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SCIENCE DIRECT®
Accounting, Organizations and Society 30 (2005) 167–191
Accounting, Organizations and Society
www.elsevier.com/locate/aos

The adoption of total cost of ownership for sourcing decisions—a structural equations analysis

Marc Wouters [a,*], James C. Anderson [b], Finn Wynstra [c]

[a] School of Business, Public Administration and Technology, University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands
[b] Kellogg School of Management, Northwestern University, USA
[c] Erasmus Research Institute of Management, Erasmus University, Rotterdam, The Netherlands

Abstract

This study investigates the adoption of total cost of ownership (TCO) analysis to improve sourcing decisions. TCO can be seen as an application of activity based costing (ABC) that quantifies the costs that are involved in acquiring and using purchased goods or services. TCO supports purchasing decision-makers in focusing on total value received and not simply price, and it extends ABC concepts and tools to an inter-organizational context. Based on ABC-adoption literature and focus-group discussions with senior purchasing executives, a model is developed to explain relationships among eight constructs hypothesized to explain TCO adoption: competitive pressure in customer markets, strategic purchasing orientation, top management support, functional management commitment, value analysis experience, adequacy of TCO information, success of TCO initiatives, and use of TCO-based review and reward systems. We test this model using multi-sample structural equation modeling on survey data collected from purchasing managers and plant maintenance managers. We find support for most of our hypotheses and, further, that the posited relationships are largely invariant across purchasing manager and plant maintenance manager perspectives.

Introduction

This study looks at the adoption of total cost of ownership (TCO) as an application of activity-based costing (ABC) concepts and tools to sourcing strategy. TCO is a cost accounting application that enables purchasing decision-makers to combine value and price in making sourcing decisions. TCO analysis quantifies the costs involved in acquiring and using offerings, such as transaction costs related to purchasing activities (e.g., ordering, freight, quality control), and the costs related to poor quality (e.g., rejection, rework, and warranties) (Carr & Ittner, 1992; Ellram, 1995) Activities that are part of the scope of TCO occur within the purchasing department as well as in other departments. As in activity-based costing, cost drivers can be at various levels, such as unit level (e.g., purchase price, quality control cost when each item must be inspected), batch level (e.g., costs of creating a purchase order, inspecting an order received), supplier sustaining level (e.g., cost of identification and certification of a supplier), and product or part sustaining level (e.g., cost of maintaining technical product information). A notable difference of TCO with typical ABC applications is that costs need to be captured

* Corresponding author.
E-mail addresses: m.j.f.wouters@utwente.nl (M. Wouters), jc-anderson@kellogg.northwestern.edu (J.C. Anderson), fwynstra@fbk.eur.nl (F. Wynstra).

0361-3682/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.aos.2004.03.002

at a greater level of detail: by supplier and by item purchased (Ellram, 1995).

Understanding and trading-off the various costs related to sourcing decisions is all the more relevant given the increased emphasis firms operating in business markets are placing on value-based market offerings, both from the supplier and the customer point of view (Anderson & Narus, 1998, 2004; Doyle, 2000; Ulaga, 2001). TCO facilitates companies in dealing with pressure in their own customer markets and making the purchasing function more value oriented. TCO also can be viewed as extending ABC to a boundary-spanning context, where the firm is reliant on cooperation and information provided by suppliers, or inferences drawn from alternative prices quoted by suppliers for changes in their market offerings (e.g., changes in materials in the core offerings, changes in supplementary services, programs, and systems). Anderson, Glenn, and Sedatole (2000) conclude that for accounting to support sourcing decisions, the "value chain perspective of strategic cost management with its focus on 'cost of ownership' rather than supplier price is essential." Baiman and Rajan (2002) discuss that accounting information is one of the inter-organizational design instruments that must be considered to stimulate cooperation between firms in the supply chain. Empirical studies suggest that achieving total cost reductions and other performance gains from supplier partnerships practices are contingent on extensive use of selection criteria beyond purchase price, such as overall value improvement (Ittner, Larcker, Nagar, & Rajan, 1999). Yet, Anderson, Thomson, and Wynstra (2000) demonstrated that purchasing managers seem to rely more on price information than on TCO information in making their sourcing decisions. Thus, we study constructs that explain the successful adoption of TCO analysis as an application and extension of ABC to sourcing decisions.

In the literature, the potential benefits of TCO have been illustrated and the technical issues of implementing TCO have been discussed (e.g., Carr & Ittner, 1992; Ellram, 1995; Ellram & Feitzinger, 1997; Ellram & Siferd, 1993). Degraeve and Roodhooft (2000) and Degraeve, Labro, and Roodhooft (2000) used TCO data from a case study in mathematical programming models for supplier selection to demonstrate cost savings potential in a real setting. There has not much been empirical research, though, which investigates the adoption of TCO. A recent US survey among purchasing professionals found that "their organizations are largely in the dark when it comes to making [total cost] calculations" (Milligan, 1999). Using case studies, Ellram and Siferd (1998) identified some factors that act as barriers to the adoption of TCO, such as user resistance and complexity of cost data. However, there is a considerable literature on the adoption of ABC (e.g., Anderson & Young, 1999; Gosselin, 1997; Krumwiede, 1998; Malmi, 1999; McGowan & Klammer, 1997; Shields, 1995). Both internal implementation variables (such as support from various levels of management, and training and other resources devoted to the innovation), as well as firm characteristics that make the innovation more or less valuable in a particular context (such as competition and decentralization) are considered in the ABC-adoption literature. We refer to Krumwiede (1998) and Anderson and Young (1999) for reviews of this literature, from which Anderson and Young (1999) compiled a list of five categories of 27 variables that are associated with ABC project outcomes, where the relevance of these factors may differ across various phases in ABC adoption. Despite this progress in the empirical literature, these findings have yet to be organized into an overall theoretical framework to guide research and managerial implications. We draw on this work as best as we can, and to further inform our model of TCO adoption, we draw inductively on some qualitative data generated through two focus-group discussions with senior purchasing managers.

This paper contributes to the existing literature on the adoption of new cost accounting systems in three significant ways. First, we study the successful adoption of TCO, which applies ABC concepts and tools to sourcing strategy, and extends these to an inter-organizational context, with the issues and complications of reliance on suppliers. Although TCO and ABC both are costing systems, TCO is focused on a firm's interfaces with suppliers to support decisions related to sourcing strategy, while internal activities are the scope of ABC systems. TCO presumes the existence of

boundary spanning activities such as cooperation of suppliers, information sharing, and trade-offs along the value chain, whereby supplier effects may be captured by looking at quoted prices for changes in market offerings. The intent of TCO analyses is to improve mutual profitability for the supplier and customer by modifying how they do business together (such as, which firm undertakes certain activities, or what the effects are of using certain materials). While it is still not often done, it is nonetheless increasingly being done today. Thus, our first contribution is to investigate what are the constructs, and relationships among them, that explain successful adoption of TCO.

Our second contribution is to apply a more sophisticated approach to theory testing and development that enables simultaneous estimation of the measurement and substantive models, and provides overall measures of goodness of fit. This study uses a more rigorous two-step approach to structural equation modeling (cf. Anderson & Gerbing, 1988) for theory testing and development than has been employed previously in management accounting research (cf. Baines & Langfield-Smith, 2003; Hunton, Wier, & Stone, 2000; Van der Stede, 2000). Under this two-step approach, a confirmatory measurement model is estimated first (and, when required, respecified), prior to the simultaneous estimation of the measurement and structural submodels. This two-step approach has several comparative strengths over a one-step approach to the modeling task. It provides an asymptotically independent test of the substantive structural model of interest, employing a chi-square difference test (Steiger, Shapiro, & Browne, 1985) where the confirmatory measurement model is the base model. It enables detection of interpretational confounding (cf. Burt, 1976), which can occur under a one-step approach, where the estimated pattern coefficients change considerably when alternative structural models are estimated. Finally, the two-step approach requires the researcher to consider the strength of explanation of the substantive structural model over that of a confirmatory measurement model. Separate assessments of the measurement model and structural model preclude having good fit of one model compensate for (and potentially mask) poor fit of the other, which can occur with a one-step approach. Related to this, the degrees of freedom for the substantive structural model are made explicit.

We estimate a model that encompasses 12 hypotheses to test relationships among eight constructs explaining successful TCO adoption. Further, this study employs multi-sample analysis (Jöreskog & Sörbom, 1993, 1996) to enable testing of differences in perspectives between two functional areas (purchasing and plant maintenance) on the posited substantive relations, without the confounding effects of measurement error. Comparing the perspective of a functional area that is a primary driver and catalyst for an accounting approach with that of a functional area that is a primary user and potential beneficiary of that approach is critical for gaining a better understanding of successful adoption of that accounting approach.

Previous studies investigating cost-systems adoption generally have used regression analysis (e.g., Krumwiede, 1998; McGowan & Klammer, 1997; Shields, 1995). Anderson and Young (1999) is an exception that used structural equation modeling to investigate ABC implementation success, examining contextual factors, factors related to the implementation process, and evaluation criteria. Although they use structural equation modeling, data limitations in their study allowed only testing of hypothesized construct relations with sum-scale representations of their constructs (i.e., testing path analysis models). Thus, although the biasing effects of measurement error on estimated construct relations were reduced, they were not eliminated, as they would be in a simultaneous estimation of measurement and structural submodels (cf. Anderson & Gerbing, 1988; Gerbing & Anderson, 1988). In the sole article in accounting to employ multiple-sample analysis with latent variables, Lanen and Larcker (1992) used a latent variable multiple regression analysis to compare two groups of companies in the same industry that were in different regulatory environments. Shields (1997) has reviewed management accounting research and calls for a greater use of new research methods, such as structural equation modeling. Smith and Langfield-Smith (2002) review articles in management accounting using structural equation modeling

and suggest that there are many potential benefits of its greater use.

The third contribution is to discuss managerial implications for TCO adoption. The empirical results seem to suggest that a certain ordering of implementation steps may be instrumental in creating TCO success. We found that value analysis experience—experience with the kind of analyses for which TCO data are input—has an impact of the adequacy of TCO information, which has an impact on the success of TCO initiatives. Given the strong focus on 'value' and 'total cost' in a more strategic orientation on purchasing (Hines, Lamming, Jones, Cousins, & Rich, 2000; Van Weele, 2001) these implementation insights may be seen as critical for any required advancement of the function. Comparing and contrasting the perspectives of two functional areas, which play different roles in successful adoption of TCO, provides further managerial insight. Purchasing is the primary catalyst in pulling data together and promoting TCO use, reinforcing its more strategic orientation. Plant maintenance is a primary functional area for use of TCO to achieve total cost reductions in maintenance, repair, and operating (MRO) supplies. Plant maintenance is perhaps the best functional area for initial application and adoption of TCO in that data can be generated from maintenance management systems, and changes in MRO sourcing does not directly affect the value that the firm's customers receive from its offerings, as changes in component materials would.

The remainder of this paper is structured as follows. We next develop a conceptual model and hypotheses about the adoption of TCO for sourcing decisions. As part of this, we draw on illustrative quotes from a pair of focus-group discussions with purchasing executives on these topics, prior to our field study. We then present the analyses and the results of testing our proposed model. We end with a discussion of our findings, and some limitations and conclusions of our research.

Model development

The model we propose encompasses eight constructs and the relationships among them that explain successful adoption of TCO. This model is shown in Fig. 1, which we consider in four subparts. First, success in using TCO initiatives for sourcing decisions (TCO initiative success), and basing performance review and reward on TCO improvements (TCO based review and reward) are the critical constructs for TCO adoption. Next, adequacy of the TCO information (TCO info. adequacy) and experience with conducting value analyses (value analysis experience) are presented as the central constructs to connect TCO adoption and management commitment. Then, management commitment consists on the one hand of top management support for TCO initiatives (top management support) and, on the other hand, of commitment from functional managers for using TCO analyses for decision making (functional management commitment). Finally, competitive pressure in the buying firm's own customer market (customer market pressure) and the strategic orientation of the purchasing function (purchasing orientation) are presented as antecedent constructs for managerial commitment to TCO initiatives.

TCO analysis success and TCO based performance review and reward

The success of TCO initiatives (*TCO initiative success*) in this study relates to the perceived financial gains and concrete results derived from using TCO analyses for sourcing decisions. The success of new cost accounting systems, such as ABC or TCO, has been conceptualized and measured in several different ways (Anderson & Young, 1999; Foster & Swenson, 1997) and this implies different meanings of success. Success can be seen as being greater usage of the new cost information for decision-making: the more it changes the output of the decision-making process, the larger financial improvements are resulting from the new cost information, or the more positive people evaluate the "overall success" of the initiative. In this study, we focus on the perceived financial gains and concrete results.

TCO based performance review and reward (*TCO based review and reward*) means that improvements in the firm's total cost of ownership of acquired offerings—not just purchase price

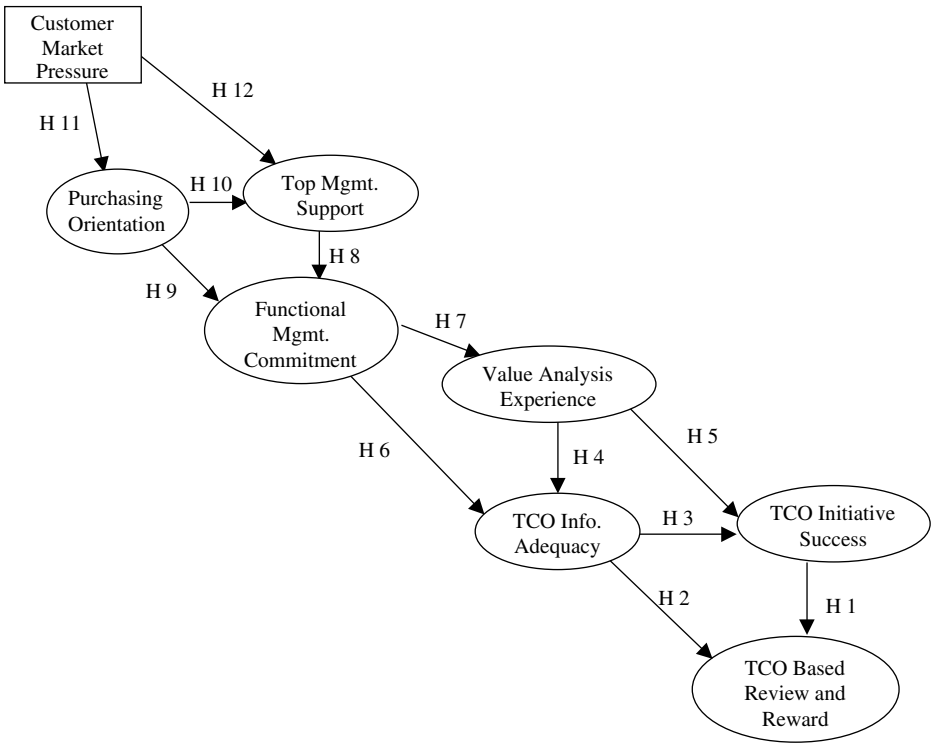

Fig. 1. Hypothesized structural model of TCO adoption.

paid—are used as a significant component of performance review and reward. We suggest that the occurrence of having success with TCO initiatives for sourcing decisions and relying on TCO analysis outcomes as a significant component of performance review and reward, are critical for successful TCO adoption. It means that the organization has experience and success with the new concept and has embedded the usage of this concept in organizational systems to direct decision-making processes. That is why we propose that these two factors, taken together, are the focal constructs for successful TCO adoption.

There is limited empirical evidence for the purchasing function, which suggests that performance measurement systems need to be adjusted to stimulate value or TCO-based purchasing decisions. The literature on organizational buying behavior has contended that such behavior may be determined by the way in which activities are measured and rewarded, but early approaches have not substantially developed this concept (Anderson & Chambers, 1985). Dumond (1991) explored the impact of different performance measurement systems on purchasing behavior in an experimental study. Results showed that participants in a purchasing task performed best on several value measures when they received effectiveness-related feedback (on potential and actual contribution to profit, supplier relation quality and customer satisfaction) as opposed to feedback on traditional efficiency measures (price paid for purchases, annual and potential price reductions, operating cost, and order processing time). In a study of 21 North American firms, though, Dumond (1994) came to the conclusion that the majority of firms predominantly use measures that tend to create a narrow, 'departmental' focus. The existing measures were not supporting purchasing professionals in focusing on the creation of value, but rather on the traditional objectives of price savings and efficiency.

We expect a positive effect of TCO success on the use of TCO based performance review and reward

(*TCO initiative success → TCO based review and reward*). The literature provides support for the relationship between the adoption of new cost accounting systems and the link to performance evaluation, because this provides incentives for employees to attend to and use the new information (e.g. Foster & Swenson, 1997; McGowan & Klammer, 1997; Shields, 1995). Here we also expect such a relationship, but with a different conception about the direction of the effect. Because of the challenges of implementing TCO analyses, we expect that as the organization experiences more success with TCO initiatives, it is more willing to use TCO for performance review. TCO success provides evidence and support for senior management to make corresponding changes in the performance review and reward system. With "success stories" to draw on (and publicize), senior management is more willing to make changes in the review and reward systems, and more likely to believe that purchasing and other functional area managers will accept them. In management practice research on the successful adoption of ABC systems, Ness and Cucuzza (1995) found that demonstrated success with using ABC in pilot projects preceded its integration into the studied firm's financial systems and performance measures.

Another line of support for this relationship comes from the agency-theory argument that as information better captures what the principal wants to achieve, that particular information becomes more suitable for performance evaluation. Feltham and Xie (1994) have referred to this as a measure being more congruent with the objectives of the principal. Thus, when TCO initiatives achieve success, this probably leads to TCO reduction becoming a more congruent measure of the principal's objectives, and hence it is more likely to be used as a performance measure. This line of reasoning is complementary to our previous argument, which stresses that TCO success is important for reducing resistance and convincing managers (who are being evaluated) that it is fair to use TCO reduction as part of performance evaluation. In short, we argue that TCO initiative success matters to agents as well as principals for making TCO reduction an informative and acceptable element of performance review and reward.

We expect that demonstrated success of TCO initiatives for sourcing decisions impacts the subsequent use of TCO for performance review and reward, and we hypothesize:

> H1: The success of TCO initiatives has a positive effect on the use of TCO for performance review and reward.

TCO information adequacy and value analysis experience

Adequacy of TCO information refers to the availability and reliability of TCO information to support sourcing decisions (*TCO info. adequacy*). Adequacy of information is considered in this study for several reasons. Anderson and Young (1999) found that management's evaluation of the value of the new ABC information is higher, as the quality of the existing pre-ABC information system is lower, and McGowan and Klammer (1997) found that the quality of the information produced by new ABC systems has a positive relation with satisfaction with ABC implementation. This suggests that the quality of TCO information would be an important factor for adoption, especially considering that generating high-quality TCO data is not a trivial challenge. Implementing TCO requires data at the supplier-level to quantify all the costs that are involved in acquiring and using alternative offerings. These costs are caused by numerous purchasing-related activities that are executed at different places within the customer organization and across the value chain with suppliers. Since sourcing decisions may impact costs of the customer firm as well as supplier costs, TCO in its most progressive form is a boundary-spanning concept that involves supplier cooperation and information sharing.

Access to data and complexity of the cost accounting system make it difficult to implement TCO (Carr & Ittner, 1992; Ellram & Feitzinger, 1997). Ellram and Siferd (1998), based on 11 case studies and previous research, point to the complexity and (lack of) availability of cost data as one of the most important barriers to the implementation of TCO concepts in purchasing decisions. Data for a sample of US purchasing

managers showed that nearly 50% rate their firms' competency for measuring total cost of ownership, on a scale of 1–10, a '5' or lower (Milligan, 1999). These difficulties are increased by the value-chain perspective of TCO, in the sense that buying firm as well as its suppliers need to understand and consistently quantify the cost ramifications of alternative offerings (Hergert & Morris, 1989).

Participants in the roundtable discussions often mentioned, that as buying firms, they found it difficult to quantify the value of alternative purchase possibilities, and they also observed that most of their suppliers were unable to demonstrate the value of their proposals.

> Well, the accountancy system is one thing, because it tends to fragment, it does not draw the process together. So you have manufacturing costs and you have marketing costs and things are separated as such. I think it's really [important] having the knowledge of how much these [acquired offerings] really do cost. (Director Purchasing Services, Chemical firm)

> We often have discussions with suppliers encouraging them, because nobody else in their supply market is making any very positive value-added offering. If they did, people would kiss them and hug them and say 'please come in,' because it is very rare—in our experience—that the supplier puts together a very good value-added case. And when we ask them why, they say 'we have been trying for years. Nobody listened, so we stopped.' I don't believe it. I don't believe they ever started it. (VP Corporate Purcurement, Electronics firm)

If the adequacy of TCO information is low, we do not expect firms to base performance evaluation on this information. Agency theory (e.g., Feltham & Xie, 1994) predicts that indicators (TCO, in this case) are more useful measures for performance evaluation as these indicators are more informative about the talents and efforts of the managers who are being evaluated.

On basis of the arguments discussed above for the hypothesized relationship between TCO success and the use of TCO for performance review and reward, we also expect that as the adequacy of TCO information is greater, TCO improvement will be used more as an element of performance review and reward (*TCO info adequacy* → *TCO based review and reward*). The roundtable discussions also provide inductive support for this. The purchasing executives pointed at the difficulties of setting up TCO as a basis for performance review and reward. They indicated the need of first having sufficiently reliable numbers to assess TCO-based performance and gaining experience and success with TCO-based sourcing decisions. Otherwise, there would be resistance to the linkage if it was thought that managers could manipulate the information unjustly to their benefit.

> H2: The adequacy of TCO information has a positive effect on the use of TCO for performance review and reward.

Furthermore, we expect that more adequate TCO information increases the success of TCO initiatives (*TCO info adequacy* → *TCO initiative success*). Managers who are more satisfied with the new costing information will use this more frequently to support decision-making (Swenson, 1995), and the quality of the information is a very important determinant of satisfaction (McGowan & Klammer, 1997).

> H3: The adequacy of TCO information has a positive effect on the success of TCO initiatives.

Value analysis experience refers to the extent of experience that the buying firm has with quantifying the total cost of purchasing alternatives (*value analysis experience*). Customer firms may assess the value of alternative suppliers' offerings through value analysis (Miles, 1989; Nishiguchi & Brookfield, 1997). A cross-functional team conducts a value analysis, typically with representatives from engineering, manufacturing, R&D, and accounting. Supplier representatives may contribute to the team's analysis as well. The product offerings' attributes are assessed in terms of their functionality or performance, the costs associated with providing the specific attributes are calculated, and lower-cost

alternatives are identified. Value analysis tends to be done on a one-off, project basis, although often employing a consistent methodology, whereas TCO analyses can be one-off studies as well as a cost management system. Value analysis and TCO projects thus are closely akin to one another, draw on the same kinds of ABC accounting information, and have the common intent of finding lower cost solutions without compromising performance. Thus, we capture value analysis and TCO analysis under a single construct which we term, for conciseness, "value analysis experience".

We expect that gaining experience with doing value analysis drives the improvement of the required information (*value analysis experience* → *TCO info. adequacy*). Initial experience with value analysis will be rather coarse and approximate, yet it lets firms develop an understanding of the data that are needed and of the changes that they need to make to capture cost data more systematically (Ness & Cucuzza, 1995). Value analysis experience is therefore expected to prompt initiatives aimed at increasing the adequacy and availability of TCO information. This is consistent with the view that learning and change arise from experience, and having acquired capacity in management accounting also creates expertise and knowledge to make changes in management accounting (Libby & Waterhouse, 1996). In the focus groups, the point about the difficulty of understanding the value or TCO implications of alternative purchase options was emphasized, and the purchasing executives explained the importance of gaining experience with value analysis and gradually building the capability to quantify these notions of value into financial benefits, together with suppliers:

> And what we're running through now is a series of trying to, first of all, identify what the added value could possibly be... and then... talk about it in dollars. We're beginning to build up some sort of expertise and practice with that. ... And what we really want to do is to try to find some models.

> I want to say that in our supply base, we don't have people beating at our door giving us value-added cases. Normally what happens is that the initiative is taken by us. ... And in most of those cases, people cannot just say 'we will add value' when they don't know how. What they really want is a discussion ... to explore where the value added is, because they don't know where they can bring the value add, because they don't know where your costs, where your problems are. (Director Purchasing Services, Chemical firm)

Therefore we hypothesize

H4: Value analysis experience has a positive effect on the adequacy of TCO information.

We further expect that the success of TCO initiatives is improved by gaining experience in doing value analysis (*value analysis experience* → *TCO initiative success*). Successful application comes about by actually being involved in value analysis initiatives. Such experiences are expected to increase the learning of applying TCO information successfully to sourcing decisions. So we hypothesize

H5: Value analysis experience has a positive effect on the success of TCO.

Functional area management commitment

Top management support in this study relates to the encouragement initiatives for developing and using TCO information receive from top management (*top management support*), whereas functional area management commitment concerns the support that managers in functional departments express for using TCO initiatives for sourcing decisions (*functional management commitment*). Functional management commitment for TCO stimulates purchasing decision-makers to investigate the value of alternative offerings and to engage in fact-based decisions. Previous studies identified top management support and commitment of non-accounting (or functional) management as important factors for ABC adoption (e.g., Anderson & Young, 1999; Krumwiede, 1998; McGowan & Klammer, 1997; Shields, 1995). Ellram and Siferd (1998) found that top management

support overcomes possible user resistance and "unfavourable corporate culture" in their case studies of TCO implementation. Functional commitment has been identified as an important element for bringing about management accounting change (Chenhall & Langfield-Smith, 1998a).

We expect functional management commitment to lead to more experience with value analysis (*functional management commitment → value analysis experience*) and to provide an impetus for improving the quality of the TCO information that is used as input for value analysis (*functional management commitment → TCO info. adequacy*).

H6: Functional management commitment has a positive effect on the adequacy of TCO information.

H7: Functional management commitment has a positive effect on value analysis experience.

Market pressure, purchasing strategy and top management support

We propose competitive pressure in customers markets (*customer market pressure*) and strategic purchasing orientation (*purchasing orientation*) as market-related factors that are relevant in spurring on TCO adoption. These effects occur in a number of steps.

First of all, we expect a direct relationship between customer market pressure and top management support for TCO adoption (*customer market pressure → top management support*). Previous results indicate that managers faced with high levels of competition may use more sophisticated cost control techniques and ask for more and different types of management accounting information before making important decisions (Khandwalla, 1972; Libby & Waterhouse, 1996). Studies on adoption of activity-based costing have found that strategy and organizational structure influence ABC adoption (Gosselin, 1997). Companies that follow a prospector strategy need a much broader range of information than defenders due to their quest for product-market opportunities.

Secondly, we expect a direct relationship between customer market pressure and the strategic purchasing orientation of the firm (*customer market pressure → purchasing orientation*). The strategic purchasing orientation refers to the importance of purchasing for contributing to and helping to realize the company's strategy, and the involvement of line-management and cross-functional processes in procurement. Van Weele (2001), for example, distinguishes six phases with respect to purchasing orientation: transactional orientation; commercial orientation; purchasing co-ordination; internal integration; external integration; and value chain integration. A critical distinction is made between the first three phases and the latter three: only in latter three phases there is a cross-functional approach to purchasing and have total cost/value considerations replaced an exclusive focus on price. A strategic purchasing orientation is consistent with performing value analysis and using TCO data. Keough (1993), Rozemeijer (2000) and Van Weele (2001) point to the role of competitive pressure in customer markets in driving firms to progress through these different phases, as is for example demonstrated by the 'mature' positions of the automobile and electronics industries in this respect. In a survey of 46 Dutch firms, Rozemeijer (2000) found a positive correlation between market pressure and the strategic orientation of the purchasing function ('maturity'). As one of the executives in our purchasing focus groups stated it:

> There is a direct correlation, I think, in our companies... between the competitive nature of our selling environment and the way in which we look at the value that you get from your supplier. (VP Corporate Procurement, Electronics firm)

The direct effects of customer market pressure capture the idea that both top management and functional management observe the environment of the organization and respond to it. Purchasing responds to customer market pressure by making the purchasing function more strategic oriented, and top management becomes more supportive of TCO. Apart from these direct effects of customer market pressure, we also expect that top managers are more supportive of TCO when they recognize that the overall purchasing orientation in their

firm is more mature, cross-functional, and value-oriented, so they know there is a generally 'fertile' ground for their specific support for TCO adoption to take root (*purchasing orientation → top management support*). Note that top management support specifically refers to support for TCO initiatives and not to management support for the general strategic orientation of purchasing.

In the next step, we expect the extent of strategic purchasing orientation to affect the commitment that functional (e.g., purchasing or maintenance) management has towards implementing TCO initiatives for sourcing decisions (*purchasing orientation → functional management commitment*). In other words, we see a more strategic purchasing orientation as a kind of prerequisite for TCO adoption. Finally, we also expect top management support to be an important condition for creating functional management commitment for TCO (*top management support → functional management commitment*). According to one of the executives in the focus-group discussions:

> . . .if you have a business where the management of that business requires purchasing to require demonstration of such a thing [sourcing based on total value or cost], then it will be done and it will be a value. If you don't have the management of the business requiring purchasing to do that, then no matter how much purchasing wants to do that, nobody is listening. (VP Corporate Procurement, Electronics firm)

All together, these arguments lead to the following hypotheses:

> H8: Top management support has a positive effect on functional management commitment.
> H9: Strategic purchasing orientation has a positive effect on functional management commitment.
> H10: Strategic purchasing orientation has a positive effect on top management support.
> H11: Customer market pressure has a positive effect on strategic purchasing orientation.
> H 12: Customer market pressure has a positive effect on top management support.

In summary, we have formulated a model and a set of hypotheses to understand TCO adoption. We have discussed several constructs explaining adoption and posit relationships among these constructs. We have proposed that successfully using TCO initiatives for sourcing decisions along with using TCO improvements as a significant component of performance review and reward system are critical constructs for TCO adoption. While having reasonably reliable and detailed TCO information available is a prerequisite to adoption, demonstrated success with TCO initiatives builds acceptance for using achieved TCO improvement as a significant component of performance review and reward of people who make sourcing decisions.

Our model posits that the various factors contributing to TCO adoption have a certain logical ordering, which we have generated from the literature and inductively from our focus group research. The starting point of our model is pressure in the firm's own customer market that is translated into a sourcing strategy as an important contribution to the firm's competitive position and that is based on value, cross-functional involvement, and line management involvement. This leads to commitment of top management and functional management for implementing TCO. However, in going from management commitment for TCO initiatives to actual TCO adoption, we see a crucial role for gaining value analysis experience. This means that purchasing decisions-makers from various functional backgrounds, and maybe even from suppliers, are trying to understand the impact of alternative product offerings. In doing so, they experience that they need TCO data. Having gone through the experience that TCO data are needed to make sourcing decisions based on value, we expect, is a crucial step to stimulate TCO adoption. Value analysis or TCO experience could stimulate the development of more adequate information and the successful use of that information. We are proposing this set of posited relations among constructs as a minimal model. There may be additional direct effects as well, augmenting the indirect relations in our model (i.e. where the effect of one construct on another is mediated through a third construct).

Research method

Questionnaire development

We generated two items for each of the eight constructs in the model, based on a literature review and informed by discussions in two business roundtable discussions. In these discussions, eight senior purchasing executives participated, from a chemical company, an appliances and electronics firm, an office equipment manufacturer, an oil company, a steel company and a pharmaceutical company. Since the original questionnaire was developed in English by the three authors, a translation into Dutch was made by one of the native speakers and this was back-translated to English by an external Dutch/English native speaker to check for any inconsistencies. The resulting items are listed in Appendix A. For each of the 16 items the research participant was asked to rate the degree to which the statement applies to the firm's TCO experience.

Data collection

We used a telephone–mail–telephone survey methodology that included both purchasing and maintenance managers, all from manufacturing industries. Both groups can be seen as purchasing decision-makers (specifically regarding MRO items), as was supported in our roundtable discussions. Hence, we assume that both groups have the same need for and interest in TCO analyses. Moreover, it is important to note that we treat our participants predominantly as *informants* on the situation at their respective firms.

From the professional associations of purchasing and maintenance professionals we obtained membership databases. From these, we selected representatives from manufacturing and technical service industries: 446 purchasing managers and 481 maintenance representatives. These people were contacted by telephone, and if they were interested in participating, a questionnaire was sent to them by fax or by e-mail. The participants were contacted again at an agreed time and the researchers then filled in the questionnaire at their end, based on the answers by the participant. In some cases, the participant preferred to return the questionnaire by fax or e-mail. Overall, 160 purchasing managers and 150 maintenance representatives completed usable questionnaires, leading to satisfactory net response rates of 35.9% (purchasing) and 31.2% (maintenance).

To check for any non-participant bias, we completed short telephone interviews with 10 non-participant purchasing managers and 10 non-participant plant maintenance managers on three variables: job experience in current function, experience with participation in value analysis teams (VT Exp), and experience with using value analysis or 'total cost of ownership' information for purchase decisions (TC Exp). Tests of differences between participants and non-participants on these variables revealed no significant differences, with one exception. Participating purchasing managers had significantly more experience than non-participants with total cost calculations (TC Exp) ($p < 0.05$). We deem this not a major issue, though, as there is no significant difference in relation to value analysis experience.

Analyses

A multi-sample analysis was conducted for the purchasing manager and plant maintenance manager samples using full-information maximum-likelihood estimation, provided by the LISREL® 8 program (Jöreskog & Sörbom, 1993, 1996). This analysis began with a test of equality of covariance matrices (Jöreskog, 1971) to assess whether or not the covariance matrices for purchasing managers and plant maintenance managers could be pooled and a single analysis conducted on this pooled covariance matrix. Rejection of the hypothesis of equality of covariance matrices means that each sample must be analyzed separately or simultaneously (which was the case).

A confirmatory measurement model was next estimated using confirmatory factor analysis (cf. Gerbing & Anderson, 1988). We specified each measure as being related to only one latent variable, the construct for which it is posited to be an indicator. Its loading on the specified construct is estimated, with its loadings on the remaining constructs set to zero. In contrast with exploratory

factor analysis, confirmatory factor analysis of measurement models specified in this way provides an explicit test of the unidimensionality of the indicators with respect to their posited underlying constructs, and the adequacy of the specified measurement model to account for the observed covariance matrix.

A series of confirmatory measurement models were estimated to determine the extent of invariance between purchasing manager and plant maintenance manager samples. One model was estimated in which the construct covariance, factor loading, and error variance parameters were constrained to be invariant across samples. A second model was estimated in which these parameters were estimated separately for each sample. This enabled a chi-square difference test to assess the hypothesis of confirmatory measurement model invariance. For comparison purposes, a final model was estimated in which the construct covariance and factor loading parameters were constrained to be invariant across samples, but the error variance parameters were estimated separately for each sample. This provided a contrasting test for partial invariance of confirmatory measurement model.

The structural model corresponding to the substantive model of interest was next tested. Measurement and structural submodels were simultaneously estimated to provide assessment of the posited construct relations without the confounding effects of measurement error (cf. Anderson & Gerbing, 1988). A series of structural models were estimated to determine the extent of invariance between purchasing manager and plant maintenance manager perspectives on the construct relations. One model was estimated in which all of the posited paths relating the constructs to one another were constrained to be invariant across samples. A second model was estimated in which these paths were estimated separately for each sample. This enabled a chi-square difference test to assess the hypothesis of structural model invariance.

After this test, several respecifications were made to the structural model that made sense from substantive theory and which significantly improved fit (Young, 1977). First, parameter estimates having non-significant estimates that were near zero were trimmed. Paths then were added one at a time, where the parameter was estimated as invariant across samples and also estimated separately for each sample. This approach enabled two chi-square difference tests to determine whether or not to add the path and whether or not it should be invariant across samples.

Results

Equality of covariance matrices

The hypothesis of equality of covariance matrices was rejected ($\chi^2 = 174.87$, $df = 136$, $p = 0.014$). Thus, the multi-sample analysis was conducted with simultaneous modeling of the separate covariance matrices for purchasing managers and plant maintenance managers.

Confirmatory measurement models

The confirmatory measurement model specified as invariant across samples provides acceptable fit, although the chi-square value remains significant ($\chi^2 = 291.53$, $df = 212$, $p < 0.001$). Specifically, the root mean square error of approximation (RMSEA) value is 0.046, the standardized root mean square residual (SRMR) value is 0.088, and the comparative fit index (CFI) value is 0.966, each of which indicate acceptable fit. Hu and Bentler (1998, 1999) have recommended goodness-of-fit indices be used in conjunction to judge acceptable model fit, and based on an extensive Monte Carlo study, recommend that a cut-off value close to 0.06 (or lower) for RMSEA, a cut-off value close to 0.08 (or lower) for SRMR, and a cut-off value close to 0.95 (or higher) for CFI "are needed before we can conclude that there is relatively good fit between the hypothesized model and the observed data" (Hu & Bentler, 1999, p. 1).

As would be expected, the confirmatory measurement model that is estimated separately for each sample provides better fit, yet its chi-square value also remains significant ($\chi^2 = 215.91$, $df = 152$, $p < 0.001$). Specifically, its RMSEA value is 0.046, its SRMR value is 0.049, and its CFI value is 0.973. Of greater interest, though, is the chi-square difference test between these two

models, which indicates that the separately estimated measurement model does not provide significantly better fit than the invariant measurement model ($\chi^2_d = 75.62$, $df = 60$, $p > 0.05$).

As would be expected, the confirmatory measurement model with partial invariance, where the error variance parameters were estimated separately for each sample, provided intermediate fit and its chi-square value remains significant ($\chi^2 = 273.97$, $df = 196$, $p < 0.001$). Specifically, its RMSEA value is 0.048, its SRMR value is 0.086, and its CFI value is 0.967. Of greater interest, though, is the chi-square difference test between these two models, which indicates that the partially invariant measurement model does not provide significantly better fit than the invariant measurement model ($\chi^2_d = 17.56$, $df = 16$, $p > 0.05$).

Thus, we conclude that the invariant confirmatory measurement model provides the most parsimonious, acceptable explanation for the purchasing manager and plant maintenance manager covariance matrices. Significance tests on the unstandardized factor loading estimates indicate that each measure is significantly related to its posited underlying construct ($p < 0.001$, with the lowest t-value being 10.96). To facilitate interpretation and comparison, we present the common metric completely standardized solution (Jöreskog & Sörbom, 1996) in Table 1. [1]

Structural models

The structural model corresponding to the substantive model of interest has a chi-square value of 353.53 ($df = 221$, $p < 0.001$) when all estimated structural parameters are specified as invariant across the purchasing manager and plant maintenance manager samples. In contrast, the structural model has a chi-square value of 340.08 ($df = 209$, $p < 0.001$) when the structural parameters are estimated separately for each sample. [2] The chi-square difference test between models indicates that there is no significant loss of explanation by constraining the structural parameter estimates to be the same across samples ($\chi^2_d = 13.45$, $df = 12$, $p > 0.05$). Thus, this result suggests that a more parsimonious, shared perspective is an acceptable representation. Further, comparing the values of the goodness-of-fit indices for the invariant structural model with those of the invariant confirmatory measurement model suggest that some respecifications can be made to improve explanation of the estimated construct covariances. Specifically, the RMSEA value is 0.058 for the invariant structural model, its group SRMR values are 0.103 and 0.083 for purchasing managers and plant maintenance managers, respectively, and its CFI value is 0.943.

The initial respecification was to trim the nonsignificant parameter estimates that were near zero. The paths *customer market pressure → top management support, purchasing orientation → functional management commitment*, *functional management commitment → TCO info. adequacy*, and *TCO info. adequacy → TCO initiative success* each were trimmed, with end result being a chi-square value of 366.92 ($df = 225$, $p < 0.001$). The first substantive respecification was to add a direct path from *top management support* to *value analysis experience*, specified as invariant across samples. This provides a significant improvement ($\chi^2 = 356.74$, $df = 224$, $p < 0.001$; $\chi^2_d = 10.18$, $df = 1$, $p < 0.005$). This path was next estimated separately for each sample, for which the results indicate that although this path significantly improves explanation, it should be freely estimated for each sample ($\chi^2 = 352.29$, $df = 223$, $p < 0.001$; $\chi^2_d = 4.45$, $df = 1$, $p < 0.05$).

The second substantive respecification was to add a direct path from *functional management commitment* to *TCO initiative success*, specified as invariant across samples. This path provides a significant improvement ($\chi^2 = 330.26$, $df = 222$, $p < 0.001$; $\chi^2_d = 22.03$, $df = 1$, $p < 0.001$). This path was next estimated separately for each sample, for which the results indicate that there is no significant loss of explanation from constraining this parameter estimate across samples ($\chi^2 = 328.52$, $df = 221$, $p < 0.001$; $\chi^2_d = 1.74$, $df = 1$, $p > 0.05$).

[1] Only the factor loadings we estimated are shown in Table 1. The loadings of the measures on all other constructs (than the one the measure is posited to indicate) are set to zero.

[2] In every structural model estimated, the measurement submodel parameters of measure loadings on constructs and measure error variances are estimated as invariant across purchasing manager and maintenance manager samples.

Table 1
Confirmatory measurement model

Measure	Customer market pressure	Purchasing orientation	Top management support	Functional management commitment	Value analysis experience	TCO info. adequacy	TCO initiative success	TCO based review and reward
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Construct loadings[a]								
CM Com	0.89							
CM Pri	0.89							
Pur Ack		0.67						
Pur Cfp		0.86						
TM Stim			0.83					
TM Init			0.87					
FM Eng				0.87				
FM Sup				0.92				
VT Exp					0.65			
TC Exp					0.81			
TC Avl						0.85		
TC Rel						0.67		
TC Gain							0.93	
TC Res							0.66	
TC Rvrw								0.85
TC Eval								0.73
Construct covariances[b]								
Construct								
1	1.00							
2	0.34	1.00						
3	0.16	0.55	1.00					
4	0.16	0.49	0.80	1.00				
5	0.09[ns]	0.38	0.65	0.73	1.00			
6	0.10[ns]	0.46	0.56	0.55	0.72	1.00		
7	0.21	0.39	0.67	0.68	0.57	0.51	1.00	
8	0.12[ns]	0.27	0.35	0.52	0.38	0.30	0.40	1.00

[a] All loadings are statistically significant ($p < 0.001$, with the small t-value being 10.96) and are invariant across purchasing manager and plant maintenance manager samples. Common metric completely standardized estimates are given.

[b] All construct covariances are statistically significant ($p < 0.05$), except where indicated by ns, and are invariant across purchasing manager and plant maintenance manager samples. Common metric completely standardized estimates are given.

The third substantive respecification was to add a direct path from purchasing orientation to TCO info. adequacy, specified as invariant across samples. This path provides a significant improvement ($\chi^2 = 323.11$, $df = 221$, $p < 0.001$; $\chi^2_d = 5.41$, $df = 1$, $p < 0.025$). This path was next estimated separately for each sample, for which the results indicate that there is no significant loss of explanation from constraining this parameter estimate to be the same across samples ($\chi^2 = 323.10$, $df = 220$, $p < 0.001$; $\chi^2_d = 0.01$, $df = 1$, $p > 0.05$).

Finally, we investigated relaxing the invariance constraints for two hypothesized structural parameters. Allowing the path from *purchasing orientation* to *top management support* to be estimated separately for each sample provides a significant improvement ($\chi^2 = 317.43$ df = 220, $p < 0.001$; $\chi^2_d = 5.68$, $df = 1$, $p < 0.025$). Interesting substantively, while this parameter remains statistically significant for each sample, purchasing managers perceive a significantly stronger relationship than do plant maintenance managers.

Allowing the path from *TCO info. adequacy* to *TCO based review and reward* to be estimated separately for each sample provides an interesting case in substantive interpretation. When this path is

constrained to be equal across samples, it falls just below statistical significance ($\beta = 0.195$, s.e. = 0.099). Freely estimating this path across samples reveals that, although there is only marginal improvement in overall model fit ($\chi^2 = 314.17$ $df = 219$, $p < 0.001$; $\chi^2_d = 3.26$, $df = 1$, $p < 0.10$), the path is statistically significant for purchasing managers ($\beta = 0.358$, s.e. = 0.132) but not for plant maintenance managers ($\beta = 0.067$, s.e. = 0.124). Thus, even though the chi-square difference test is borderline and falls below traditional statistical significance, we believe that the structural model with this path freely estimated provides better explanation because it does not obscure this difference between purchasing manager and plant maintenance manager perspectives. [3]

We provide the parameter estimates for our final structural model in Fig. 2, and the parameter estimates for the measurement submodel in Table 2. The close correspondence of the estimates in Table 2 with their counterparts in Table 1, provides evidence against interpretational confounding (cf. Anderson & Gerbing, 1988). Although the chi-square difference between our final structural model and the confirmatory measurement model remains statistically significant ($\chi^2_d = 22.64$, $df = 7$, $p < 0.005$), the values of the other goodness-of-fit indices suggest acceptable fit and that the remaining difference is not of practical significance. Specifically, the RMSEA value is 0.048 for the final structural model, and its group SRMR values are 0.065 for both purchasing managers and plant maintenance managers, and its CFI value is 0.959. Of practical interest, the difference in CFI values (0.007) shows that the difference in explanation of the observed covariances between the final structural model and the confirmatory measurement model is less than one percent (cf. Anderson & Gerbing, 1988). [4]

Of the 12 hypotheses in our initial structural model in Fig. 1, eight received significant support. Three hypothesized direct effects are found simply to be indirect effects, mediated by another construct. The hypothesized effect of pressure in the customer market on top management support for TCO initiatives (*customer market pressure → top management support*) is found to be an indirect effect, mediated by strategic purchasing orientation (purchasing orientation). Similarly, the hypothesized effect of strategic purchasing orientation on functional management commitment to TCO initiatives (*purchasing orientation → functional management commitment*) is found to be an indirect

[3] To provide further support for our posited relation that *TCO initiative success* has a positive effect on *TCO based review and reward*, we also tested the reverse relation, *TCO based review and reward → TCO initiative success*. To provide a base model for comparison, we estimated the model where no relation between these two constructs was specified ($\chi^2 = 328.19$, $df = 220$; RMSEA = 0.050; CFI = 0.954). The model adding the reverse path *TCO based review and reward → TCO initiative success* does not significantly improve goodness-of-fit over the base model ($\chi^2 = 326.78$; $df = 219$; $\chi^2_d = 1.41$, $df = 1$, $p > 0.05$; RMSEA = 0.051; CFI = 0.954) and the path coefficient is not significant ($\beta = 0.089$, s.e. = 0.069, $t = 1.30$, $p > 0.05$). In contrast, the model adding the posited path *TCO initiative success → TCO based review and reward* does significantly improve goodness-of-fit over the base model ($\chi^2 = 314.17$; $df = 219$; $\chi^2_d = 14.02$, $df = 1$, $p < 0.001$; RMSEA = 0.048; CFI = 0.959) and the path coefficient is significant ($\beta = 0.303$, s.e. = 0.077, $t = 3.93$, $p < 0.001$).

[4] We conducted a specification search (MacCallum, 1986) to determine whether any of several potential reciprocal paths, suggested by a reviewer, would significantly improve on our final structural model. Although none of the specified reciprocal paths yielded significant reciprocal path coefficients, one of the results did suggest an alternative model that has virtually equivalent fit. Specifying a structural model with a path from *value analysis experience to functional management commitment*, the opposite direction from what we posit, has a significant standardized path coefficient of 0.33, with $\chi^2 = 312.17$, df = 219, $p < 0.001$; RMSEA = 0.047; SRMR = 0.064 for purchasing managers and 0.065 for maintenance managers; and CFI = 0.960. As would be expected, the standardized path coefficients for the common antecedent construct to these two constructs are affected by this change in path direction: the standardized path coefficient from *top management support* to *value analysis experience* increases to 0.77 for purchasing managers and 0.57 for maintenance managers (now statistically significant), while the standardized path coefficient from *top management support* to *functional management commitment* decreases to 0.60. However, as evidence of the stability of the structural model, only two of the rest of the standardized path coefficients change at all, and then only trivially, by 0.01. Thus, changing the direction of the path between *functional management commitment* and *value analysis experience* has virtually no effect on the remainder of the structural model. We believe that *functional management commitment* facilitates *value analysis experience*, not the reverse, reinforcing the need for theory to resolve this dilemma (Young, 1977).

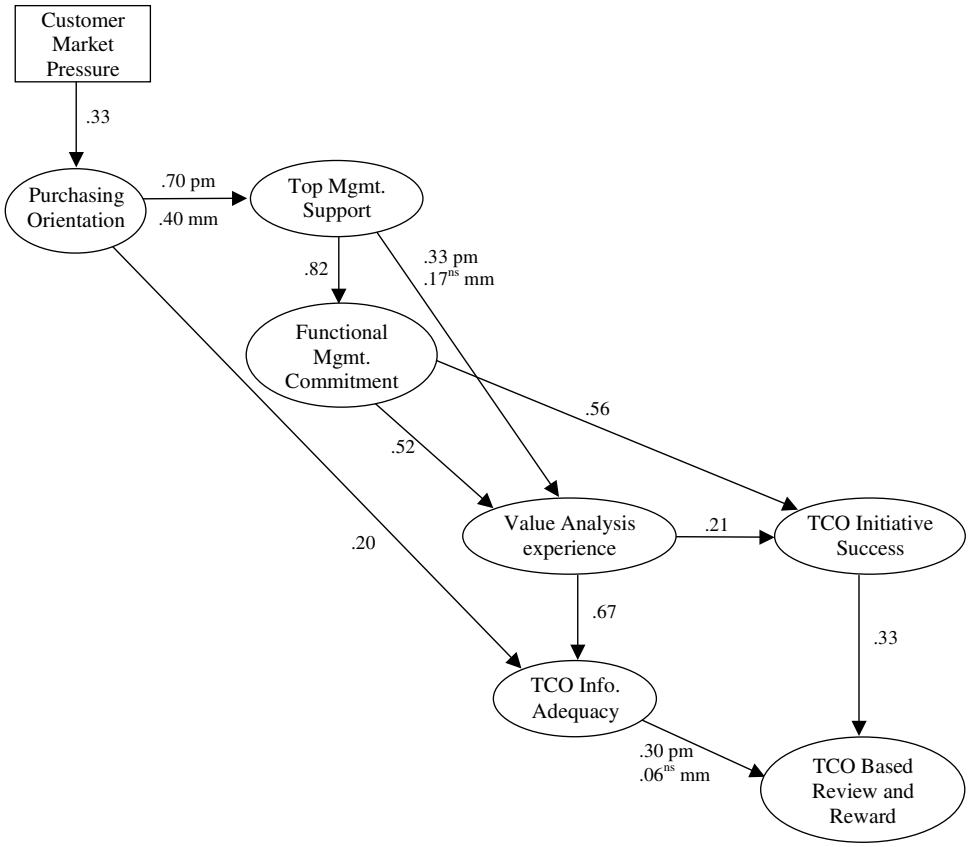

Fig. 2. Structural model of TCO adoption for purchasing managers and plant maintenance managers. *Note:* All parameter estimates are statistically significant ($p < 0.05$), except those indicated by ns. Parameter estimates are invariant across purchasing managers (pm) and plant maintenance managers (mm), except where separate estimates are given and indicated by pm and mm. Separate estimates are significantly different from one another, except for TCO info. adequacy → TCO based review and reward. Common metric completely standardized estimates are presented.

effect, mediated by top management support for TCO initiatives. Lastly, the hypothesized effect of functional management commitment to TCO initiatives on TCO information adequacy (*functional management commitment → TCO info. adeqacy*) is found to be an indirect effect, mediated by value analysis experience. The hypothesized effect of TCO information adequacy on TCO initiative success (*TCO info. adeqacy → TCO initiative success*) is found to be not significant, with this relationship instead simply accounted for by a common antecedent, *value analysis experience*.

Elaborating on our initial structural model, we found that three direct paths needed to be added where we had hypothesized simply indirect effects, mediated by another construct. Strategic purchasing orientation is found to have an invariant direct influence on TCO information adequacy, instead of the indirect influence through functional management commitment to TCO initiatives we had hypothesized. Top management support for TCO initiatives is found to have a direct influence on value analysis experience for the purchasing manager perspective, in addition to the hypothesized indirect influence through functional management commitment to TCO initiatives, which we also found. Finally, functional management commitment to TCO initiatives is found to have an invariant direct influence on success of TCO initiatives, in addition to the hypothesized indirect

Table 2
Measurement submodel of final structural model

Measure	Customer market pressure	Purchasing orientation	Top management support	Functional management commitment	Value analysis experience	TCO info. adequacy	TCO initiative success	TCO based review and reward
Construct loadings								
CM Com	0.90							
CM Pri	0.88							
Pur Ack		0.67						
Pur Cfp		0.87						
TM Stim			0.83					
TM Init			0.85					
FM Eng				0.87				
FM Sup				0.92				
VT Exp					0.66			
TC Exp					0.79			
TC Avl						0.84		
TC Rel						0.67		
TC Gain							0.93	
TC Res							0.66	
TC Rvrw								0.80
TC Eval								0.77

Note. All loadings are statistically significant ($p < 0.001$, with the small t-value being 7.08) and are invariant across purchasing manager and plant maintenance manager samples. Common metric completely standardized estimates are given.

influence through value analysis experience, which we also found.

Discussion

The research investigated factors that explain the successful adoption of TCO for sourcing decisions, such as the adequacy of TCO information, the success of past TCO initiatives, and the use of TCO improvement as a basis for performance review and reward. TCO builds on ABC and extends the use of cost information to sourcing decisions by capturing all costs related to the acquisition and use of purchased goods or services. TCO aims to quantify trade-offs between the various costs that occur within the purchase department, in other departments of the buying firm, and within the supplying firm. TCO is one way to get further benefits of ABC, and this study investigated what the factors are that contribute to this application and extension of ABC to sourcing decisions.

First, the study provides conceptual contributions to the literature on the adoption of TCO and other cost accounting systems. While reinforcing the relevance of some factors identified previously, the research has identified functional strategy and experience with using the new cost accounting data for analysis purposes as important new factors. The study also provides new evidence on the relationship between the various factors involved, such as the notion that new cost information may first be made available and successfully used before subsequently becoming a component in performance review and reward systems. Second, the research provides a methodological contribution by employing sophisticated structural equation modeling to estimate models and test differences in perspectives between different functional areas without the confounding effects of measurement error. Third, there are managerial implications of the research. We discuss each of these contributions in turn.

Conceptually understanding successful adoption of TCO

This study found that top management support and functional (non-accounting) commitment to improved cost information are important factors for adoption of TCO, which reinforced previous

findings in the literature on the adoption of new cost accounting systems. Top management support strongly impacted functional management commitment. In fact, we did not find support for a direct impact from purchasing strategy on functional commitment for TCO initiatives, but this relationship was mediated through top management support. This reinforces the crucial role that top management plays in supporting new cost accounting practices. This may be especially needed for initiatives such as TCO, which require inter-functional cooperation. Top management support and functional management commitment were found to strongly impact experience with conducting value analysis, and functional commitment also was found to have a direct impact on the success of TCO initiatives.

This study found that purchasing orientation—the extent to which this is strategic and truly cross-functional—is an important element for TCO adoption. This is reinforced by the fact that we did not find support for a direct relationship between customer market pressure and top management support, so market pressure alone is not sufficient for top management to support a TCO initiative. This may suggest that top management will only support the introduction and application of TCO tools for sourcing decisions when purchasing, in response to customer market conditions, has become a strategic and truly cross-functional process. Actions from either top management or purchasing managers, or most likely both, are required to increase the perceived strategic importance of the purchasing function. While previous studies have found a relationship between the firm strategy and the adoption of new cost accounting systems (Gosselin, 1997), this finding points to the importance of embedding cost accounting innovations in broader functional strategies.

A main contribution of this study is to demonstrate the importance of value analysis experience for the adoption of TCO. Value analysis experience, which might also be labelled "TCO experience", refers to the extent of experience that the buying firm has with quantifying the total cost of purchasing alternatives. This was found to be an important factor for the structural improvement of TCO information and for the success of TCO initiatives. In other words, the process of performing particular analyses and using certain data in that process, affects the quality of the data that are *input* to it and the concrete benefits of using the *outputs* of it. The crucial role that experience with value analysis and TCO seems to play here, is also apparent from the lack of direct impact from functional management commitment on the perceived adequacy of TCO information, while there is an indirect impact, through value analysis experience. This suggests that functional management commitment for TCO initiatives leads to value analysis experience, which then creates an impetus for improving cost accounting data. Management commitment in itself is—although necessary—not sufficient to produce adequate TCO information. Value analysis experience also leads to success of TCO initiatives for sourcing decisions, while the adequacy of the TCO information has no direct impact on the success of TCO initiatives. More generally, this suggests that experience with the analyses that requires certain cost accounting data is an important factor for the adoption of new cost accounting techniques. Cost accounting data for managerial purposes are not useful on their own, but these become meaningful when brought into a context of problems, dilemmas, questions, and decisions. This is consistent with the finding of Chenhall and Langfield-Smith (1998b) that benefits from activity-based costing techniques appear to be associated with the effective implementation of a range of management techniques.

Another contribution of this study is to show that adequate TCO information and successful usage of TCO lead to greater use of TCO improvement as a component of performance reviews. This suggests that high-quality information and demonstrated benefits are the basis for starting to use the outcomes made possible from new cost accounting information to evaluate people. Rather than looking at review and reward systems as a means for getting new accounting information adopted—people will use the new information when the measurement of their performance depends on it—our findings show that using TCO improvement as a significant component of performance review and reward follows from positive experiences with TCO initiatives.

Any modeling task requires choices which constructs and measures to include. The model is structured and bounded by choices that the researchers have made. While other constructs might also be interesting, including those would change the focus of the model, especially if some of the existing constructs would have to be excluded to keep the modeling task manageable. For example, rather that having customer market pressure as an exogenous variable, we might have included variables trying to explain customer market pressure. Or, instead of relating top management support only to purchasing orientation, we might have included other variables for explaining top management support. However, we then may not have been able to include the constructs of *TCO initiative success* or *TCO based review and reward*. We choose to focus on what we thought to be the most central constructs for this study.

Using multi-sample analysis to test differences in perspectives

The study demonstrated the use of a rigorous two-step approach to structural equation modeling in management accounting for testing models of cost systems adoption (cf. Anderson & Gerbing, 1988). Structural equation modeling has not been used frequently in management accounting research (cf. Anderson & Young, 1999; Hunton et al., 2000). Confirmatory factor analysis was used to test whether the observed measures adequately reflect the underlying constructs (the latent variables), and then the structural model of the relationships between latent variables was estimated without the confounding effect of measurement error. The study also demonstrated the use of multi-sample structural equation modeling to test differences in perspectives between a promoting, catalyst functional area (such as purchasing or accounting) and a using functional area (such as plant maintenance) in the adoption of innovative accounting systems, without the confounding effects of measurement error.

We advocate the broader use of multi-sample structural equation modeling. Understanding commonalties and differences in perspectives makes a significant contribution to our understanding of the successful adoption of accounting systems. Multi-sample structural equation modeling represents an excellent way to overcome measurement problems in management accounting research (as also discussed by Smith & Langfield-Smith, 2002) while contrasting two perspectives on the adoption and use of management accounting information. Accounting, or purchasing in the case of TCO, can be seen as the function that is the main promoter or initiator of advanced cost management systems, while other functions are the main users of such information, such as plant maintenance in the case of MRO items. Our study provides an illustration of how multi-sample structural equation modeling can be employed in such research settings. The analysis showed that strategic purchasing orientation has an impact on top management support, and this relationship is significant for purchasing managers as well as for plant maintenance managers, but more strongly for the first group. This might be explained by purchasing managers being more likely to be exposed to and perceive such a connection. The analysis also showed that the relationship between top management support and value analysis experience is only significant for purchasing managers, but not for maintenance managers. Purchasing managers might think they need top management support to stimulate the use of value analysis, while the plant maintenance managers may think they only need their own functional management support. Furthermore, the analysis showed that the impact of TCO adequacy on TCO performance review and reward was only significant for purchasing managers but not for maintenance managers. This might indicate that flexible compensation or incentive pay—and as part of that, incentive pay being based on TCO reduction—is applied more widely for purchasing than for maintenance managers. Multi-sample structural equation modeling enables such differences in perspectives on the construct relations to be detected and tested.

TCO analysis in practice

Our findings suggest some managerial implications for the implementation of TCO accounting

systems. The model estimates indicate that there is a certain ordering of steps to take in implementation. Top management support is required, but first the purchasing strategy must show a clear commitment to value-based purchasing. A purchasing orientation that takes a cross-functional approach and considers total cost/value considerations gains top management support for TCO initiatives. Top management support can spur on functional management commitment to using TCO initiatives for sourcing decisions. The step from management commitment to TCO adoption requires first getting value analysis experience to create a clear understanding of the kinds of data, and level of detail needed for TCO analysis. Demand for these new kinds of information fuels the systematic generation of that information. Value analysis experience can be used to improve the quality of the information. Once the information is available and reliable, and the firm has some concrete success stories of using that information to obtain tangible benefits from improved sourcing decisions, the firm can begin to change the performance review and reward system. To do that too early would mean that purchasing decision-makers might not yet be willing to change and embrace TCO as a progressive way of doing business with suppliers. Viability of the new cost information and its contribution to firm performance needs to be demonstrated before adoption of the TCO concept and its use as part of performance review and reward.

The results also suggest that both functions need to be involved in the implementation process: the functional area that is a primary driver and catalyst for an accounting approach, as well as the functional area that is a primary user and potential beneficiary of that approach. One difference, though, might be that top management support could especially be aimed at purchasing—the catalyst function—to directly stimulate value analysis experience. Maintenance managers do not see top management support as having a significant (direct) impact on the actual experience with value analysis and using TCO information. This could also reflect that adoption of TCO-based decision-making ultimately has a broader intended scope than just maintenance items, and this would give top management support a greater "leverage" effect for stimulating value analysis when it is aimed at the purchasing function.

TCO is an accounting technique that is clearly relevant to sourcing decisions for MRO supplies or production component changes that do not affect the performance of the market offering, as perceived by the customer. Most existing definitions and calculations of TCO, though, do not capture the incremental value associated with an acquired offering that will be realized downstream from the purchasing firm. An acquired component that contributes to superior performance in the firm's market offering to its customers may increase the revenue potential of the market offering into which that component is incorporated, thereby increasing the component's value to the purchasing firm (Carr & Ittner, 1992; Ellram & Feitzinger, 1997). For example, Dupont's SilverStone® non-stick finish has a significantly higher price than generic non-stick finishes and the process of applying it to cookware also is significantly more costly than generic finishes, yet the significantly greater durability it provides enables the cookware manufacturer to charge a significantly higher price (to retailers and, in turn, consumers) than they can for cookware coated with a generic non-stick finish. This is a difference that the cookware manufacturer's evaluation of purchasing alternatives needs to consider. The trade-off for sourcing decisions in such settings would require a *total value of ownership* (TVO) approach, which captures both total cost considerations in ownership, but also performance advantages gained by the purchasing firm to create value for its customers and receive additional revenues and profits that it otherwise could not. Having a TVO analysis of alternative buying opportunities related to different end products is not only relevant for the sourcing decisions, but also for negotiating an equitable return for this superior performance provided to customers.

TVO builds on the concept of "value" that is used in the marketing literature. Value can be defined as the worth in monetary terms of the economic, technical, service, and social benefits a customer firm receives in exchange for the price it pays for a product offering, taking into consider-

ation competing suppliers' offering and prices (Anderson, Jain, & Chintagunta, 1993; Anderson & Narus, 1998, 2004). Purchase price in business markets is what a customer firm pays a supplier for its product offering. With these definitions, a product offering's value and price are independent of each other. Further, in business markets, the value provided nearly always exceeds the price paid—the difference being the customer's incentive to purchase (Anderson & Narus, 1998, 2004).

Limitations and conclusions

One limitation of the present study is that we did not have representation of the accounting perspective on the adoption of TCO. We focused on the purchasing managers and plant maintenance managers who were involved in sourcing decisions. We compared the perspectives of these functions, but we were not able to make a comparison with the accounting function. The maintenance function represents the end-user of TCO information, and the purchasing function is a primary initiator of TCO analysis. We feel that the involvement of these functions is a strong point of the present study, though, considering that many previous studies on the introduction and usage of accounting information rely mainly on responses from accountants in organizations.

Another limitation is that the maintenance function involved in sourcing MRO items may be seen as a specialized area of sourcing decisions and the usage of TCO information. The results may not be particularly relevant for other sourcing decisions, such as for materials and components. However, the functional area of plant maintenance and the sourcing of MRO items represents a clearly defined area where TCO can be applied without having to also include even harder to estimate effects that relate to revenue enhancement opportunities associated with alternative purchasing options.

From a measurement perspective, a limitation of our research is that we had only two measures of each construct. A consequence of this is that the unidimensionality of the measures with respect to their posited underlying constructs is solely assessed through external consistency (i.e., the pattern of the relationships of the two indicators of the same construct with indicators of other constructs). Although our measurement model results suggest acceptable unidimensionality, having four measures of each construct would enable assessment of their unidimensionality through internal consistency as well as external consistency, which would provide a more rigorous and preferable assessment (cf. Anderson & Gerbing, 1982).

A final limitation is that causal inferences made from structural equation modeling must be consistent with established principles of scientific inference (cf. Cliff, 1983). First, models are never confirmed by data; rather, they gain support by failing to be disconfirmed. Second, temporal order is not an infallible guide to causal relations. Third, in what is known as nominalistic fallacy, naming something does not necessarily mean that one understands it. Finally, although use of the two-step approach preserves the ability to make some inferences, respecification typically limits the ability to infer causal relations. Application of these principles will have the effect that, in most research situations, only qualified statements of causal inference can be justified.

We have built a substantive, structural model that implies a temporal ordering to the constructs that we study. Because we then estimate this model using cross-sectional data, care must be exercised in making strong statements about the causal directions. The results of our specification searches, which we provide in Footnotes 3 and 4, indicate that certain causal directions are more plausible than the reverse or reciprocal causation. Even though temporal order is not an infallible guide to causal relations, longitudinal research designs, such as cross-lagged panel models (Bagozzi, 1980; Maruyama, 1998), do enable stronger statements to be made about causal direction and reciprocal causation over time.

One avenue for future research is to explore opportunities for expanding the scope of TCO beyond total cost trade-offs to a TVO concept, which recognizes that the value of a higher priced offering may come from revenue improvements and not only, or not at all, come from total cost savings. A firm may be able to offer a better end product to its customers and increase its revenues by working with a particular supplier. Is it possible

to connect alternative purchase options with revenue enhancement? How can a firm understand what alternative purchase options mean for its own processes, but also for its customers and other parties further along the value chain? Thus, there is room for expanding the TCO concept to a broader total value concept that captures the cost and revenue impact at various firms along the value chain resulting from the purchase decisions that a firm makes.

Acknowledgements

The authors gratefully acknowledge the financial support for the research provided by the Institute for the Study of Business Markets (ISBM), located at Penn State University. James C. Anderson also gratefully acknowledges the financial support provided by the School of Business, Public Administration & Technology, University of Twente, The Netherlands, where he is a Visiting Research Professor; and the Department of Technology Management, Eindhoven University of Technology, where he was a Visiting Research Professor when this research began. The authors also thank David F. Larcker and the Reviewers for their constructive comments.

Appendix A

Measures of constructs

1. How much experience do you have with participation in value analysis teams? (VT Exp)
2. How much experience do you have with using value analysis or 'total cost of ownership' information for purchase decisions? (TC Exp)
3. How extensively available, in your experience, is information related to 'total cost of ownership' or value analysis for purchase decisions? (TC Avl)
4. How reliable, in your experience, is information related to 'total cost of ownership' or value analysis for purchase decisions? (TC Rel)
5. Top management recognizes purchasing as an important contributor to the competitive position of the firm. (Pur Ack)
6. In our company, purchasing relates to strategic and truly cross-functional processes, with high involvement of line-management. (Pur Cfp)
7. Our end-markets are characterized by intensive and strongly growing competition. (CM Com)
8. Our end-markets are characterized by a strong pressure on prices. (CM Pri)
9. Senior management has actively encouraged greater use of total cost of ownership (TCO) analyses for decision making. (TM Stim)
10. Please indicate to which degree TCO initiatives have the support of top management. (TM Init)
11. There is a sense of commitment to conducting TCO analyses from managers in your department. (FM Eng)
12. Managers in your department actively support the use of TCO analyses for decision making. (FM Sup)
13. The TCO analyses conducted at your firm have resulted in significant financial gains. (TC Gain)
14. The TCO analyses that have been done at your firm generally have produced disappointing results. [Reverse-coded] (TC Res)
15. Reducing total cost of ownership (TCO) is a significant component of your performance review and reward system. (TC Rvw)
16. The 'total cost of ownership' for acquired goods and services and your performance evaluation and compensation are strongly linked. (TC Eval)

Note. Each item was measured on a 7-point Likert scale, with the exception of six measures that had different response alternatives: VT Exp: 1 = no experience at all, 4 = participated a few times, and 7 = participate very frequently; TC Exp: 1 = no experience at all, 4 = used a few times, and 7 = use very frequently; TC Avl: 1 = not available at all, 4 = reasonably available, and 7 = completely available; TC Rel: 1 = not reliable at all, 4 = reasonably reliable, 5 = completely reliable; TM Init: 1 = no support at all and 7 = full support; and TC Eval: 1 = completely disconnected and 7 = very strongly connected.

These measures are linked to the constructs as specified in Tables 1 and 2.

Appendix B

Observed covariance matrix for purchasing managers

VT Exp	3.389															
TC Exp	1.697	2.744														
TC Avl	1.146	1.311	2.103													
TC Rel	0.761	0.746	0.941	1.489												
Pur Ack	0.570	0.279	0.513	0.366	2.113											
Pur Cfp	1.250	0.803	0.930	0.731	1.396	2.799										
CM Com	0.292	0.162	0.169	0.190	0.358	0.595	2.440									
CM Pri	0.250	0.095	0.258	0.344	0.499	0.730	1.891	2.489								
TM Stim	1.458	1.372	1.301	0.870	0.832	1.528	0.422	0.487	2.875							
TM Init	1.125	1.346	1.113	0.723	0.904	1.309	0.201	0.238	1.954	2.668						
FM Eng	1.195	1.360	0.923	0.629	0.705	1.296	0.517	0.503	1.492	1.742	2.381					
FM Sup	1.421	1.529	1.103	0.727	0.695	1.466	0.370	0.489	1.639	1.698	2.138	2.800				
TC Gain	1.272	1.388	1.027	0.775	0.421	1.145	0.383	0.437	1.565	1.683	1.539	1.875	3.065			
TC Res	−0.783	−0.958	−0.701	−0.600	−0.269	−0.846	−0.306	−0.355	−0.795	−0.926	−0.979	−1.118	−1.644	2.116		
TC Rvw	1.379	0.684	0.659	0.381	0.560	0.953	0.357	0.424	1.179	0.829	1.372	1.679	1.215	−0.618	3.489	
TC Eval	0.897	0.632	0.932	0.548	0.581	1.025	0.152	0.203	1.177	0.836	1.065	1.292	0.959	−0.300	2.181	3.625

Observed covariance matrix for plant maintenance managers

VT Exp	2.423															
TC Exp	1.247	2.570														
TC Avl	0.777	1.008	1.836													
TC Rel	0.617	0.734	1.051	1.607												
Pur Ack	0.621	0.203	0.338	0.240	2.382											
Pur Cfp	0.666	0.385	0.648	0.451	1.416	2.518										
CM Com	0.576	−0.091	0.071	−0.038	0.988	0.579	2.423									
CM Pri	0.432	−0.011	0.123	−0.063	0.819	0.429	2.025	2.553								
TM Stim	0.723	1.048	0.627	0.489	0.706	0.917	0.393	0.321	2.559							
TM Init	0.703	1.028	0.618	0.516	0.474	0.566	0.172	0.367	1.859	2.572						
FM Eng	0.947	1.074	0.796	0.666	0.391	0.520	0.255	0.278	1.384	1.409	2.272					
FM Sup	1.036	1.344	0.755	0.802	0.445	0.679	0.020	0.194	1.453	1.628	1.787	2.370				
TC Gain	0.753	0.902	0.778	0.607	0.454	0.605	0.450	0.498	1.146	1.175	1.119	1.273	2.307			
TC Res	−0.354	−0.377	−0.436	−0.398	−0.387	−0.282	−0.183	−0.293	−0.890	−1.051	−0.649	−0.711	−1.233	1.955		
TC Rvw	0.349	0.375	0.261	0.158	0.046	0.049	0.050	0.134	0.368	0.380	0.630	0.577	0.639	−0.358	2.568	
TC Eval	0.690	0.819	0.312	0.212	0.038	0.217	0.215	0.326	0.389	0.351	0.716	0.650	0.639	−0.290	1.611	2.567

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