational economic theoretical perspective, firms' adoption of activity-based costing (ABC) should be mainly driven by technological factors, of which especially product diversity is strongly suggested to be a major determinant of the demand for ABC systems (Abernethy, Lillis, Brownell, & Carter, 2001; Al-Omiri & Drury, 2007). Product diversity refers to conditions in which products place different demands on a firm's activities or activities place different demands on its resources, and is generally considered to be the most important cause of distorted product costs by traditional (non-activity-based) cost systems (e.g., Cooper, 1988; Kaplan & Cooper, 1998).

Since its introduction in the literature in the late 1980s, several streams of empirical research on ABC have developed, of which research on the determinants of ABC adoption is a major one (e.g., Gosselin, 1997; Krumwiede, 1998). The results of this research, in which the influence of many potential determinants has been studied, are generally inconclusive. This has led researchers into arguing that more research in this area is necessary (e.g., Abernethy et al., 2001; Drury & Tayles, 2005), since the source of the inconclusive results may not only be substantial, but may also be methodological (Al-Omiri & Drury, 2007).

* Tel.: +31 20 598 6068; fax: +31 20 598 9870.
E-mail address: m.schoute@feweb.vu.nl.

0890-8389/$ – see front matter
doi:10.1016/j.bar.2011.02.002

Most studies to date have, for example, used inconsistent definitions of and measurement instruments for both ABC adoption and its (proposed) determinants, and some have used rather simple, bivariate statistics. More importantly, no study has yet explored effects other than linear, additive ones for any of the potential determinants of ABC adoption, although the results of qualitative field research suggest such effects may exist in practice (e.g., Abernethy et al., 2001). Despite its strong theoretical foundation, similar to the other studied (potential) determinants, the results of empirical research on the relationship between product diversity and ABC adoption have also generally been inconclusive, suggesting that there either may be no strong relationship, or that methodological issues may have prevented researchers from consistently finding it.

The purpose of this paper is to re-examine the relationship between product diversity and ABC adoption, using a dataset of survey responses from 191 Dutch, medium-sized manufacturing firms. Improving upon the measurement of product diversity and distinguishing between ABC adoption (defined as either using or implementing ABC) and use (defined as using ABC), it examines whether the relationship is curvilinear (inverted U-shaped) and/or moderated by usage of advanced manufacturing technologies (AMT).

This paper contributes to the literature on the determinants of ABC adoption in at least three ways. First, previous survey research has been criticized for adopting a rather simplistic approach to the notion of product diversity (Abernethy et al., 2001). In these studies, it has either been measured as the number of products (or product variants) produced in a firm, or by using a composite multi-item scale with respect to the complexity (diversity) of manufacturing and costing in a firm. Both types of measures seem to insufficiently capture the exact nature of product diversity. This study therefore develops and uses a new, more comprehensive measure of product diversity, that essentially combines the main underlying elements of both previously used types of measures. Second, previous survey research (e.g., Al-Omiri & Drury, 2007; Krumwiede, 1998) has implicitly assumed that the relationship between product diversity and ABC adoption is linear; the assumption has been that increased product diversity leads to corresponding increases in firms' likelihood of adopting ABC. Positing a linear relationship ignores the possibility that there may be nonlinear effects of product diversity on firms' likelihood of adopting ABC. The results of this study show that, consistent with the underlying theory, product diversity, on average, is positively related to both ABC adoption and ABC use, but also that these relationships are inverted U-shaped; i.e., that they are positive up to a point and then begin to decline. From a practical perspective, this latter finding means that firms are more likely to adopt and use ABC at moderate levels of product diversity than at high levels of product diversity. Third, previous survey research (e.g., Al-Omiri & Drury, 2007; Krumwiede, 1998) has also implicitly assumed that the relationship between product diversity and ABC adoption is additive; the assumption has been that product diversity does not have a joint (or interactive) effect with other contextual factors on firms' likelihood of adopting ABC. In their field study, however, Abernethy et al. (2001) find evidence that the relationship between product diversity and ABC adoption may be moderated by usage of AMT, and argue that this moderation effect requires extensive testing. This study provides such testing and shows that the relationship with ABC use (but not with ABC adoption) is negatively moderated by usage of AMT. From a practical perspective, this finding means that the effect of product diversity on firms' likelihood of using ABC is stronger when the level of usage of AMT is relatively low than when this level is relatively high. Overall, the results of this study indicate that the inconclusive results of previous survey research on the relationship between product diversity and ABC adoption at least partially seem to have been caused by methodological issues.

The remainder of this paper is structured as follows. Section 2 reviews the literature and develops the hypotheses. Section 3 describes the research methods used. Section 4 presents and discusses the results. Section 5 summarizes and concludes.

2. Literature review

The main focus of this study is on the nature (form) of the relationship between product diversity and ABC adoption. Product diversity refers to "conditions in which [products] place different demands on [a firm's] activities or activities place different demands on [its] resources. This situation arises, for example, when there is a difference in mix or volume of products that causes an uneven assignment of costs" (CAM-I, 1992). Different types of diversity include: physical size, complexity and batch size (Cooper, 1988; Miller, 1996). Product diversity is generally considered to be the most important cause of distorted product costs by traditional cost systems that use responsibility-based cost pools and only volume-based cost allocation bases (e.g., Cooper, 1988; Kaplan & Cooper, 1998). When products consume indirect and support resources in different proportions (i.e., in levels disproportionate to their production volumes), an activity-based cost system that uses activity-based cost pools and hierarchical (e.g., batch-level, product-sustaining and facility-related) cost allocation bases better (more accurately) captures the variation in resource consumption by different products (e.g., Cooper, 1988; Kaplan & Cooper, 1998). Theory thus strongly suggests that product diversity is a major determinant of the demand for ABC systems.

A number of survey studies have previously studied the relationship between product diversity and ABC adoption, but overall they have found inconclusive results, with studies showing either a positive relationship (e.g., Malmi, 1999), no relationship (e.g., Al-Omiri & Drury, 2007), or even a negative relationship (e.g., Bjørnenak, 1997) (see Table 1). As also shown in Table 1, however, these studies have used a variety of research method choices. In particular, these studies have used inconsistent definitions of and measurement instruments for both ABC adoption and product diversity, and some have used rather simple, bivariate statistics, which suggests that the source of the inconsistent results may not only be substantial, but may also be methodological (Al-Omiri & Drury, 2007).

This study therefore develops and uses a new measure of product diversity, which (as will be explained in greater detail in the Research method section) is more comprehensive than existing measures and better captures the exact nature of product diversity. In addition, this study distinguishes between ABC adoption (defined as either using or implementing ABC) and use

Table 1
Previous survey research on the relationship between product diversity and ABC adoption versus this study.

Study	Research method choices				Results
	Sample	Statistical method(s)	Measurement of ABC adoption	Measurement of product diversity	
Bjørnenak (1997)	75 Norwegian manufacturing firms	*t*-test, Kruskall–Wallis test[a]	ABC adopters (defined as firms that have at least decided (planned) to implement ABC) vs. ABC non-adopters	Degree of customization[b] (measured on a five-point scale ranging from 1 (standardized production) to 5 (totally customized production))	–
				Number of product variants (measured using a $\log_{10}$ N scale)	n.s.
Krumwiede (1998)	225 U.S. manufacturing firms	Logistic regression analysis	ABC adopters (defined as firms that have at least approved implementation of ABC, including firms that have later abandoned it) vs. ABC non-adopters	Degree of potential for cost distortions (measured using a composite four-item scale)	+
Malmi (1999)	490 Finnish manufacturing firms	Mann–Whitney test	ABC adopters (defined as firms that are either using or implementing ABC) vs. ABC non-adopters	Number of different products (measured using a $\log_{10}$ N scale)	+
Clarke, Hill, and Stevens (1999)	204 Irish firms	Chi-square test	Implemented ABC vs. Assessing ABC vs. Rejected ABC vs. Not considered ABC	Number of product lines (measured on a four-point scale, where 1 = single product, 2 = 2 to 5 products, 3 = more than 5 similar products, and 4 = more than 5 dissimilar products)	n.s.
Al-Omiri and Drury (2007)	176 U.K. firms	Logistic regression analysis	ABC adopters (defined as firms that have at least approved implementation of ABC, excluding firms that have later abandoned it) vs. ABC non-adopters	Volume diversity[c] (measured using a composite two-item scale)	n.s.
				Support diversity[c] (measured using a composite two-item scale)	n.s.
This study	191 Dutch manufacturing firms	Logistic regression analysis	Both ABC adopters (defined as firms that are either using or implementing ABC) and ABC users (defined as firms that are using ABC) vs. ABC non-adopters/users	Number of different products (measured using a $\log_2$ N scale) multiplied by the average score on three dimensions (measured on a five-point scale ranging from 1 (not at all) to 5 (to a very great extent)) with respect to the extent to which these products differ on average	

Notes: The symbols displayed in the Results column indicate the relationship found, as follows: +, positive; -, negative; n.s., no significant relationship.

[a] Since Bjørnenak (1997) statistically compares only two (and not more than two) independent groups in terms of their level of product diversity, the Mann–Whitney test (instead of the Kruskall–Wallis test) would have been the more obvious choice here (even though these two tests provide the same *p*-value in this situation).

[b] Note that this study considers ‘degree of customization’ to be a similar, *but conceptually different construct* than ‘product diversity’.

[c] Volume diversity occurs when products are produced in different batch sizes, whereas support diversity occurs when varying support is given to each product by various support departments (Al-Omiri & Drury, 2007; see also Cooper, 1988 and Estrin, Kantor, & Albers, 1994).

(defined as using ABC), which is done since both 'implementation' and 'use' have been widely used as criteria for considering a firm to be an ABC adopter or not in prior studies (e.g., Innes, Mitchell, & Sinclair, 2000; Malmi, 1999). This study thus distinguishes two (rather broad) ABC implementation stages. This seems important given the finding of Anderson (1995) and Krumwiede (1998) that the importance of contextual factors seems to vary for different stages of the ABC implementation process, and the fact that research by Gosselin (1997) indicates that firms frequently remain in a certain stage of this process, for instance by taking the decision to invest resources for the implementation of ABC, but never actually implementing it, which suggests that (to the extent that such decisions are systematically related to these contextual factors) the strength of the relationship between contextual factors and ABC adoption and use may differ in practice. Unfortunately, previous research provides insufficient guidance to enable the development of specific hypotheses on differences in their relationship with the technological factors that this paper focuses on; i.e., to distinguish their associations with product diversity and usage of AMT at a theoretical level.

Based on the above discussion, the following hypothesis is formulated:

Hypothesis 1 (H1): Product diversity is positively related to firms' likelihood of (a) adopting and (b) using ABC.

Prior studies on the relationship between product diversity and ABC adoption have, as almost all empirical management accounting research to date (Luft & Shields, 2003), implicitly assumed that this relationship is linear. It may very well be, however, that in practice, similar to other relationships involving cost-benefit considerations, this relationship is curvilinear. In order to accurately capture the complexity of underlying fundamental work processes, conditions of high product diversity will typically require a very complex (activity-based) cost system. Such a system is not only complex in design, making it complicated for potential users, but also typically costly to implement and operate. It may even be so costly that the potential benefits of implementing such a complex ABC system do not exceed its costs in conditions of high product diversity. Firms may also implement a relatively simple(r) ABC system in such conditions (Kaplan & Cooper, 1998), but the higher the level of product diversity, the less accurate (and thus the less of an improvement over alternative cost systems) such a simple(r) ABC system then generally will be. Firms may therefore prefer to invest their money in other ways to manage their product diversity, such as in redesigning their (especially support) work processes, and/or in improving their existing (traditional) cost system rather than in implementing an ABC system, in conditions of high product diversity. As a consequence, in such conditions firms' likelihood of adopting ABC is expected to be lower than in conditions of somewhat lower levels of product diversity. In conditions of low to moderate product diversity, however, the costs of implementing an accurate ABC system will typically be much lower, and in such conditions firms' likelihood of adopting ABC is expected to constantly increase as the level of product diversity increases (as hypothesized earlier). This implies that overall the relationship between product diversity and firms' likelihood of adopting ABC will be curvilinear (inverted U-shaped); that is, it will be positive up to a certain point (at a moderate level of product diversity) and then begin to decline. Accordingly, taking the distinction made in this study between ABC adoption and use into account, the following hypothesis is formulated:

Hypothesis 2 (H2): The relationship between product diversity and firms' likelihood of (a) adopting and (b) using ABC is curvilinear (inverted U-shaped).

AMT is an umbrella term used to describe a variety of computer-controlled automated process technologies, which can provide cost-efficient flexibility and flow in manufacturing (e.g., Jonsson, 2000). Following Adler (1988), three broad types (categories) of AMT are generally distinguished in the literature: design, manufacturing and administrative AMT. Design AMT focus on the design of products and processes, manufacturing AMT on the actual manufacturing and physical transformation of the products, and administrative AMT on tracking operations (Jonsson, 2000). This study focuses on manufacturing AMT. Typical examples of such technologies are computer-aided manufacturing (CAM), flexible manufacturing systems (FMS) and automated material handling systems. In their qualitative field study of the relationship between product diversity and cost system design choices in five divisions of two firms, Abernethy et al. (2001) find this relationship to be influenced by the extent to which the divisions use AMT to manage their product diversity. It appears that the decision to invest in advanced manufacturing technologies moderates the relationship between product diversity and cost system design, as firms have a choice whether to manage their product diversity by investing in AMT, which in general will reduce their batch- and product-related costs and thus their need to adopt an ABC system, or by investing in such a sophisticated cost system. Therefore, these two options are partially considered to be an "either-or" choice, suggesting that the relationship between product diversity and ABC adoption is negatively moderated by usage of AMT. Accordingly, taking the distinction made in this study between ABC adoption and use into account, the following hypothesis is formulated:

Hypothesis 3 (H3): The relationship between product diversity and firms' likelihood of (a) adopting and (b) using ABC is negatively moderated by the extent to which these firms use advanced manufacturing technologies.

Fig. 1 shows the conceptual research model describing the relationships examined in this study. In addition to product diversity and its interaction with usage of AMT, a number of other factors related to firms' fundamental work processes have also been shown to influence their ABC adoption choices, including degree of customization (Bjørnenak, 1997; Drury & Tayles, 2005), number of production lines (Groot, 1999), organizational size (Innes et al., 2000; Krumwiede, 1998; Malmi, 1999), TQM usage (Cagwin & Bouwman, 2002; Krumwiede, 1998), JIT usage (Al-Omiri & Drury, 2007; Cagwin & Bouwman, 2002; Krumwiede, 1998), and the structure of firms' production process (Ittner, Lanen, & Larcker, 2002; Krumwiede, 1998). Since

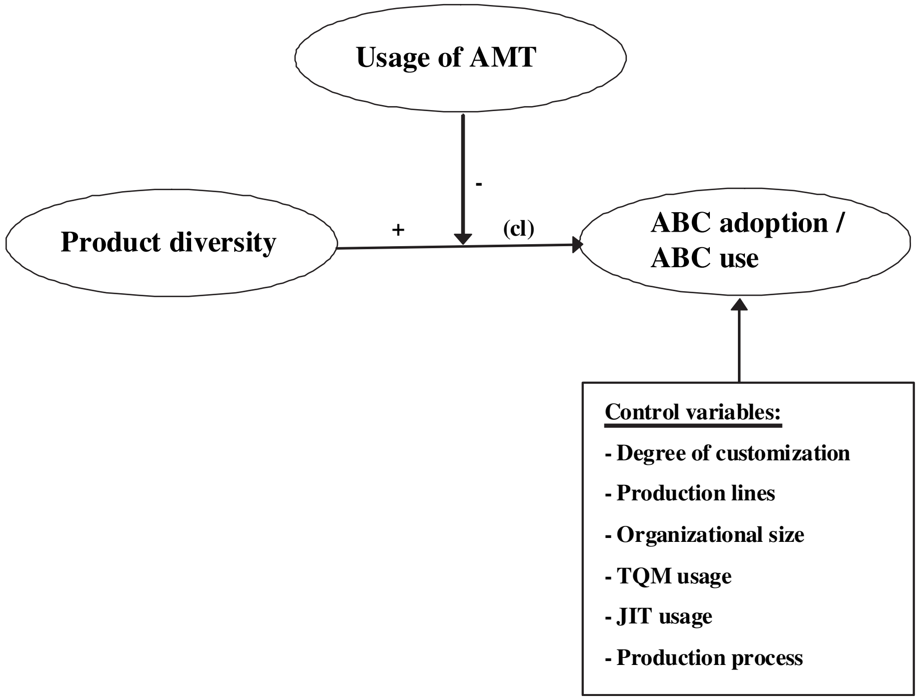

Fig. 1. Conceptual research model. Notes: AMT = advanced manufacturing technologies; (cl) = curvilinear relationship.

these factors may not only influence firms' ABC adoption choices, but may also be associated with product diversity and usage of AMT, their influence will be controlled for in the empirical analyses (see also Fig. 1).

3. Research method

3.1. Sample and data collection

The data in this paper are taken from a large-scale, multi-purpose survey, conducted in 2002, on the use of cost systems in medium-sized, Dutch manufacturing firms (see also Schoute, 2009). Medium-sized firms were targeted because larger firms commonly consist of a number of organizational units, which may not all use similar cost systems, whereas smaller firms may not use sophisticated cost allocation systems at all. The sample was confined to manufacturing firms, as these are assumed to be a relatively homogeneous group, distinct from non-manufacturing firms. The database REACH was used to select the sample for this study. This database contains comprehensive financial and economic information on the largest 5000 Dutch firms for the most recent ten-year period. Firms were included in the sample if (a) they had between 50 and 500 employees, and (b) their main activity was in a manufacturing industry. These criteria yielded 2108 (independent) firms representing all major manufacturing industries. Next, these firms were categorized into two groups, based on the amount of information available in the database. This division was made because resources were limited, so that most resources could be spent on those firms for which the database contained the fullest information. The first group contained all firms providing full information for at least three years (672 firms), which was a requirement for one of the (other) purposes of the survey. The second group contained all other firms (1436 firms). Since larger firms have an obligation to disclose this information, the firms in the first group are larger than those in the second group.

Firm-level data on cost systems, and characteristics of the firm unavailable in the database, were collected with a 14-page questionnaire mailed to either the general manager or the financial manager in each firm. These managers were chosen as respondents as they should be able to provide the information required for the purposes of the study. Many recommendations from Dillman's (2000) Tailored Design Method were followed in this part of the study. The questionnaire was extensively pretested with four management accounting faculty colleagues and six financial managers, to assess and enhance understandability and content validity. The procedure for firms in the first group consisted of, at the most, four moments of contact: contact by phone, and sending a questionnaire, reminder postcard and replacement questionnaire. The procedure for firms in the second group consisted of, at the most, two moments of contact: sending a questionnaire and replacement questionnaire. In all cases, together with the questionnaire and the replacement questionnaire, the respondent was sent an accompanying letter explaining the purposes of the study and guaranteeing confidentiality, as well as a postage-paid return envelope. Also, at the final moment of contact in each procedure, the respondent was sent a postage-paid return card asking the reason(s) for leaving the questionnaire unanswered.[1]

The overall usable response rate was 10.7%. From the first group 137 firms returned a questionnaire, from the second group 81, and 14 questionnaires were returned anonymously. Seven returned questionnaires were unusable and were deleted.[2] For the analyses of this paper all questionnaires are pooled. Except for the difference by design in organizational size, there are no a priori reasons to assume that the responses from firms in the first group will differ from responses from firms in the second.[3] Consistent with this presumption, Chow-type tests (e.g., Greene, 2000) for all the models show no significant differences between the two groups. To investigate the possibility of non-response bias, the respondents were compared to the non-respondents in terms of industry representation. The results show that the firms that responded are from similar industries as the firms that did not respond.[4] Second, an early-late respondents analysis was conducted. This analysis, with early and late respondents respectively defined as having sent back the initial or the replacement questionnaire, shows no significant difference in means or proportions for any of the variables examined in this study, suggesting the absence of non-response bias. The average respondent is 41 years of age (median = 40.5 years), is working for his/her employer for almost 9 years (median = 5 years), and has held his/her position for a little more than 5 years (median = 3 years). Also, 175 (77.8%) respondents are working as financial managers, 34 (15.1%) as general managers, and 16 (7.1%) did not disclose whether they are working as a financial or a general manager.

For the analyses reported in this paper, due to missing values, the available number of observations is less than the overall sample. The overall percentage of missing values was slightly below 3%. To test whether the missing values were missing completely at random (MCAR), Little's MCAR test was performed, which was not significant (($\chi^2 = 6939.939$, $df = 6910$, $p = 0.397$). This implies that the imputation method has no impact on the results, and therefore any imputation method can be used (Hair, Anderson, Tatham, & Black, 1998). These values were dealt with in two steps. In the first step, where appropriate, they were handled using EM imputations (e.g., Allison, 2001). In the second step, remaining missing values were handled using listwise deletion. The sample left after listwise deletion comprised 193 cases. Two additional observations were removed from the dataset after an extensive examination of regression diagnostics, however.[5] This left a usable sample of 191 cases for the analyses reported in this paper.

3.2. Measures

This section describes all the variables examined in this study and the measurement instruments used to measure them (see also the Appendix). Except for the data on the firms' size, which were collected from the database out of which the firms were selected, all data are from the survey. Both independent variables, 'product diversity' (*PD*) and 'usage of AMT' (*AMT*), were measured using multi-item instruments, for which composite scales were constructed by averaging the scores on their indicators. Average scores, as opposed to factor scores, were used because these instruments are, based on theoretical considerations (and using the criteria developed by Jarvis, MacKenzie, and Podsakoff (2003)), considered to be formative-indicator constructs (linear combinations in which the construct depends upon the indicators) in this study, as opposed to reflective-indicator constructs (linear combinations in which the indicators are the result of the construct) (Bisbe, Batista-Foguet, & Chenhall, 2007; Bollen & Lennox, 1991). Each of their elements captures differing aspects of the constructs, that collectively define the constructs, that do not necessarily have to covary, and that each may have different antecedents and/or consequences (cf. Jarvis et al., 2003). This implies that most commonly used reliability and validity tests are meaningless with formative-indicator constructs (Bisbe et al., 2007; Jarvis et al., 2003). Three measurement instruments are nonlinear. First, both 'product diversity' (*PD*) and 'production lines' (*PRLIN*) were measured using a $\log_2 N$ scale and are therefore inherently nonlinear. Second, for 'organizational size' (*SIZE*) the scale was transformed into a (nonlinear) ln-scale because the distribution of the original values was highly skewed (i.e., nonnormal).

3.2.1. Dependent variables

ABC adoption (ABC_ADOP) and *ABC use (ABC_USE)*. In most prior surveys firms using ABC have either been identified with a question directly asking respondents to indicate whether their firm uses ABC or not (e.g., Kallunki & Silvola, 2008), or with a question asking respondents to indicate which of several stages toward ABC implementation best describes their firm's current situation (e.g., Al-Omiri & Drury, 2007). Following this last procedure, in this study respondents were asked to

[1] The main reasons for leaving the questionnaire unanswered (269 firms) were: "Questionnaire would take too long to fill out" (52%) and "General policy against filling out questionnaires" (30%).

[2] Several respondents had skipped (or missed) multiple pages of the questionnaire containing the survey's most important questions, while others overall had too many missing values (>40%).

[3] A *t*-test for two independent samples indeed shows a significant difference in means between the two groups for organizational size in the final usable sample ($t(189) = 8.308$, $p < 0.001$). Of the other variables only the 'degree of customization' (*CUST*) variable ($t(189) = 2.059$, $p = 0.041$) also shows a significant difference at a significance level of 0.10.

[4] A one-sample Chi–Square test shows no significant difference in industry representation between neither the overall usable sample ($N = 225$) nor the final usable sample ($N = 191$) and the sample yielded from the database ($\chi^2(13, 225) = 18.09$, $p = 0.154$ and $\chi^2(13, 191) = 16.86$, $p = 0.206$, respectively).

[5] As emphasized by Cohen et al. (2003, p. 411), careful screening for potentially outlying cases is especially important for (logistic) regression analysis including power polynomials and/or interaction terms. The two cases were removed after carefully examining the leverage, discrepancy and influence of all cases, using the measures and cutoffs suggested by Cohen et al. (2003), Menard (2001) and Pregibon (1981). With the two cases included, logistic regression analysis shows that, compared to the results presented in this paper, in the full ABC adoption model (Model 1) the same effects are statistically significant. In the full ABC use model (Model 3), however, *AMT* and *PD***AMT* are no longer significant.

indicate which of five stages best described their firm's current situation with respect to ABC: (a) currently using ABC, (b) currently implementing ABC, (c) currently considering ABC adoption, (d) no consideration of ABC to date, or (e) rejected ABC after assessment. Firms of which the respondents indicated that they were (a) using ABC are considered ABC users ($ABC\_USE = 1$), whereas firms of which the respondents indicated that they were either (a) using or (b) implementing ABC are considered ABC adopters ($ABC\_ADOP = 1$).

Responses to additional questions aimed only at the ABC adopters[6] show that, on average, approximately 76.2% of the planned implementation process of ABC was finished in the sample firms at the moment of research (range: 10%–100%), and that the implementation process (so far) had gone according to plan "to a considerable extent" ($M = 3.58$, $SD = 0.76$).[7] Furthermore, as much as 80.8% of the respondents indicated that the ABC system in their firm encompasses all production units, whereas 65.4% indicated that their firm's ABC system is integrated with other information systems.[8] Finally, the responses show that, on average, the sample firms update the structure (e.g., the activities) of their ABC system on a yearly basis ($M = 4.96$, $SD = 1.02$), and the contents (e.g., the costs) on a half-yearly basis ($M = 3.73$, $SD = 1.93$).[9] More importantly, Mann–Whitney tests show that the firms that indicated to be using ABC had finished significantly more of their planned implementation process than the firms that indicated to be implementing ABC ($z = -2.674$, $p = 0.007$), and also that their implementation process (so far) had gone according to plan to a higher extent ($z = -2.160$, $p = 0.031$). This, at least to some extent, empirically validates the distinction made in this paper between ABC adopters (which include firms currently implementing ABC) and ABC users (which exclude these firms), and suggests that the difference between the firms in these two stages toward ABC implementation is mainly a matter of timing (with some firms simply having started implementing ABC earlier or to have done it more quickly than others).

3.2.2. Independent variables

3.2.2.1. Product diversity (PD). In prior surveys on ABC adoption, product diversity has either been measured as the number of products (or product variants) produced in a firm (e.g., Malmi, 1999), or by using a composite multi-item scale with respect to the complexity (diversity) of manufacturing and costing in a firm (e.g., Krumwiede, 1998). Both types of measures seem to insufficiently capture the exact nature of product diversity. As emphasized by Abernethy et al. (2001), producing multiple products does not in itself generate a demand for an ABC system. It is only when these products differ in terms of, for example, the batch sizes in which they are produced, that different products will consume disproportionate levels of indirect and support resources relative to their production volumes and the potential for the reporting of distorted product costs by traditional cost systems becomes significant. On the other hand, when a firm produces only a small number of products, the demand for an ABC system will in general be low, even when these products differ substantially. Hence, the nature of product diversity is not so much reflected in *either* (a) the number of products produced *or* (b) the extent to which the products differ from each other on several, relevant dimensions, but in their *combined* effect. In line with this reasoning, in this study *PD* was measured by two questions. First, respondents were asked to indicate the number of different products (stock-keeping units) produced in their firm. This was measured using a $\log_2 N$ scale, where N is the number of products produced; i.e., it is assumed that the nature of product diversity is best reflected by a base 2 logarithmic function. Note that this function is nonlinear (concave): a one-unit in-/decrease in the number of products produced is assumed to have a larger influence on the level of product diversity when the firm produces only one or a few products, than when the firm already produces many products.[10] Second, respondents were asked, on a five-point scale ranging from 1 (not at all) to 5 (to a very great extent), to indicate to what extent the products (stock-keeping units) produced in their firm differ on average on three dimensions: physical size, complexity and batch size. The $\log_2 N$ scores were multiplied by the average of the scores on the three dimensions to obtain the measure of product diversity. To test the construct's criterion-related validity, its association was analyzed with a statement, measured on a five-point scale (1 = not at all to 5 = to a very great extent), concerning the extent to which the respondent's firm "offers a wide variety of products" ($r(191) = 0.470$, $p < 0.001$ and $r(178) = 0.473$, $p < 0.001$, respectively).[11] This indicates that firms with a higher level of *PD* are indeed more diversified in terms of products produced.

---

[6] Due to missing values, the available number of observations for these additional questions is 26 (out of the 33 ABC adopters). Given this rather limited number of observations, non-parametric statistical tests were used to analyze the interrelationships among the responses to these six questions, and their associations with the firms' ABC adoption status. To investigate the possibility of non-response bias for these items, the 26 respondents were compared to the 7 non-respondents on all variables examined in this study, which only shows a significant difference between the two groups in terms of the proportion of ABC users ($\chi^2(1) = 3.82$, $p = 0.051$), with a higher proportion of ABC users among the respondents. This probably reflects the fact that some of the firms had just started implementing ABC and were not in a position yet to answer these questions.

[7] These two aspects are significantly positively correlated ($r_s = 0.648$, $p < 0.001$).

[8] Surprisingly, these two aspects turn out to be negatively associated: comparatively, companywide ABC systems are implemented as stand-alone systems more than expected, while partial ABC systems are more than expected implemented as integrated systems ($\chi^2(1) = 3.277$, $p = 0.070$).

[9] These two aspects are significantly positively correlated ($r_s = 0.654$, $p < 0.001$).

[10] The number of different products (stock-keeping units) produced in the firms indicated by the respondents were transformed into $\log_2$ scores by taking the log base 2 of the highest number in each response category. Response categories were used instead of asking respondents to provide specific numbers, as the latter option would likely have led to more missing values or a higher level of unreliability.

[11] In addition, in this study also the guidelines developed by Diamantopoulos and Winklhofer (2001), which concern four issues critical for formative-indicator constructs (content specification, indicator specification, indicator collinearity and external validity), were used to validate the 'product diversity' (*PD*) and 'usage of AMT' (*AMT*) variables. Overall, the findings based on these guidelines also suggest that the instruments used to measure these two constructs are valid measures. (A document containing this additional validity assessment of the 'product diversity' (*PD*) and 'usage of AMT' (*AMT*) variables is available from the author upon request.)

Usage of AMT (AMT) was measured using the part of an (adapted) instrument developed by Boyer, Ward, and Leong (1996) concentrating on manufacturing AMT. Respondents were asked, on a five-point scale ranging from 1 (not at all) to 5 (to a very great extent), to indicate the extent to which nine advanced manufacturing technologies are used in their firm's production process. Compared to the original instrument two adaptations were made. First, in order to be consistent throughout the questionnaire, a five-point scale was used instead of the seven-point scale used by Boyer et al. (1996). Second, instead of asking respondents to indicate the amount of investment made in the AMT on a scale ranging from "no investment" to "heavy investment" as Boyer et al. (1996) did, respondents were asked to indicate the extent to which the AMT are used in their firm's production process. This last adaptation was made in order to address two shortcomings identified by Boyer and Pagell (2000): (1) that the original instrument does not discriminate between technological leaders and firms that invest a lot of money in technologies that end up not (or hardly) being used, and (2) that the original instrument implicitly assumes that a heavy investment is an important investment, which is not necessarily the case. A composite scale was constructed by averaging the scores on the nine technologies (items) (cf. Boyer, Leong, Ward, & Krajewski, 1997), which were all included since (a) in principle, they can all be used by firms to manage their product diversity (which is the theoretical argument underlying the hypothesized moderating effect of usage of AMT on the relationship between product diversity and ABC adoption), and (b) the fact that for formative-indicator constructs the items used as indicators must cover the entire scope of the construct (given that eliminating an indicator from its measurement instrument may omit a unique part of its conceptual domain and change its meaning; Diamantopoulos & Winklhofer, 2001). To test the construct's criterion-related validity, its association was analyzed with a statement, measured on a five-point scale (1 = not at all to 5 = to a very great extent), concerning the extent to which the respondent's firm "produces products in innovative ways" ($r(191) = 0.343$, $p < 0.001$ and $r(178) = 0.359$, $p < 0.001$, respectively). This indicates that firms with a higher level of *AMT* are more innovative in terms of manufacturing.

3.2.3. Control variables

The control variables were measured as follows. To measure *degree of customization (CUST)*, respondents were asked to indicate the percentage of their firm's production that is customized. To measure *production lines (PRLIN)*, respondents were asked to indicate the number of production lines in their firm. Similar to 'product diversity' (*PD*), this was measured using a $\log_2$ N scale. *Organizational size (SIZE)* was measured as (the natural logarithm of) the number of employees. The data for this measure were obtained from the REACH database. *TQM usage (TQM)* was measured by directly asking the respondents to indicate whether their firm uses Total Quality Management (TQM) or not. Similarly, *JIT usage (JIT)* was measured by directly asking the respondents to indicate whether their firm uses Just-In-Time management (JIT) or not. Finally, to measure *production process (PRPRO)*, respondents were asked to indicate which of the following four classifications best describes the structure of their firm's production process: homogeneous mass production (*HomMass* – used as the reference group), heterogeneous mass production (*HetMass*), serial unit production (*SerUnit*), or unit production (*Unit*).

3.3. Some statistical considerations

For the analyses of this paper, logistic regression analysis including power polynomials and interactions is used, combined with a graphical analysis in order to further explore the (nonlinear and nonadditive) form of the relationship between product diversity and firms' ABC adoption choices. Separate models are estimated for ABC adoption and for ABC use. In all cases, however, ABC adopters and ABC users are compared with the same group, ABC non-adopters/users. This means that in the analyses of ABC users, firms of which the respondents indicated that they are currently implementing ABC are left out of the estimation samples. Such firms probably have more in common with users of ABC than with non-users. Therefore, considering them to be ABC non-users would possibly distort observable differences between the groups.[12] Furthermore, all continuous independent and control variables were mean centered before entering them in the logistic regression models. This procedure is widely recommended when estimating models containing power polynomials and/or interactions (e.g., Cohen, Cohen, West, & Aiken, 2003), as in such models centering has both interpretational advantages (as it yields meaningful interpretations of each first-order regression coefficient of independent variables entered into the regression model), and eliminates nonessential multicollinearity.[13] Finally, as argued earlier, 'product diversity' (*PD*) was measured using a $\log_2$ N scale and is therefore inherently nonlinear. Note that both the base 2 logarithmic function used to measure this variable and its hypothesized curvilinear (inverted U-shaped) relationship with firms' likelihood of adopting and using ABC are concave and thus have a decreasing slope. This implies that any effects found for the hypothesized curvilinear (inverted U-shaped)

[12] It would also have been interesting to treat the ABC non-adopters/users, ABC implementers and ABC users as three logically *ordered* outcome categories reflecting an underlying continuum of propensity to adopt ABC, and to more directly examine the influence of the independent (and control) variables on the movement along this latent continuum. However, since the model would contain a power polynomial and an interaction term, ordinal logistic regression is not appropriate for this purpose, given that its underlying assumption of parallel slopes is indefensible. Alternatively, a series of nested dichotomous logistic regressions could have been used (Cohen et al., 2003), but unfortunately the limited number of ABC implementers and ABC users in the sample makes it impossible to appropriately analyze the contrast between these two groups.

[13] Variance inflation factors (VIFs) indicate that, after mean centering, multicollinearity is not a problem in any of the logistic regression analyses (below 1.5 for the continuous independent variables, and below 4.5 for the dummy independent variables).

relationship would have been even stronger if the nature of product diversity would not have been assumed to be best reflected by a base 2 logarithmic function, but would have been measured as being inherently linear instead.

4. Results and discussion

4.1. Descriptive statistics

The number of ABC adopters in the final sample is 33, whereas the number of ABC users is 20. Although comparable to earlier studies (e.g., Groot, 1999; Innes et al., 2000), the ABC adoption and use rates (17.3% and 10.5%, respectively) are thus fairly low. This may partly be explained by the widespread use of the (somewhat similar) "cost pool method" (or "cost center method") in the Netherlands (Groot, 1999).[14] Table 2 presents the descriptive statistics for the independent and control variables used in this study.

As shown in Table 2, a number of statistically significant differences in means are observed between the groups.[15] Both the ABC adopters and the ABC users differ significantly from the ABC non-adopters/users on the following continuous independent and control variables: *PD* and *PRLIN*. This indicates that, on average, the adopters and users of ABC produce a larger number of and more different products (stock-keeping units), and operate a larger number of production lines, than the non-adopters/users. These differences for *PD* provide some initial support for hypothesis 1. In addition, the ABC users also differ significantly from the ABC non-adopters/users on the continuous variable *AMT*, which indicates that, on average, the users of ABC use more advanced manufacturing technologies than the non-adopters/users. For the dichotomous control variables, two significant associations are found with ABC adoption, and one with ABC use. Comparatively, firms with a homogeneous mass production process have adopted ABC more than expected ($\chi^2(1) = 2.936$, $p = 0.087$), whereas firms with a serial unit production process have adopted it less than expected ($\chi^2(1) = 3.257$, $p = 0.071$). Similarly, firms with a serial unit production process also use ABC relatively less than expected ($\chi^2(1) = 5.426$, $p = 0.020$). No significant associations are found with TQM and JIT usage.

Table 3 presents the Pearson correlations for the independent and control variables.

As shown in Table 3, *PD* and *AMT* are significantly positively correlated in the ABC adoption sample ($N = 191$), but not in the ABC use sample ($N = 178$). *PD* is also significantly positively correlated with *PRLIN*, and (in the ABC adoption sample) negatively with *HomMass*. This indicates that, as the sample firms produce a larger number of and more different products (stock-keeping units), they operate a larger number of production lines. Furthermore, these results suggest that firms with a homogeneous mass production process produce a smaller number of and less different products (stock-keeping units) than firms with one of the other three types of production processes. Similarly, *AMT* is also significantly positively associated with *PRLIN*, *TQM* and *JIT* (and *HomMass* in the ABC use sample), and negatively with *Unit*. This indicates that, as the sample firms use more advanced manufacturing technologies, they operate a larger number of production lines. Furthermore, these results suggest that firms that use TQM and/or JIT use more advanced manufacturing technologies than firms that do not use these lean production techniques, and that firms with a unit production process use less advanced manufacturing technologies than firms with one of the other three types of production processes.

4.2. Logistic regression analysis results

Table 4 presents the results of four logistic regression models testing the influence of product diversity (as reflected by its linear and quadratic terms), usage of AMT, and their linear-by-linear interaction effect on ABC adoption (Panel A) and ABC use (Panel B), respectively. As the results of the models with the control variables included (Models 1 and 3) are very similar to the results of the models with these variables excluded (Models 2 and 4), this section will concentrate on the results of the full models (Models 1 and 3).

Models 1 and 3 are both significant. Of the independent variables, in Model 1, the full ABC adoption model, only the effects of *PD* and PD^2 are significant, whereas in Model 3, the full ABC use model, also the effects of *AMT* and *PD***AMT* are significant. The significant coefficient for *PD* in both models reflects the average linear slope of the logistic regression of ABC adoption and ABC use on product diversity as part of the models, when *AMT* equals its sample mean, and implies that the overall linear trend in the data is positive. This provides support for H1, which predicts that product diversity is positively related to firms' likelihood of adopting and using ABC. The significant coefficient for PD^2 in both models indicates that overall the slope is curvilinear. More specifically, given that this coefficient is negative, it indicates a curve that is inverted U-shaped (concave

[14] See Boons, Roberts, and Roozen (1992) for an analysis of the similarities and differences between ABC and the German/Dutch cost pool method, which is grounded in German cost theory.

[15] In addition, differences between the three groups of ABC non-adopters/users ($n = 158$) were also tested on: (1) "currently considering ABC adoption" ($n = 36$), (2) "no consideration of ABC to date" ($n = 87$), and (3) "rejected ABC after assessment" ($n = 35$). For the continuous independent and control variables no significant differences in means between the three groups were found. For the dichotomous control variables significant associations were found with *JIT* and *Unit*. The results indicate that firms that are currently considering ABC adoption use JIT relatively more than expected, whereas firms that have either rejected ABC after assessment or not considered ABC to date use it less ($\chi^2(2) = 5.201$, $p = 0.074$). Also, firms with a unit production process have not considered ABC to date relatively more than expected, whereas such firms either have rejected ABC after assessment or are currently considering ABC adoption relatively less than expected ($\chi^2(2) = 4.602$, $p = 0.100$).

Table 2
Descriptive statistics.

Variables	Total sample ($N = 191$)		ABC adopters ($n = 33$)		ABC users ($n = 20$)		ABC non-adopters/ users ($n = 158$)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
PD	23.73	12.78	28.23**	10.59	28.51**	9.74	22.79	13.03
AMT	2.15	0.73	2.31	0.78	2.42*	0.83	2.12	0.72
CUST	0.65	0.37	0.64	0.35	0.56	0.36	0.65	0.37
PRLIN	2.73	1.42	3.13*	1.39	3.32**	1.35	2.65	1.41
SIZE	4.96	0.61	5.01	0.51	5.08	0.45	4.94	0.63
	n	%	*n*	%	*n*	%	*n*	%
TQM	84	44.0	18	54.5	10	50.0	66	41.8
JIT	69	36.1	14	42.4	9	45.0	55	34.8
HomMass	15	7.9	5	15.2	3	15.0	10	6.3
HetMass	49	25.7	10	30.3	8	40.0	39	24.7
SerUnit	85	44.5	10	30.3	4	20.0	75	47.5
Unit	42	22.0	8	24.2	5	25.0	34	21.5

Notes: $N = 191$; ***, **, * indicates significance (of differences in means relative to the ABC non-adopters/users) at the 0.01, 0.05 and 0.10 level (two-tailed), respectively. The following abbreviations are used in the table: PD = product diversity; AMT = usage of AMT; CUST = degree of customization; PRLIN = production lines; SIZE = organizational size; TQM = TQM usage; JIT = JIT usage; HomMass = homogeneous mass production; HetMass = heterogeneous mass production; SerUnit = serial unit production; Unit = unit production.

downward); i.e., a curve that is positive up to a point and then begins to decline. This provides support for H2, which predicts that the relationship between product diversity and firms' likelihood of adopting and using ABC is curvilinear (inverted U-shaped), and implies that firms are more likely to adopt and use ABC at moderate levels of product diversity than at high levels of product diversity. The insignificant coefficient for *PD*AMT*, the linear-by-linear interaction effect of product diversity and usage of AMT, in Model 1, and its significant coefficient in Model 3, imply that the relationship between product diversity and ABC adoption is not moderated by usage of AMT, but the relationship between product diversity and ABC use is. This provides support for H3b, which predicts that the relationship between product diversity and firms' likelihood of using ABC is negatively moderated by the extent to which these firms use advanced manufacturing technologies, but not for H3a, which predicts a similar moderating effect on the relationship between product diversity and firms' likelihood of adopting ABC. The significant coefficient for *PD*AMT* in Model 3 implies that the effect of product diversity on firms' likelihood of using ABC is stronger when the level of usage of AMT is relatively low than when this level is relatively high.

In order to further explore the (nonlinear and/or nonadditive) form of the relationships between product diversity and ABC adoption and ABC use, Figs. 2 and 3 provide graphical presentations of the joint (or interaction) effect of product diversity and usage of AMT on firms' likelihood of adopting and using ABC, respectively. For the range between two *SD*s below and two *SD*s above the mean of *PD*, the figures plot the regression of *ABC_ADOP* and *ABC_USE* on *PD* and PD^2 at three values of *AMT*: the mean (AMT_mean), one *SD* below the mean (AMT_low), and one *SD* above the mean (AMT_high). Both graphs clearly show that, consistent with the significant effects of *PD* and PD^2 in both models, overall all slopes have a positive linear trend, but are also curvilinear (inverted U-shaped). Furthermore, in Fig. 2, consistent with the insignificant coefficient for *PD*AMT* in Model 1, the three slopes are almost parallel, suggesting the non-existence of a linear-by-linear interaction effect of product diversity and usage of AMT on firms' likelihood of adopting ABC. In Fig. 3, however, consistent with the significant coefficient for *PD*AMT* in Model 3, the three slopes are clearly not parallel, suggesting the existence of such an interaction effect on firms' likelihood of using ABC. Therefore, Fig. 3 provides support for the qualitative findings of Abernethy et al. (2001), especially

Table 3
Pearson correlations for the independent and control variables (for the ABC adoption and ABC use samples).

Variables	PD	AMT	CUST	PRLIN	SIZE	TQM	JIT	HomMass	HetMass	SerUnit	Unit
PD	–	0.114	0.095	0.181**	0.012	0.079	−0.008	−0.104	0.009	0.096	−0.060
AMT	0.134*	–	0.045	0.180**	−0.049	0.184**	0.168**	0.131*	0.051	0.012	−0.152**
CUST	0.098	0.041	–	−0.034	−0.042	0.048	0.111	−0.187**	−0.166**	−0.053	0.359***
PRLIN	0.193***	0.212***	−0.030	–	0.111	0.017	0.131*	0.025	0.272***	−0.048	−0.248***
SIZE	0.029	−0.001	−0.049	0.132*	–	0.139*	−0.033	−0.062	0.142*	−0.168**	0.089
TQM	0.087	0.181**	0.034	0.034	0.149**	–	0.205***	0.020	0.050	−0.017	−0.045
JIT	0.010	0.163**	0.118	0.144**	−0.024	0.190***	–	0.015	−0.130*	0.038	0.084
HomMass	−0.120*	0.090	−0.210***	0.001	−0.075	0.055	0.024	–	−0.168**	−0.251***	−0.149**
HetMass	0.022	0.077	−0.172**	0.291***	0.157**	0.059	−0.117	−0.171**	–	−0.535***	−0.317***
SerUnit	0.102	0.035	−0.032	−0.045	−0.145**	−0.051	0.050	−0.261***	−0.526***	–	−0.473***
Unit	−0.068	−0.182**	0.355***	−0.253***	0.058	−0.037	0.048	−0.155**	−0.312***	−0.475***	–

Notes: ***, **, * indicates significance at the 0.01, 0.05 and 0.10 level (two-tailed), respectively. The Pearson correlations for the ABC adoption sample ($N = 191$) are presented below the diagonal; the Pearson correlations for the ABC use sample ($N = 178$) are presented above the diagonal. The following abbreviations are used in the table: PD = product diversity; AMT = usage of AMT; CUST = degree of customization; PRLIN = production lines; SIZE = organizational size; TQM = TQM usage; JIT = JIT usage; HomMass = homogeneous mass production; HetMass = heterogeneous mass production; SerUnit = serial unit production; Unit = unit production.

Table 4
Logistic regression analysis results for the ABC adoption and use models.

Independent variables	Panel A: ABC adoption models		Panel B: ABC use models	
	Model 1 (Full model)	Model 2 (Partial model)	Model 3 (Full model)	Model 4 (Partial model)
PD	0.078***	0.057***	0.146***	0.094***
	(0.027)	(0.022)	(0.052)	(0.039)
	0.279	0.194	0.314	0.205
PD^2	−0.004***	−0.003**	−0.007***	−0.005**
	(0.002)	(0.001)	(0.003)	(0.002)
	−0.200	−0.143	−0.213	−0.154
AMT	0.282	0.332	0.989**	0.808**
	(0.314)	(0.285)	(0.462)	(0.381)
	0.058	0.065	0.122	0.101
PD * AMT	−0.012	−0.011	−0.083**	−0.058*
	(0.025)	(0.023)	(0.044)	(0.034)
	−0.033	−0.029	−0.139	−0.098
CUST	−0.343		−1.561*	
	(0.667)		(0.923)	
	−0.035		−0.097	
PRLIN	0.099		0.145	
	(0.163)		(0.208)	
	0.039		0.035	
SIZE	−0.096		0.128	
	(0.356)		(0.466)	
	−0.016		0.013	
TQM	0.386		0.192	
	(0.426)		(0.554)	
	0.054		0.016	
JIT	0.237		0.616	
	(0.442)		(0.587)	
	0.032		0.050	
PRPRO	−(**)		−(**)	
HetMass	−1.411*		−1.345	
	(0.769)		(1.011)	
	−0.173		−0.100	
SerUnit	−2.065***		−2.875***	
	(0.771)		(1.083)	
	−0.288		−0.241	
Unit	−0.900		−0.551	
	(0.857)		(1.122)	
	−0.105		−0.038	
Intercept	−0.066	−1.275***	−0.767	−1.852***
	(0.781)	(0.255)	(1.041)	(0.336)
R^2_L	0.130	0.066	0.248	0.117
G_M	22.887**	11.566**	31.078***	14.651***

Notes: $N = 191$ for the ABC adoption sample (Panel A) and $N = 178$ for the ABC use sample (Panel B); Cell statistics are unstandardized coefficients, standard errors and standardized coefficients. ***, **, * indicates significance at the 0.01, 0.05 and 0.10 level (two-tailed), respectively. Chow-type test results for Model 1: $\chi^2(13) = 12.910$, $p = 0.455$, for Model 2: $\chi^2(5) = 4.026$, $p = 0.546$, for Model 3: $\chi^2(13) =$ error (no unique solution could be found for the group (track) with the less intensive data collection procedure), and for Model 4: $\chi^2(5) = 8.305$, $p = 0.140$. All continuous independent and control variables were mean centered before entering to avoid nonessential multicollinearity. Statistical significance of b is determined using the likelihood ratio test for the continuous independent variables, and using the Wald test for the dummy independent variables and for the intercept. Standardized logistic regression coefficients are estimated using the procedure suggested by Menard (2001; see also 2004). The following abbreviations are used in the table: PD = product diversity; AMT = usage of AMT; CUST = degree of customization; PRLIN = production lines; SIZE = organizational size; TQM = TQM usage; JIT = JIT usage; HomMass = homogeneous mass production; HetMass = heterogeneous mass production; SerUnit = serial unit production; Unit = unit production.

where it indicates that, at high levels of product diversity, firms with a relatively high (low) level of usage of AMT are less (more) likely to use ABC.

Of the control variables, in Model 1, the full ABC adoption model, only the effect of *PRPRO* is significant, whereas in Model 3, the full ABC use model, also the effect of *CUST* is significant. Since the effect of *PRPRO* serves as a protection test for its constituent parts, these may be interpreted. Two of these parts, *HetMass* and *SerUnit*, are significantly negatively associated with ABC adoption in Model 1, whereas in Model 3 only *SerUnit* is significantly associated with ABC use. Although not all differences with the reference group (i.e., firms with a homogeneous mass production process) are significant, both models suggest that firms with a homogeneous mass production process are the most likely to adopt and use ABC, followed by firms with a unit production process, firms with a heterogeneous mass production process, and firms with a serial unit production process. The finding that firms with a homogeneous mass production process are the most likely to adopt and use ABC is consistent with the results of prior studies (Ittner et al., 2002; Krumwiede, 1998). The order of the other groups is inconsistent with the results of Ittner et al. (2002), however, in that they have found that firms with a hybrid production process are more likely to use ABC than firms with a discrete production process. This suggests that other factors besides those that have

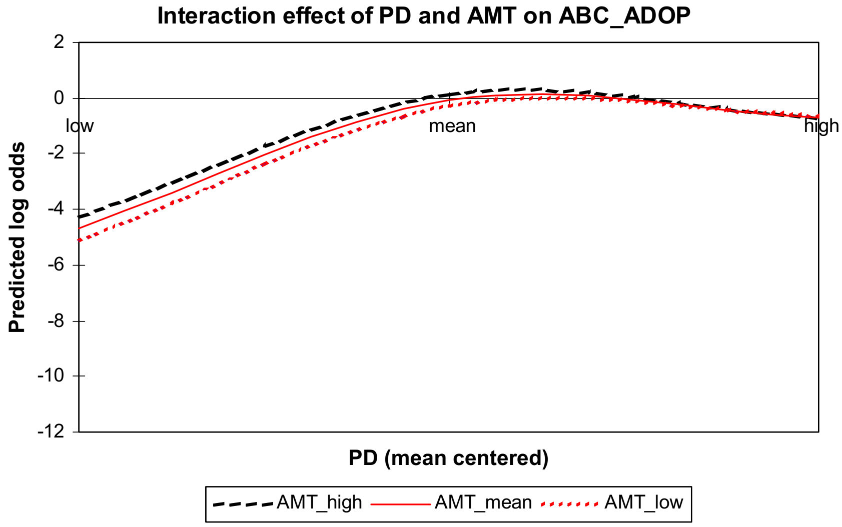

Fig. 2. Graphical presentation of the joint effect of product diversity (*PD*) and usage of AMT (*AMT*) on firms' likelihood of adopting ABC (*ABC_ADOP*) (Full model only). Notes: For the range between two *SDs* below and two *SDs* above the mean of *PD*, this figure plots the regression of *ABC_ADOP* on *PD* and PD^2 at three values of *AMT*: the mean (AMT_mean), one *SD* below the mean (AMT_low), and one *SD* above the mean (AMT_high).

already been argued in the literature to be underlying the influence of the structure of firms' production process on ABC adoption choices, importance of ABC cost drivers (cf. Reeve, 1993) and uncertainties associated with made-to-order production (cf. Krumwiede, 1998), may also be underlying this influence. The negative association of degree of customization with ABC use is consistent with the results of Bjørnenak (1997) and Drury and Tayles (2005). Finally, none of the other control variables is significant in Models 1 and 3, which for 'organizational size' may be caused by the fact that the study focuses on medium-sized firms only, causing the range of this variable to be restricted.

In Models 2 and 4, the partial models, ABC adoption and ABC use are regressed on product diversity (as reflected by its linear and quadratic terms), usage of AMT, and their linear-by-linear interaction effect. Both models are significant. More importantly, their results are consistent with those of the full models. This indicates that the results of Models 1 and 3 are robust to excluding the control variables, and provides additional support for H1, H2 and H3b (and no support for H3a).

5. Summary and conclusions

This paper uses a dataset of survey responses from 191 Dutch, medium-sized manufacturing firms to re-examine the relationship between product diversity and ABC adoption. Improving upon the measurement of product diversity and

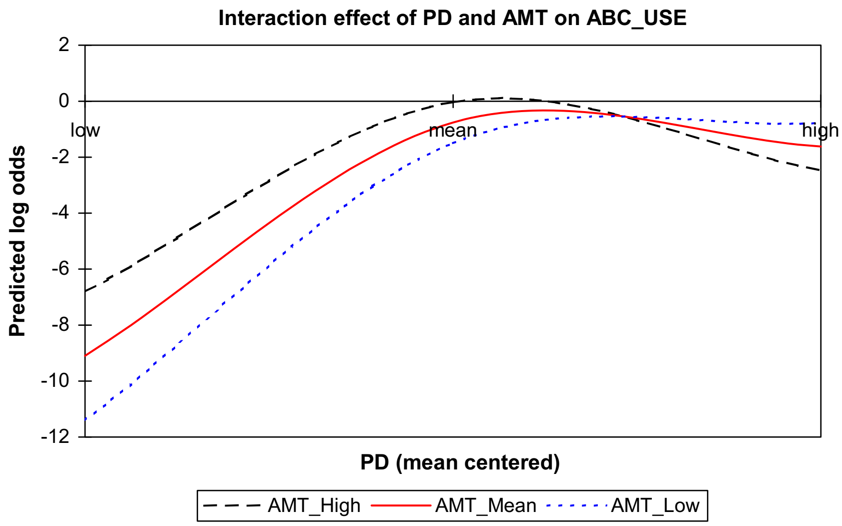

Fig. 3. Graphical presentation of the joint effect of product diversity (*PD*) and usage of AMT (*AMT*) on firms' likelihood of using ABC (*ABC_USE*) (Full model only). Notes: For the range between two *SDs* below and two *SDs* above the mean of *PD*, this figure plots the regression of *ABC_USE* on *PD* and PD^2 at three values of *AMT*: the mean (AMT_mean), one *SD* below the mean (AMT_low), and one *SD* above the mean (AMT_high).

distinguishing between ABC adoption and use, it examines whether the relationship is curvilinear (inverted U-shaped) and/or moderated by usage of AMT. The results show that product diversity, on average, is positively related to both ABC adoption and ABC use, but also that these relationships are indeed inverted U-shaped; i.e., that they are positive up to a point and then begin to decline. From a practical perspective, this latter finding means that firms are more likely to adopt and use ABC at moderate levels of product diversity than at high levels of product diversity. The results also show, however, that the relationship with ABC use (but not with ABC adoption) is negatively moderated by usage of AMT, which from a practical perspective means that the effect of product diversity on firms' likelihood of using ABC is stronger when the level of usage of AMT is relatively low than when this level is relatively high. Overall, these results indicate that the inconclusive results of previous survey research on the relationship between product diversity and ABC adoption at least partially seem to have been caused by methodological issues.

Some of the empirical results merit further discussion. First, prior studies have used many inconsistent definitions of and measurement instruments for both ABC adoption and its determinants, which is likely to at least be partially responsible for the inconclusive results of these studies to date. This study adds to this inconsistency as it develops and uses a new measure of product diversity, which is argued to be more comprehensive than existing measures and to better capture the exact nature of product diversity. The usage of this new measure may have contributed to finding results that differ from those of some of the prior studies, for example on the positive, but curvilinear relationships between product diversity and ABC adoption and ABC use. Future research could further develop and validate the measurement instrument used in this study to measure product diversity.

Second, this study finds that the relationship between product diversity and ABC use (but not ABC adoption) is negatively moderated by usage of AMT, supporting qualitative findings of Abernethy et al. (2001). Their findings also suggest, however, that the joint effect of product diversity and usage of AMT on cost system design choices may be mediated by the cost structure (i.e., the proportion of batch- and/or product-related costs) of firms, which was not tested in this study. Future research could examine this mediation effect, as well as the joint (or interaction) effects of other contextual factors on firms' ABC adoption choices.

Third but related to the former two points, this study distinguishes between ABC adoption and use, and examines the relationship of product diversity (and a number of other technological factors) with both of these stages of the ABC implementation process. Overall, the associations of product diversity and usage of AMT with (and therefore their effects on) ABC use appear to be somewhat stronger than those with (on) ABC adoption. Future research could further examine these differences in findings for ABC adoption and ABC use, and could also explore to what extent the effects found in this study also apply to other stages in the ABC implementation process.

As with any study, the findings of this study are subject to a number of potential limitations. Because cross-sectional research can establish associations, but not causality, the direction of effects cannot be established with certainty. Also, there may be omitted variables which may bias the results. Another issue that may potentially influence the findings is measurement error. The dependent variable in this paper, ABC adoption, is a typical example of a practice-defined variable (cf. Luft & Shields, 2003), and such variables are more likely to suffer from measurement error than theory-defined variables. Research developing a better measurement instrument for this variable could significantly contribute to the literature.[16] Finally, there is the issue of generalizability. The response rate in this study is rather low and, consequently, the sample size rather small. Although comparisons with the sampling database show that the sample is representative in terms of industry, it may be biased with respect to other (unknown) variables. Despite these potential limitations, this study presents a step further in our understanding of the determinants of ABC adoption in practice.

Acknowledgments

This paper is based on my dissertation completed at VU University Amsterdam. I express my appreciation to the members of my dissertation committee, Tom Groot (supervisor), Shannon Anderson, Jan Bouwens, Kees Camfferman, Fred Lindahl, and Marc Wouters, for their assistance and guidance. I also thank Eelke Wiersma for his helpful comments on an earlier version of the paper.

Appendix. Measurement instruments used

ABC_ADOP/ABC_USE: Please indicate which of the following five stages best describes your firm's situation with respect to activity-based costing (ABC – product costing based on activities). *(Please check one possibility.)*

a) Currently using ABC
b) Currently implementing ABC
c) Currently considering ABC adoption
d) No consideration of ABC to date
e) Rejected ABC after assessment

[16] For example, Bisbe et al. (2007) suggest specifying activity-based cost management (ABCM) as a higher-order construct which has dimensions of cost drivers and value drivers which, in turn, both have indicators that elaborate specifically on what cost and value drivers mean.

PD: How many different products (stock-keeping units) are being produced in your firm? *(Scale: $\log_2 N$ scale ranging from "1–2" to ">512". Please check one possibility.)*
Please indicate, by circling the appropriate number below, to what extent the products (stock-keeping units) produced in your firm differ on average on the following dimensions *(Scale: 1 = not at all, 2 = to a little extent, 3 = to some extent, 4 = to a considerable extent and 5 = to a very great extent)*

Physical size
Complexity
Batch size

AMT: Please indicate, by circling the appropriate number below, to what extent the following advanced manufacturing technologies are used in your firm's production process *(Scale: 1 = not at all, 2 = to a little extent, 3 = to some extent, 4 = to a considerable extent and 5 = to a very great extent)*

Computer-aided manufacturing (CAM)
Robotics
Real-time process control systems
Group technology (GT)
Flexible manufacturing systems (FMS)
Computerized numerical control machines (CNC)
Automated material handling systems
Environmental control systems
Bar coding/automatic identification

CUST: What percentage of the production is approximately customized in your firm? *(Scale: ____%)*
PRLIN: How many production lines does your firm have? (*Scale: $\log_2 N$ scale ranging from "1–2" to ">128". Please check one possibility*.)
TQM/JIT: For each of the following management concepts and techniques, please indicate if your firm is currently using it *(Scale: "No" or "Yes")*

Total Quality Management (TQM)
Just-In-Time (JIT)

PRPRO: Which classification best describes the structure of the production process in your firm? *(Please check one possibility.)*

a) Homogeneous mass production
b) Heterogeneous mass production
c) Serial unit production
d) Unit production

Additional questions aimed only at the ABC adopters:

- Which part of the planned implementation process of ABC is approximately finished in your firm at this point in time? *(Scale: ____%)*
- To what extent has the implementation process of ABC (so far) gone according to plan in your firm? *(Scale: 1 = not at all, 2 = to a little extent, 3 = to some extent, 4 = to a considerable extent and 5 = to a very great extent)*
- Does the ABC system in your firm encompass all production units? *(Scale: "No" or "Yes")*
- Is the ABC system in your firm integrated with other information systems? *(Scale: "No" or "Yes")*
- How frequently are the structure (e.g., the activities) and the contents (e.g., the costs) of the ABC system in your firm updated? *(Please check one possibility for each.)*
  a) More than monthly
  b) Monthly
  c) Quarterly
  d) Half-yearly
  e) Yearly
  f) Two-yearly
  g) Less than two-yearly

References

Abernethy, M. A., Lillis, A. M., Brownell, P., & Carter, P. (2001). Product diversity and costing system design choice: field study evidence. *Management Accounting Research, 12*(3), 261–279.

Adler, P. S. (1988). Managing flexible automation. *California Management Review, 30*(3), 34–56.

Al-Omiri, M., & Drury, C. (2007). A survey of factors influencing the choice of product costing systems in UK organizations. *Management Accounting Research, 18*(4), 399–424.

Allison, P. A. (2001). *Missing data. Sage university papers series on quantitative applications in the social sciences, 07-136*. Thousand Oaks (CA): Sage.

Anderson, S. W. (1995). A framework for assessing cost management system changes: the case of activity based costing implementation at General Motors, 1986–1993. *Journal of Management Accounting Research, 7*, 1–51.

Bisbe, J., Batista-Foguet, J.-M., & Chenhall, R. (2007). Defining management accounting constructs: a methodological note on the risks of conceptual misspecification. *Accounting, Organizations and Society, 32*(7–8), 789–820.

Bjørnenak, T. (1997). Diffusion and accounting: the case of ABC in Norway. *Management Accounting Research, 8*(1), 3–17.

Bollen, K. A., & Lennox, R. (1991). Conventional wisdom on measurement: a structural equation perspective. *Psychological Bulletin, 110*(2), 305–314.

Boons, A. N. A. M., Roberts, H. J. E., & Roozen, F. A. (1992). Contrasting activity-based costing with the German/Dutch cost pool method. *Management Accounting Research, 3*(2), 97–117.

Boyer, K. K., Leong, G. K., Ward, P. T., & Krajewski, L. J. (1997). Unlocking the potential of advanced manufacturing technologies. *Journal of Operations Management, 15*(4), 331–347.

Boyer, K. K., & Pagell, M. (2000). Measurement issues in empirical research: improving measures of operations strategy and advanced manufacturing technology. *Journal of Operations Management, 18*(3), 361–374.

Boyer, K. K., Ward, P. T., & Leong, G. K. (1996). Approaches to the factory of the future: an empirical taxonomy. *Journal of Operations Management, 14*(4), 297–313.

Cagwin, D., & Bouwman, M. J. (2002). The association between activity-based costing and improvement in financial performance. *Management Accounting Research, 13*(1), 1–39.

CAM-I. (1992). In N. Raffish, & P. B. B. Turney (Eds.), *The CAM-I glossary of activity-based management (version 1.2)*. Arlington (TX): CAM-I.

Clarke, P. J., Hill, N. T., & Stevens, K. (1999). Activity-based costing in Ireland: barriers to, and opportunities for, change. *Critical Perspectives on Accounting, 10*(4), 443–468.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah (NJ): Lawrence Erlbaum.

Cooper, R. (1988). The rise of activity-based costing – part two: when do I need an activity-based cost system? *Journal of Cost Management, Fall*, 41–48.

Diamantopoulos, A., & Winklhofer, H. (2001). Index construction with formative indicators: an alternative to scale development. *Journal of Marketing Research, 38*(2), 269–277.

Dillman, D. A. (2000). *Mail and internet surveys: The tailored design method* (2nd ed.). New York (NY): Wiley.

Drury, C., & Tayles, M. (2005). Explicating the design of overhead absorption procedures in UK organizations. *The British Accounting Review, 37*(1), 47–84.

Estrin, T. L., Kantor, J., & Albers, D. (1994). Is ABC suitable for your company? *Management Accounting, April*, 40–45.

Gosselin, M. (1997). The effect of strategy and organizational structure on the adoption and implementation of activity-based costing. *Accounting, Organizations and Society, 22*(2), 105–122.

Greene, W. H. (2000). *Econometric analysis* (4th ed.). Upper Saddle River (NJ): Prentice Hall.

Groot, T. L. C. M. (1999). Activity-based costing in U.S. and Dutch food companies. *Advances in Management Accounting, 7*, 47–63.

Hair, J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data analysis* (5th ed.). Upper Saddle River (NJ): Prentice Hall.

Innes, J., Mitchell, F., & Sinclair, D. (2000). Activity-based costing in the U.K's largest companies: a comparison of 1994 and 1999 survey results. *Management Accounting Research, 11*(3), 349–362.

Ittner, C. D., Lanen, W. N., & Larcker, D. F. (2002). The association between activity-based costing and manufacturing performance. *Journal of Accounting Research, 40*(3), 711–726.

Jarvis, C. B., MacKenzie, S. B., & Podsakoff, P. M. (2003). A critical review of construct indicators and measurement model misspecification in marketing and consumer research. *Journal of Consumer Research, 30*(2), 199–218.

Jonsson, P. (2000). An empirical taxonomy of advanced manufacturing technology. *International Journal of Operations & Production Management, 20*(12), 1446–1474.

Kallunki, J.-P., & Silvola, H. (2008). The effect of organizational life cycle stage on the use of activity-based costing. *Management Accounting Research, 19*(1), 62–79.

Kaplan, R. S., & Cooper, R. (1998). *Cost and effect: Using integrated cost systems to drive profitability and performance*. Boston (MA): Harvard Business School Press.

Krumwiede, K. R. (1998). The implementation stages of activity-based costing and the impact of contextual and organizational factors. *Journal of Management Accounting Research, 10*, 239–277.

Luft, J., & Shields, M. D. (2003). Mapping management accounting: graphics and guidelines for theory-consistent empirical research. *Accounting, Organizations and Society, 28*(2–3), 169–249.

Malmi, T. (1999). Activity-based costing diffusion across organizations: an exploratory empirical analysis of Finnish firms. *Accounting, Organizations and Society, 24*(8), 649–672.

Menard, S. (2001). *Applied logistic regression analysis* (2nd ed.). Sage university papers series on quantitative applications in the social sciences, 07–106. Thousand Oaks (CA): Sage.

Menard, S. (2004). Six approaches to calculating standardized logistic regression coefficients. *The American Statistician, 58*(3), 218–223.

Miller, J. A. (1996). *Implementing activity-based management in daily operations*. New York (NY): Wiley.

Pregibon, D. (1981). Logistic regression diagnostics. *Annals of Statistics, 9*, 705–724.

Reeve, J. M. (1993). Cost management in continuous process environments. In B. J. Brinker (Ed.), *Handbook of cost management*. New York (NY): Warren Gorham and Lamont. (Chapter C3).

Schoute, M. (2009). The relationship between cost system complexity, purposes of use, and cost system effectiveness. *The British Accounting Review, 41*(4), 208–226.