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The role of manufacturing practices in mediating the impact of activity-based costing on plant performance

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Abstract

We study the impact of activity-based costing (ABC) on adoption of world-class manufacturing (WCM) practices and plant performance. In contrast to earlier research that estimates the direct impact of ABC on plant performance, we develop an alternative research model to study the role of world-class manufacturing practices as a mediator of the impact of ABC. Analysis of data from a large cross-sectional sample of US manufacturing plants indicates that ABC has no significant direct impact on plant performance, as measured by improvements in unit manufacturing costs, cycle time, and product quality. We find, however, that WCM practices completely mediate the positive impact of ABC on plant performance, and thus advanced manufacturing capabilities represent a critical missing link in understanding the overall impact of ABC. Our results provide a different conceptual lens to evaluate the relationship between ABC adoption and plant performance, and suggest that ABC adoption by itself does not improve plant performance.

Introduction

Activity-based costing (ABC) was designed with the objective of providing managers with accurate activity-based cost information by using cost drivers to assign activity costs to products and services. Proponents of ABC argue that it provides accurate cost data needed to make appropriate strategic decisions in terms of product mix, sourcing, pricing, process improvement, and evaluation of business process performance (Cooper & Kaplan, 1992; Swenson, 1995). These claims may have led many firms to adopt ABC systems. A survey of the 1000 largest firms in the United Kingdom showed that 19.5% of these companies have adopted ABC (Innes & Mitchell, 1995). Another survey released by the Cost Management

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Group (1998) of the Institute of Management Accountants indicated that 39% of organizations have approved ABC adoption.[1]

Assessing the impact of ABC on manufacturing plant performance is recognized as an important research question. Prior research has typically focused on the direct impact of ABC while ignoring its indirect impact in supporting other organizational capabilities. While past studies have reported moderate levels of benefits from ABC adoption (Foster & Swenson, 1997; Ittner & Larcker, 2001), few have extended this work to evaluate the linkages between "beliefs" that represent successful outcomes and the operational measures of plant performance. Furthermore, the definition of ABC success has often been vaguely defined in terms of subjective beliefs regarding "financial benefit", "satisfaction with ABC", or "use of ABC system for decision making". In light of these methodological deficiencies, we argue that a more rigorous approach is needed to measure the impact of ABC. It is also important to focus on process-level performance measures, instead of firm-level financial metrics, since the potential impact of ABC implementation may be appropriated before they are reflected in a firm's aggregate performance. Evidence of past ABC implementation failures have led researchers to suggest that ABC success depends on other contextual and process factors, such as organizational structure, task characteristics, management support, information technology, and the external environment (Anderson, Hesford, & Young, 2002).

In this study, we focus on the mechanism through which ABC impacts plant performance, in terms of its role as an enabler of organizational capabilities rather than its direct impact. Specifically, we study the association between implementation of ABC and world-class manufacturing (WCM) capabilities, and their impact on plant-level operational performance. Using a large cross-sectional sample of US manufacturing plants, we find that ABC has a positive association with the development of process-centric capabilities required to successfully implement WCM. We also find that ABC does *not* have a significant direct impact on plant performance measures. Instead, its impact on plant performance is *mediated* through the development of WCM capabilities, which allow plants to leverage the process capabilities offered by ABC into significant improvements in plant performance.

Our study makes contributions in several areas. Our fundamental contribution involves the development of an empirically validated framework which indicates that the impact of ABC on plant performance is *completely mediated* through its enablement of WCM capabilities. Second, since ABC is implemented and used at the business process level, we focus our attention on operational process performance measures by treating the manufacturing plant as a unit of analysis. This allows us to avoid the drawbacks associated with prior studies which have mostly focused on aggregated, firm-level financial measures. Third, our results suggest that the conceptual lens through which prior research has traditionally studied the impact of ABC needs to be revisited and validated using different types of modeling and measurement approaches. Contrary to the findings of Ittner, Lanen, and Larcker (2002) we find that, although the direct impact of ABC is not significant, ABC has a statistically significant *indirect* effect on plant performance that is mediated through its support for advanced manufacturing capabilities.

The rest of our paper is organized as follows. In the next section, we review the related literature on ABC, advanced manufacturing practices, and plant performance. We then present our conceptual research framework and research hypotheses, followed by a description of our research data and design. Next, we describe our statistical estimation results, followed by a discussion of our results, contributions, and limitations. We summarize our findings and the implications of our study in the last section.

Background

The ABC literature defines an activity as a discrete task that a firm undertakes to make or deliver

[1] Implementation of ABC has been observed not only in manufacturing firms but also in service sector firms (Cooper & Kaplan, 1992).

a product/service, and uses cost drivers to assign activity costs to products, services or customers related to these activities (Cooper, 1988; Ittner et al., 2002). Traditional costing systems use bases like direct labor and machine hours to allocate expenses, associated with indirect and support activities, to products and services. On the other hand, ABC segregates the expenses of indirect and support resources by activities, and then assigns those expenses based on the drivers of these activities (Cooper & Kaplan, 1991). Hence, ABC provides plant mangers with a more structured approach to evaluate the expenses associated with specific activities used to support a product.

The body of prior research regarding the impact of ABC has produced mixed evidence. On one hand, proponents of ABC have argued that ABC helps to capture the economics of production processes more closely than traditional cost-based systems, and may provide more accurate costing data (Cooper & Kaplan, 1991; Ittner, 1999). Prior research suggests that implementation of ABC should lead to operational and strategic benefits within organizations (Anderson & Young, 1999; Cooper & Kaplan, 1991). Researchers have argued that operational benefits may emanate from improved visibility into the (a) economics of the production processes, and (b) causal cost drivers. Strategic benefits may arise from availability of better information for product development, sourcing, product mix and other strategic decisions (Anderson, 1995; Shields, 1995).

Researchers have claimed that, since ABC may provide greater visibility into business processes and their cost drivers, it may allow managers to eliminate costs related to non-value added activities and improve the efficiencies of existing processes (Carolfi, 1996). Improved information visibility may also enable the deployment of quality-related initiatives by identifying activities that are associated with poor product quality, and their cost drivers (Ittner, 1999; Cooper, Kaplan, Maisel, Morrissey, & Oehm, 1992). Hence, prior research suggests that ABC may be associated with adoption of process improvement activities, such as total quality management (TQM) programs (Ittner & Larcker, 1997a, 1997b; Anderson et al., 2002).

On the other hand, Datar and Gupta (1994) claimed that increasing the number of cost pools and improving the specification of cost bases may increase the frequency of errors in product cost measurement. Banker and Potter (1993) and Christensen and Demski (1997) suggest that the ability of ABC to produce accurate cost estimates depends on other factors, such as the competitiveness of markets and the quality of the organization's information technology infrastructure. Noreen (1991) suggests that ABC implementation may provide beneficial results only under specific conditions. Similarly, empirical studies that have examined the impact of ABC on firm performance have also produced mixed results (Ittner & Larcker, 2001; Gordon & Silvester, 1999). Many of these studies rely on manager's beliefs regarding the success of ABC implementation, but they do not indicate whether ABC adopters achieved higher levels of operational or financial performance compared to non-adopters (Shields, 1995; McGowan & Klammer, 1997; Foster & Swenson, 1997). Other studies have suggested that many ABC adopters have abandoned their implementations, raising concerns about the potential impact of ABC on performance (McGowan & Klammer, 1997).

In this study, we explore the relationships between ABC implementation and WCM practices, and their impact on plant performance. Unlike prior studies, which focus on measuring the direct impact of ABC on plant performance, our focus is directed at the role of ABC as an enabler of WCM practices which, in turn, have an impact on plant performance. In their study on relationships between incentive systems and JIT implementation, Fullerton and McWatters (2002, p. 711) note that the shift to world-class manufacturing strategies requires accompanying changes in firms' management accounting systems. They argue that by providing a better understanding of the inter-relationships between manufacturing processes, demand uncertainty and product complexity, ABC implementation allows plant managers to direct relevant process improvements which facilitate implementation of other WCM initiatives. Cooper and Kaplan (1991) also claim that ABC may help plant managers to develop a better understanding of the sources of cost variability, which allows them to manage resource demand and rationalize changes in product mix.

The arguments in support of ABC are based on the presumed comparative advantage that firms may derive from greater transparency and accuracy of information obtained from ABC (Cagowin & Bouwman, 2002). However, Kaplan (1993) and others have cautioned that not every ABC implementation will produce direct benefits. Indeed, the role of other facilitators and contextual factors, such as implementation of related organizational initiatives, has gained greater importance in this debate (Anderson et al., 2002; Henri, 2006). A fundamental motivation of our research is to better understand the overall impact of ABC on plant performance by studying its *indirect* impact on plant WCM capabilities. We argue that ABC implementation should impact plant performance only by supporting the implementation of advanced manufacturing capabilities, which provide managers with the flexibility to adapt to changing product and demand characteristics. Without such capabilities, ABC is unlikely to improve manufacturing performance by itself. Unlike previous studies that have studied the impact of ABC on firm-level performance, we observe that isolating the impact of ABC at the plant-level allows us to trace ABC's impact on specific plant performance measures, and overcomes the potential for confounding when multiple business processes are aggregated at the firm level. We discuss our conceptual framework and research hypotheses in the next section.

Conceptual research model

We posit that adoption of ABC by itself may not provide much direct value, but may facilitate the implementation of advanced manufacturing practices and other organizational capabilities which, in turn, may be associated with sustainable improvements in plant performance. Unlike previous research that has in the large part explored the direct impact of ABC, our research model allows for the possibility of plant performance improvements due to implementation of WCM practices that may be *enabled* by capabilities associated with the adoption of ABC systems.

WCM practices entail a broad range of manufacturing capabilities, which allow plant managers to adapt to the volatility and uncertainty associated with changes in customer demand and business cycles in agile manufacturing environments (Flynn, Schroeder, & Flynn, 1999; Sakakibara, Flynn, Schroeder, & Morris, 1997; Banker, Potter, & Schroeder, 1995). These practices include just-in-time manufacturing (JIT), continuous process improvement, total quality management (TQM), competitive benchmarking, and worker autonomy through the use of self-directed work teams. Advanced manufacturing practices provide the capabilities necessary to react to rapid changes in lot sizes and setup times, as the manufacturing focus shifts to flexible and agile processes that are characterized by quick changeover techniques to handle production of low volume orders with high product variety (Kaplan, 1983; Flynn et al., 1999).

Traditional costing systems, which are based on assumptions of long production runs of a standard product with static specifications, are not relevant in such dynamically changing environments. However, proponents have argued that ABC may provide more accurate information on the activities and transactions that impact product costs in manufacturing environments characterized by production of smaller lot sizes, high broad mix, and frequent changeovers (Krumwiede, 1998). By providing timely information about the costs of resources, especially when production runs are shorter or the production method changes, ABC implementation may provide the process infrastructure necessary to support managerial decision-making capabilities in fast-paced manufacturing processes (Kaplan, 1983).

Hence, we study the impact of ABC on its ability to support implementation of WCM capabilities, and examine its indirect impact on plant performance through its enablement of such capabilities. Our conceptual research model describing the relationship between ABC, manufacturing capabilities and plant performance is shown in Fig. 1. The model comprises of two stages. The first stage describes how ABC may facilitate implementation of world-class manufacturing practices.

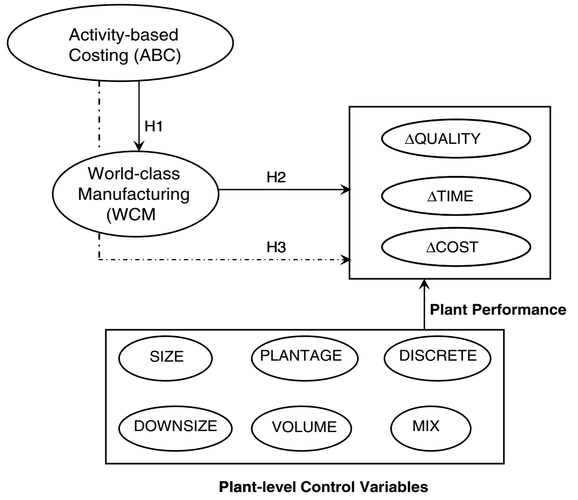

Fig. 1. Conceptual research model. *Note*: Plant performance is represented using three separate dependent variables that are grouped together in the figure for ease of representation. Our regression models are estimated using each performance variable as a dependent variable in a separate multivariate regression.

The second stage describes the impact of advanced manufacturing capabilities, as embodied by WCM, on plant performance. The key difference between our research model and that of prior studies is our focus on the relationship between ABC and WCM, and the role of manufacturing capabilities as a *mediator* of the impact of ABC on plant performance, as represented by the dotted arrow in Fig. 1.

Impact of activity-based costing on world-class manufacturing

In his early work on the challenges of implementing new types of management accounting models to measure manufacturing performance, Kaplan (1983, p. 702) noted that "...accounting systems must be tightly integrated with plant production planning and scheduling systems so that production managers are rewarded for efficient utilization of bottleneck resources and reduced inventory levels throughout the plant...". Prior research has suggested that ABC is more beneficial when it supports the implementation of advanced manufacturing practices (Shields & Young, 1989; Kaplan, 1992; Cooper, 1994). For example, Anderson and Young (1999) reviewed several ABC studies that reported positive relations between the success of ABC adoption and implementation of various advanced manufacturing practices. They argue that ABC facilitates more accurate identification and measurement of the cost drivers associated with value added and non-value added manufacturing activities, which makes it easier to develop better cost control and resource allocation capabilities – necessary prerequisites for successful implementation of world-class manufacturing.

In world-class manufacturing environments, the accounting systems, compensation, incentive structure, and performance measurement practices are different from those that are used in traditional manufacturing (Miltenburg, 1995; Milgrom & Roberts, 1995). For example, traditional manufacturing processes entail the use of performance measures that track unit manufacturing costs related to (a) equipment utilization, (b) ratios of direct and indirect labor to volume, (c) number of set-ups, and (d) number of orders. On the other hand, performance measures relevant to WCM implementation track (a) actual cost and quality, (b) cycle time reduction, (c) delivery time and on-time delivery rate, and (d) actual production as a percentage of planned production (Miltenburg, 1995, p. 336). By enabling the measurement of costs related to specific activities, products, and customers, ABC may provide more accurate identification and measurement of new types of performance measures that are a critical component of successful WCM implementations (Argyris & Kaplan, 1994; Krumwiede, 1998).

Proponents claim that ABC may support the implementation of WCM capabilities in several ways. First, by allowing plant managers to track costs accurately and enabling identification of redundant resources, ABC may support implementation of TQM and other quality/process improvement programs.[2] Second, ABC may support process-related investments in cycle time

[2] See Ittner (1999) for an example of the benefits of activity-based costing for quality improvement at a telecommunications firm.

reduction by facilitating the timely identification of non-value-added activities (Kaplan, 1992). Third, ABC may allow plant managers to make better resource allocation decisions by focusing the product line and accurately anticipating the effect of changes in the product mix on the profitability of manufacturing operations. Hence, they argue that ABC implementation may provide the process discipline necessary to analyze activities, gather and trace costs to activities, and establish relevant output measures–capabilities that are useful in flexible manufacturing environments (Cooper & Kaplan, 1991, 1999).

Implementation of ABC may be associated with greater use of self-directed teams and worker autonomy, which are also important capabilities of WCM (Anderson & Young, 1999). Similarly, "best practices" data on cost pools, activity centers, and cost drivers can be incorporated into the design and use of ABC systems which may improve plant managers' abilities to make better strategic product decisions, and thereby support implementation of WCM programs (Elnathan, Lin, & Young, 1996; Atkinson, Banker, Kaplan, & Young, 2001). Therefore, we posit that ABC facilitates successful implementation of WCM capabilities. In contrast to Ittner et al. (2002), who treat advanced manufacturing practices as causal variables in explaining adoption of ABC, we posit that ABC supports implementation of WCM practices, which in turn, may improve plant performance. Accordingly,

Hypothesis H1: Plants which implement ABC are more likely to implement world-class manufacturing practices.

Impact of world-class manufacturing on plant performance

Implementation of WCM practices can enable plants to react quickly to changes in customer demand, and thereby carry lower levels of inventory, improve cost efficiencies, increase the flexibility of production facilities through use of planning and scheduling software, and improve overall plant productivity (Banker, Bardhan, Chang, & Lin, 2006). Investments in JIT and flexible manufacturing practices help to reduce setup times that permit shorter production runs, thereby allowing for more efficient inventory control, as well as lower product defect rates (Kaplan, 1983; Hendricks & Singhal, 1997; Sakakibara et al., 1997).

Techniques that are commonly deployed, within the scope of JIT implementations, include pull/Kanban systems, lot-size reductions, cycle-time reductions, quick changeover techniques, and bottleneck removal practices. Research on the performance impact of JIT has been extensively documented in the literature (Sakakibara et al., 1997; Hendricks & Singhal, 1997). Reported benefits range from reduced work in progress and finished goods, to better quality and higher firm productivity. Based on prior empirical evidence, researchers have found that firms which adopted JIT production are better aligned to customer needs, have shorter lead times, and faster time to market (Srinivasan, Kekre, & Mukhopadhyay, 1994).

Implementation of WCM practices also entails adoption of other process improvement practices, such as total quality management (TQM) and continuous process improvement programs (Fullerton & McWatters, 2002). The fundamental elements of process improvement programs consist of competitive benchmarking, statistical process control, and employee empowerment (Schroeder & Flynn, 2001). Such process improvement practices, stemming from greater attention to product quality and time to market issues may enable manufacturing plants to develop advanced manufacturing capabilities. Based on firm-level data, researchers have found that implementation of TQM and other advanced manufacturing practices have a positive impact on firm performance, through realization of lower product cost, higher quality, and better on-time delivery performance (Banker, Field, & Sinha, 2001; Banker et al., 1995; Hendricks & Singhal, 1997; Ittner & Larcker, 1995, 1997a).

Hence, we posit that implementation of WCM practices in manufacturing plants may be positively related to improvements in plant-level performance as defined by plant cost, quality and time-to-market measures. Therefore, we hypothesize that

Hypothesis H2: Plants that have implemented WCM practices are more likely to be associated with significant improvements in plant performance.

H2a: Plants which implement WCM practices are more likely to realize improvements in plant manufacturing costs.

H2b: Plants with WCM practices are more likely to realize improvements in plant quality.

H2c: Plants with WCM practices are more likely to realize improvements in time to market.

Impact of ABC on plant performance: a mediation mechanism

Proponents have argued that, by enabling easier identification of non-value added activities and simplification of cost measurements, ABC enables implementation of advanced manufacturing practices, especially in processes that are characterized by quick changeovers and a range of support activities.[3] Documenting and understanding activities is a necessary prerequisite to improving business processes, since activities are the building blocks of business processes. If ABC adoption results in more accurate costing then plant performance may improve because of greater ability to implement process improvement initiatives, facilitating the simplification of business processes by removing non-value added activities.

Successful implementation of WCM practices requires the development of business process models to identify and eliminate non-value added activities. In this respect, ABC implementation entails *a priori* development of such process models to identify and analyze activities, trace costs to activities, and analyze activity-based costs. Similarly, plant managers can use information gathered through ABC analyses to conduct a Pareto analyses of the major cost drivers, an important ingredient in most TQM and competitive benchmarking initiatives. Scenario analysis related to pricing, product mix, and profitability is also possible, which are useful in the deployment of JIT capabilities. Hence, successful WCM implementations may leverage the streamlining of business processes due to ABC adoption.

ABC analyses allow plants to develop activity-based management (ABM) business models which managers may adopt to improve their organizational effectiveness (Chenhall & Langfield-Smith, 1998). In addition, ABC implementation may be correlated with and hence serve as a surrogate for unobservable factors, such as management leadership and worker training, that are important components of successful WCM implementation. Hence, implementation of WCM may allow plants to leverage the capabilities offered by ABC (i.e. accurate cost allocations and management support) into improvements in plant performance. Our approach differs from the prior literature which has primarily studied the direct impact of ABC on plant performance (Ittner et al., 2002). Instead, we argue that it is important to view the role of ABC as a *potential enabler* of manufacturing capabilities, and study its indirect impact on plant performance as completely mediated by WCM. This perspective argues that ABC may support improvements in manufacturing capabilities which are, in turn, associated with improvements in plant performance (Henri, 2006).

Hypothesis H3: The positive association between ABC implementation and plant performance is mediated through implementation of world-class manufacturing practices.

An alternative perspective, with respect to the role of ABC, is that the interaction between WCM capabilities and ABC implementation may jointly determine plant performance. The *interaction* perspective argues that advanced manufacturing capabilities, when combined with deployment of ABC methods, create complementarities that explain variations in plant performance (Cagowin & Bouwman, 2002). In other words, WCM and ABC may each have a direct effect on performance, but would add more value when used in combination (i.e., the presence of WCM will increase the

[3] Low volume production creates more transactions per unit manufactured than high volume production (Cooper & Kaplan, 1988).

strength of the relationship between ABC and performance). In this framework, the interaction effects of ABC and WCM need to be estimated to study the overall impact of ABC on plant performance. We explore the interaction perspective further when we discuss our estimation results.

Fig. 1 represents the conceptual research model that describes our hypothesized relationship between ABC and implementation of WCM practices, and the role of WCM as a *mediator* of the impact of ABC on plant performance.

Research design

We now describe the characteristics of the data collected and approach for measuring the variables of interest in our study.

Data collection

Data for this research was drawn from a survey of manufacturing plants across the US, conducted in the year 1999 by *IndustryWeek* and *PricewaterhouseCoopers Consulting*. The survey consisted of a questionnaire which was mailed to plants with two-digit standard industrial classification (SIC) codes from 20 to 39, and that employed a minimum of 100 people. Data were collected on a range of manufacturing, management and accounting practices used within each plant. We have described the questions relevant to our research model in Appendix.

The survey was mailed to approximately 27,000 plant managers and controllers from *IndustryWeek's* database of manufacturing plants. Plant managers provided data on the extent of implementation of ABC and a broad range of advanced manufacturing practices and plant characteristics. Data on plant performance measures were based on assessments of plant records by plant controllers.[4] A total of 1757 plants responded to the questionnaire for an overall response rate of 6.5%. The usable sample contains 1250 plants that provided complete responses to the variables of interest in our model.[5]

We present the distribution of the manufacturing plants in our sample by industry in Table 1, and compare it to the distribution of manufacturers, reported in the Statistical Abstract of the United States and published by the US Census Bureau (2000). Since we obtained the data from a secondary data source, we did not have information with respect to the profiles of non-respondent plants. To evaluate the generalizibility of our findings, we compared the average plant productivity per employee of our sample plants to the average productivity of all US manufacturing plants, as reported by the US Census Bureau (2000). The average plant productivity per employee of our sample was $221,698, while the average productivity in the US Census data was reported to be $225,440. The difference in average plant productivity was not statistically significant (t-statistic = 0.37; p-value = 0.35).

Measurement of variables

The ABC adoption variable was defined based on the response to the survey question asking whether ABC was implemented at the plant (0 = not implemented, 1 = plan to implement, 2 = extensively implemented). For the purpose of our study, we collapsed the first two categories into one category, which represents plants that have not implemented ABC at the time of the survey. Hence, we measure ABC as a 0–1 dummy variable where zero represents "no implementation" and one represents "extensive implementation". The number of plants that have adopted ABC extensively in our sample is 248, an adoption rate of 19.8%.

We have three dependent variables in our research model. The variable ΔCOST denotes the change in unit manufacturing costs in the last five years. ΔQUALITY denotes the change in plant first-pass quality yield in the last five years. ΔTIME

[4] Since data on the independent and dependent variables was provided by different sources, this mitigates the concerns associated with common methods bias.

[5] While the net usable response rate of 4.6% is small, it is comparable to large plant operations surveys as reported in Stock, Greis, and Kasarda (2000) and Roth and van der Velde (1991).

Table 1
Distribution of sample plants by industry

Industry sector	SIC code	Number of plants in sample	Percent of sample	Percent of US manufacturers[a]	% ABC Adopters in sample[b]
Non-durable manufacturing					
Food and kindred products	20	47	3.76%	5.76%	12.76%
Tobacco products	21	1	0.08	0.03	100
Textile mill products	22	23	1.84	1.70	21.74
Apparel and other textile products	23	13	1.04	6.45	38.46
Lumber and wood products	24	25	2.00	10.13	16.00
Furniture and fixtures	25	43	3.44	3.33	27.91
Paper and allied products	26	56	4.48	1.79	28.57
Printing and publishing	27	19	1.52	17.19	26.32
Chemicals and allied products	28	86	6.88	3.41	26.74
Petroleum and coal products	29	5	0.40	0.59	40.00
Durable manufacturing					
Rubber and plastics products	30	74	5.92	0.52	13.51
Leather and leather products	31	5	0.40	0.51	40.00
Stone, clay and glass products	32	39	3.12	4.52	20.51
Primary metal industries	33	67	5.36	1.73	16.42
Fabricated metal products	34	153	12.24	10.47	16.99
Industrial machinery and equipment	35	225	18.00	15.54	13.03
Electronics and electrical equipment	36	168	13.44	4.71	19.05
Transportation equipment	37	103	8.24	3.41	26.21
Instruments and related products	38	76	6.08	3.23	17.11
Miscellaneous manufacturing	39	22	1.76	4.97	31.82
Total		1250	100%	100%	

[a] *Source*: US Census Bureau (2000).
[b] The percentage equals the number of ABC adopters divided by the number of plants in the 2-digit SIC group.

represents a factor comprising of the change in manufacturing cycle time and the change in lead time during the last five years, and thus is indicative of the "time to market" for each plant. The measurement scale of the plant performance variables was ordered in manner such that higher values represent improvements in performance over time.[6]

WCM represents a composite factor that consists of six types of advanced manufacturing practices, as described in the survey questionnaire. The six indicators were measured using a 0–1 scale, where zero represents "no or some implementation", and one indicates "extensive implementation". Next, we constructed WCM as a six-item *summative index* that represents the degree of implementation of the six types of advanced manufacturing capabilities.[7] This index measures both the range and depth of manufacturing capabilities in each plant. Hence, for each plant, WCM consists of seven levels and can take any value between zero and six (since the six indicators are measured as 0–1 variables). Our approach for constructing this *summative measure* of manufacturing capability is consistent with similar approaches in the literature (Krumwiede, 1998; Loh & Venkatraman, 1995) that use a summative index when an increase in any of the indicators is associated with a corresponding increase in the construct of interest.

[6] A value of ΔQUALITY = 1 indicates that first-pass quality yield "declined more than 20%", while ΔQUALITY = 5 indicates that quality yield "improved more than 20%". On the other hand, ΔCOST = 1 indicates that unit manufacturing costs "increased more than 20%", while ΔCOST = 7 suggests that costs "decreased more than 20%".

[7] We note that exploratory factor analyses (EFA) suggests that the six items load on a single factor (with Eigen value = 2.13) which accounts for 36% of variance in the data. Furthermore, the EFA provides support for the validity and unidimensionality of the WCM factor.

We include additional variables to control for the impact of plant characteristics on manufacturing capabilities and plant performance. There are six control variables in our model, which include plant size (SIZE) measured in terms of number of employees, plant age in years (PLANTAGE), nature of manufacturing operations (DISCRETE), degree of product mix (MIX), product volume (VOLUME), and the extent of downsizing in the last five years (DOWNSIZE). Larger plants are more likely to have the scale and financial resources required to justify adoption of advanced manufacturing practices and activity-based costing programs. SIZE is likely to impact plant performance since smaller plants are likely to be more agile in responding to customer needs compared to larger plants *ceteris paribus* (Hendricks & Singhal, 1997). Plant AGE is also likely to play a significant role since older plants are less likely to adopt advanced manufacturing practices and often fail to realize the impact of technology-enabled processes on plant performance.

Product MIX is defined as the mix of products produced and is measured as a binary variable based on low or high product diversity. Plants with high product diversity are more likely to implement ABC (Cooper, 1989) as it may provide more accurate estimates of overhead usage. DISCRETE represents a binary variable with a value of one if the nature of manufacturing for primary products is discrete manufacturing, and zero for process or hybrid manufacturing. Descriptive statistics of our model variables are provided in Table 2.

Estimation results

First, we estimate the impact of ABC on the implementation of WCM using an *ordered logit regression* model, where the dependent variable represents an ordered choice variable of *seven* possible states of WCM implementation: WCM = 0 (no or some implementation on all six indicators) and WCM = 6 (extensive implementation on all six indicators).

Our methodology is consistent with Krumwiede's (1998) approach to evaluate the antecedents of different stages of ABC implementation in

Table 2
Descriptive statistics and correlations of model variables ($N = 1250$)

	ABC	WCM	DISCRETE	DOWNSIZE	SIZE	PLANTAGE	VOLUME	MIX	ΔCOST	ΔQUALITY	ΔTIME
ABC	1.00	0.11 (0.00)	−0.03 (0.22)	0.02 (0.45)	0.05 (0.09)	0.02 (0.47)	0.02 (0.46)	0.01 (0.81)	0.06 (0.04)	0.01 (0.72)	0.05 (0.07)
WCM	0.12 (0.00)	1.00	−0.03 (0.34)	0.04 (0.20)	0.21 (0.00)	−0.01 (0.69)	0.08 (0.01)	0.04 (0.18)	0.21 (0.00)	0.24 (0.00)	0.31 (0.00)
DISCRETE	−0.03 (0.22)	−0.01 (0.70)	1.00	−0.08 (0.00)	0.03 (0.30)	−0.07 (0.01)	−0.18 (0.00)	0.04 (0.15)	−0.00 (0.96)	0.01 (0.76)	0.08 (0.01)
DOWNSIZE	0.02 (0.40)	0.03 (0.35)	−0.09 (0.00)	1.00	0.03 (0.22)	0.10 (0.00)	−0.02 (0.42)	0.01 (0.66)	0.06 (0.04)	0.01 (0.79)	−0.03 (0.27)
SIZE	0.05 (0.06)	0.22 (0.00)	0.03 (0.33)	0.03 (0.29)	1.00	0.08 (0.00)	0.19 (0.00)	0.04 (0.15)	−0.03 (0.29)	0.01 (0.68)	0.08 (0.01)
PLANTAGE	0.01 (0.86)	−0.03 (0.24)	−0.06 (0.02)	0.10 (0.00)	0.06 (0.04)	1.00	−0.07 (0.01)	0.09 (0.00)	−0.13 (0.00)	−0.05 (0.05)	−0.02 (0.41)
VOLUME	0.02 (0.46)	0.09 (0.00)	−0.18 (0.00)	−0.02 (0.38)	0.20 (0.00)	−0.07 (0.01)	1.00	−0.22 (0.00)	0.08 (0.00)	0.02 (0.40)	−0.00 (0.87)
MIX	0.01 (0.81)	0.03 (0.22)	0.04 (0.15)	0.01 (0.60)	0.04 (0.17)	0.06 (0.02)	−0.22 (0.00)	1.00	−0.01 (0.60)	−0.01 (0.60)	0.06 (0.02)
ΔCOST	0.06 (0.03)	0.23 (0.00)	−0.00 (0.90)	0.06 (0.04)	−0.02 (0.53)	−0.12 (0.00)	0.08 (0.00)	−0.02 (0.510)	1.00	0.18 (0.00)	0.29 (0.00)
ΔQUALITY	0.01 (0.59)	0.25 (0.00)	0.01 (0.74)	0.01 (0.64)	0.03 (0.35)	−0.04 (0.12)	0.02 (0.52)	−0.01 (0.78)	0.18 (0.00)	1.00	0.26 (0.00)
ΔTIME	0.06 (0.04)	0.31 (0.00)	0.08 (0.00)	−0.03 (0.28)	0.07 (0.01)	−0.29 (0.30)	−0.02 (0.54)	0.07 (0.02)	0.29 (0.00)	0.26 (0.00)	1.00
Minimum	0.00	0.00	0.00	1.00	1.00	1.00	0.00	0.00	1.00	1.00	1.00
Maximum	1.00	6.00	1.00	3.00	5.00	4.00	1.00	1.00	7.00	6.00	6.00
Mean	0.19	4.00	0.59	1.75	2.73	3.57	0.54	0.75	4.53	3.14	3.30
Median	0.00	4.00	1.00	2.00	2.00	4.00	1.00	1.00	5.00	3.00	3.50
Std. Dev.	0.39	1.61	0.49	0.76	1.08	0.78	0.50	0.43	1.46	0.90	0.86

p-Values are shown in parentheses. Spearman correlation coefficients are in the top triangle and Pearson coefficients are in the bottom triangle.

manufacturing firms. Tests for multicollinearity (Belsley, Kuh, & Welsch, 1980) indicated no evidence of multicollinearity in our data (BKW index = 1.06, variance inflation factor = 1.15). Our ordered logit regression results are presented in Table 3.

The "logit coefficient" column reports the results of an ordered logit test for the seven states of WCM. The logit results indicate that our model has significant explanatory power (Chi-square = 82.67; pseudo $R^2 = 0.07$). The ordered logit coefficients indicate that adoption of ABC has a positive impact on WCM implementation (coefficient value = 0.499; $\chi^2 = 15.15$; p-value < 0.0001). Hence, our results support hypothesis H1, and suggest that plants that implement ABC are more likely to implement WCM practices. The ordered logit results also indicate that plant SIZE and product VOLUME have a positive impact on the extent of WCM implementation. Larger plants may be more likely to implement WCM capabilities due to availability of greater plant resources, and plants with high VOLUME may be more likely to implement WCM to deal with the complexity involved in managing high volume production.

The mediating role of WCM

Next, we estimate the impact of ABC and WCM on the three measures of plant performance, ΔCOST, ΔQUALITY, and ΔTIME, using ordinary least squares (OLS) regressions. For each dependent variable, we estimate the relationships between ABC, WCM and plant performance as specified by the following system of equations:

$$\Delta\text{PERFORMANCE} = \alpha_0 + \alpha_1 * \text{ABC} + \alpha_2 * \text{DOWNSIZE} + \alpha_3 * \text{SIZE} + \alpha_4 * \text{PLANTAGE} + \alpha_5 * \text{DISCRETE} + \alpha_6 * \text{VOLUME} + \alpha_7 * \text{MIX} + \varepsilon_1 \quad (1)$$

$$\Delta\text{PERFORMANCE} = \beta_0 + \beta_1 * \text{WCM} + \beta_2 * \text{DOWNSIZE} + \beta_3 * \text{SIZE} + \beta_4 * \text{PLANTAGE} + \beta_5 * \text{DISCRETE} + \beta_6 * \text{VOLUME} + \beta_7 * \text{MIX} + \varepsilon_2 \quad (2)$$

$$\Delta\text{PERFORMANCE} = \delta_0 + \delta_1 * \text{WCM} + \delta_2 * \text{ABC} + \delta_3 * \text{DOWNSIZE} + \delta_4 * \text{SIZE} + \delta_5 * \text{PLANTAGE} + \delta_6 * \text{DISCRETE} + \delta_7 * \text{VOLUME} + \delta_8 * \text{MIX} + \varepsilon_3 \quad (3)$$

In order to test our proposed model, we follow the approach prescribed by Baron and Kenny (1986). Eq. (1) estimates the direct impact of ABC on plant performance. Eq. (2) estimates the marginal impact of the mediating variable, WCM, on plant performance. Eqs. (1) and (2) represent non-nested model specifications which estimate the independent impact of ABC and WCM, respectively, on plant performance. Finally, both predictor variables, ABC and WCM, are included in a single regression model specified in Eq. (3). We observe that Eq. (2) represents a *complete* mediation model, whereas Eq. (3) represents a *partial* mediation model where the impact of ABC is partially mediated through WCM. The dependent variable, ΔPERFORMANCE, represents the respective change (Δ) in the three performance measures: COST, QUALITY, and TIME. The system of equations estimated separately for each performance measure.

We report OLS regression results in Table 4.[8] The estimated coefficients in the three columns of each panel in Table 4 correspond to the regression models specified in Eqs. (1)–(3). First, we estimate the *direct* impact of ABC on plant performance in the absence of the WCM variable. Estimated regression coefficients for Eq. (1) are shown in columns (1), (4) and (7) of Table 4 (i.e., first column of each panel). The regression coefficient of ABC is statistically significant for ΔCOST and ΔTIME ($p < 0.10$), and it appears that ABC has a positive impact on improvements in plant costs and time to market.[9] ABC does not have significant explanatory power in the ΔQUALITY regression model as indicated by low R^2 values.

[8] We also used ordered logit regressions to estimate the system of equations in (1). The ordered logit results are consistent with our OLS estimation results.

[9] The adjusted R^2 for these models was low (between 1.38% and 2.75%) and our analysis of the F-statistics indicates that only the ΔCOST regression model was significant at $p < 0.05$. We have not included these results in our tables due to space limitations.

Table 3
Factors influencing WCM implementation: ordered logit regression

Variable	Logit coefficient	Chi-square
ABC	0.50	15.15***
DOWNSIZE	0.05	0.56
SIZE	0.34	48.56***
PLANTAGE	−0.08	1.73
DISCRETE	−0.02	0.02
VOLUME	0.212	4.04**
MIX	0.19	2.56
Pseudo-R^2 (%)	0.07	
Chi-square	82.67*** (p-value < 0.001)	
N	1250	

***, **, * Indicates significance at the 1%, 5%, and 10% (one-sided) level, respectively.

Variable definition

ABC = 1 if implemented *extensively*, zero if there is no ABC implementation in the plant.

WCM = Six-item summative index that measures the degree of implementation of six types of manufacturing practices: JIT, TQM, Kanban, continuous process improvement, competitive benchmarking, self-direct teams. WCM can take any value between zero and six.

For each manufacturing practice, 0 = no or some implementation, 1 = extensive implementation

Δ(QUALITY): Change in first-pass quality yield of finished products over the last five years:
1 = Declined more than 20%, 2 = declined 1–20%, 3 = no change, 4 = improved 1–20%, 5 = improved more than 20%.

Δ(COST): Change in unit manufacturing costs, excluding purchased materials, over the last five years:
1 = Increased more than 20%, 2 = increased 11–20%, 3 = increased 1–10%, 4 = no change, 5 = decreased 1–10%, 6 = decreased 11–20%, 7 = decreased more than 20%.

Δ(TIME): Factor comprised of the 5-year change in manufacturing *cycle time* and plant *lead time*:
Δ(Cycle time): Change in manufacturing cycle time over the last five years:
1 = No reduction, 2 = decreased 1–10%, 3 = decreased 11–20%, 4 = decreased 21–50%, 5 = decreased more than 50%.
Δ(Lead time): Change in customer lead time over the last five years:
1 = Increased more than 20%, 2 = increased 1–20%, 3 = no change, 4 = decreased, 1–20%, 5 = decreased more than 20%.

DISCRETE = 1 if nature of manufacturing operations for primary products is discrete; else zero.

DOWNSIZE: Extent of plant-level downsizing in the past five years.
1 = No change, 2 = extent of downsizing increased 1–10%, 3 = extent of downsizing increased 11–20%, 4 = extent of downsizing increased 21–50%, 5 = increased 51–75%, and 6 = increased more than 75%.

SIZE: Number of employees at the plant location.
1 = Less than 100; 2 = 100–249; 3 = 250–499; 4 = 500–999; 5 = greater than 1000 employees.

PLANTAGE: Number of years since plant start-up.
1 = Less than 5 years; 2 = 5–10 years; 3 = 11–20 years; 4 = more than 20 years.

VOLUME = 1 if plant exhibits high volume production, and zero otherwise.

MIX = 1 if plant exhibits high product mix, and zero otherwise.

Next, estimated regression coefficients for Eq. (2) are shown in columns (2), (5) and (8) of Table 4. The regression results indicate that the impact of WCM on all plant performance measures is positive and significant at $p < 0.01$. In other words, implementation of advanced manufacturing capabilities is associated with improvements in plant costs ($\beta_1 = 0.20$, $p < 0.01$), quality ($\beta_1 = 0.14$, $p < 0.01$), and time to market ($\beta_1 = 0.16$, $p < 0.01$). Hence, our results support hypothesis H2 with respect to the association between WCM implementation and performance.

Finally, we estimate the *full* model in Eq. (3) that includes the direct impact of WCM on plant performance and an additional direct path from ABC to the dependent variable. The full model results, as reported in columns (3), (6), and (9) of Table 4, indicate that ABC does *not* have a direct, significant impact on any of the three measures of plant performance. When the impact of the WCM

Table 4
Impact of WCM and ABC on plant performance

	Panel A ΔCOST			Panel B ΔQUALITY			Panel C ΔTIME		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	5.05 (20.50)***	4.46 (17.58)***	4.46 (17.56)***	3.28 (21.36)***	2.85 (18.19)***	2.86 (18.19)***	3.11 (21.30)***	2.61 (17.80)***	2.61 (17.78)***
WCM	–	0.20 (7.79)***	0.19 (7.62)***	–	0.14 (8.78)***	0.14 (8.78)***	–	0.16 (11.15)***	0.16 (11.02)***
ABC	0.22 (2.13)**	–	0.14 (1.43)	0.024 (0.37)	–	−0.03 (−0.47)	0.11 (1.82)*	–	0.05 (0.83)
DOWNSIZE	0.142 (2.63)**	0.13 (2.47)**	0.13 (2.46)**	0.016 (0.48)	0.016 (0.48)	0.01 (0.23)	−0.03 (−0.96)	−0.04 (−1.32)	−0.04 (−1.33)
SIZE	0.06 (−1.48)	−0.11 (−2.89)***	−0.11 (−2.93)***	0.009 (0.40)	−0.03 (−1.28)	−0.03 (−1.27)	0.06 (2.53)**	0.01 (0.53)	0.01 (0.51)
PLANTAGE	−0.24 (−4.54)***	−0.23 (−4.36)***	−0.23 (−4.38)***	−0.062 (−1.89)*	−0.06 (−1.89)*	−0.05 (−1.64)*	−0.03 (−0.98)	−0.02 (−0.64)	−0.02 (−0.65)
DISCRETE	0.04 (0.48)	0.05 (0.61)	0.05 (0.65)	0.017 (0.33)	0.03 (0.54)	0.03 (0.53)	0.12 (2.47)**	0.14 (2.80)***	0.14 (2.83)***
VOLUME	0.25 (2.84)***	0.22 (2.52)**	0.22 (2.52)**	0.03 (0.59)	0.01 (0.17)	0.01 (0.17)	0.006 (0.12)	−0.02 (−0.42)	−0.02 (−0.42)
MIX	0.05 (0.53)	0.02 (0.21)	0.02 (0.20)	−0.015 (−0.24)	−0.04 (−0.64)	−0.04 (−0.64)	0.12 (2.11)**	0.09 (1.72)*	0.09 (1.72)*
N	1250	1250	1250	1250	1250	1250	1250	1250	1250
Adjusted R^2	0.027	0.068	0.069	0.002	0.056	0.056	0.014	0.101	0.102
F Value	5.93***	14.19***	12.68***	0.70	11.74***	10.29***	3.49**	21.07***	18.52***

t-Statistics are shown in parentheses. ***,**,* Indicates significance at the 1%, 5%, and 10% level, respectively.
Note: Plant performance is represented using three separate dependent variables. We estimated the *three* regression models as separate multivariate regressions.

variable is included in the model, ABC adoption is not associated with any improvement in plant costs ($\delta_2 = 0.14$, t-stat $= 1.43$), quality ($\delta_2 = -0.03$, t-stat $= -0.47$), or time to market ($\delta_2 = 0.05$, t-stat $= 0.83$). In contrast, WCM continues to have a significant positive impact on all plant performance measures, and the magnitude of the WCM coefficient is very similar to its estimate in Eq. (2).

The adjusted R^2 values for the complete mediation models are not significantly different from the R^2 values of their corresponding full (i.e., partial mediation) models. For instance, adding the ABC variable in column (3) results in an increase of 0.1% (=0.001) in the ΔCOST model's explanatory power, compared to its corresponding R^2 shown in column (2). Similarly, introducing ABC in the ΔQUALITY and ΔTIME models, results in statistically *insignificant* increases in model R^2 of 0.0% and 0.1%, respectively. Hence, our results support hypothesis H3, indicating that WCM *completely mediates* the impact of ABC on plant performance.

We also test an alternative specification based on a perspective that the interaction between ABC and WCM implementation may have an impact on plant performance. The interaction model (Luft & Shields, 2003) is specified as

$$\begin{aligned}\Delta\text{PERFORMANCE} &= \gamma_0 + \gamma_1 * \text{WCM} + \gamma_2 * \text{ABC} + \gamma_3 * \text{ABC} * \text{WCM} \\ &\quad + \gamma_4 * \text{DOWNSIZE} + \gamma_5 * \text{SIZE} + \gamma_6 * \text{PLANTAGE} \\ &\quad + \gamma_7 * \text{DISCRETE} + \gamma_8 * \text{VOLUME} \\ &\quad + \gamma_9 * \text{MIX} + \varepsilon_4 \qquad (4)\end{aligned}$$

The results indicate that the interaction term (i.e., ABC ∗ WCM) is not statistically significant for any of the plant performance measures. The estimated magnitude of the coefficient of the interaction term (i.e., γ_3) was −0.04 (p-value = 0.48), −0.02 (p-value = 0.57), and −0.03 (p-value = 0.39) for the ΔCOST, ΔQUALITY, and ΔTIME models respectively. These results indicate that the interaction model is *not supported* by empirical evidence based on analyses of the impact of ABC on operational measures of plant performance. On the other hand, the complete mediation model provides a better explanation of variations in plant performance.

Comparison of two non-nested models

We compared the R^2 values associated with the ABC and WCM models in Table 4, and observe that WCM provides greater explanatory power of the variance in plant performance measures. In order to discriminate between these two competing specifications (i.e., ABC → Performance versus WCM → Performance), we evaluate them as non-nested models using Vuong's (1989) likelihood ratio test for model selection that does not assume under the null that either model is true (Dechow, 1994). It allows us to determine which independent variable (ABC or WCM) has relatively more explanatory power, and represents a more powerful alternative since it can reject one hypothesis in favor of an alternative.

We report the results of Vuong's test on non-nested models in Table 5. We conduct the Vuong's test for each pair of competing non-nested model specifications in Panels A, B, and C, of Table 4. Comparing the models in Eqs. (1) and (2) for the performance variable ΔCOST, we find that Vuong's z-statistic of 4.72 is significant at $p < 0.01$, which indicates that the WCM model in Eq. (2) provides greater explanatory power of the variance in ΔCOST, compared to the ABC model in Eq. (1). Similarly, Vuong's z-statistic scores of 6.91 and 7.45 are statistically significant (at $p < 0.01$) for the ΔQUALITY and ΔTIME models, respectively. Our results thus indicate that the direct role of ABC in explaining variations in plant performance is relatively small when compared to that of WCM.[10] Contrary to the findings reported in Ittner et al. (2002), our findings imply that the complete mediation model provides a superior specification to study the impact of ABC on plant performance.

Table 5
Results of likelihood ratio tests for non-nested model selection ($N = 1250$)

	Vuong's z-statistic	p-Value
ΔCOST: ABC vs. WCM	4.72***	0.00
ΔQUALITY: ABC vs. WCM	6.91***	0.00
ΔTIME: ABC vs. WCM	7.45***	0.00

A significant z-statistic indicates that ABC is rejected in favor of WCM as a better predictor of variance in plant performance.
*** Indicates significance at the 1% level.

Table 6
Overall impact of ABC on plant performance ($N = 1250$)

Mediated path	Estimated path coefficient
ABC → WCM → ΔCOST	0.08 (0.02)**
ABC → WCM → ΔQUALITY	0.05 (0.02)**
ABC → WCM → ΔTIME	0.06 (0.01)***

p-Values are shown in parentheses. ***, **, * Indicates significance at the 1%, 5%, and 10% level, respectively.

Estimating the overall impact of ABC

We next estimate the magnitude of the *overall* impact of ABC, based on the pathway that links ABC to ΔPERF through WCM, where ΔPERF represents the change (Δ) in COST, QUALITY, and TIME, respectively. We calculate the magnitude of the overall impact of ABC on ΔPERF as the cross-product of (a) the marginal impact of ABC on WCM, and (b) the marginal impact of WCM on ΔPERF. That is

$$\frac{\partial(\Delta \mathrm{PERF})}{\partial(\mathrm{ABC})} = \frac{\partial(\Delta \mathrm{PERF})}{\partial(\mathrm{WCM})} \times \frac{\partial(\mathrm{WCM})}{\partial(\mathrm{ABC})} \quad (5)$$

The path estimates for the plant performance measures are shown in Table 6. Our results indicate that the overall impact of ABC on ΔCOST is equal to 0.08 which is statistically significant at $p < 0.05$. Similarly, the overall impact of ABC

[10] We also estimated the model, shown in Fig. 1, using structural equation model (SEM) analyses. We then estimated a reverse causal model (i.e., WCM → ABC → Performance) to examine whether ABC is a better predictor of performance, compared to WCM. Our SEM fit statistics for the reverse model fall outside the acceptable range for good model fit. Consistent with the results reported above, and contrary to the findings reported in Ittner et al. (2002), this suggests that WCM has greater explanatory power than ABC to explain variations in plant performance.

on ΔQUALITY and ΔTIME are significant, and equal to 0.05 and 0.06, respectively.

Hence, our results support H3 and indicate that there exists an *indirect* relationship between ABC and plant performance, where WCM completely mediates the impact of ABC on performance. These results are consistent with our theoretical framework which suggests that, although ABC does *not* have a direct impact, it has a significant overall impact on performance.[11]

Discussion

We highlight the role played by WCM as a mediator of the impact of ABC on plant performance. We find that ABC has a significant overall impact on reduction in product time to market and unit manufacturing costs, and on improvement in quality. Our results are consistent with prior research which suggests that successful implementation of advanced manufacturing initiatives requires prior adoption of compatible management accounting systems (Milgrom & Roberts, 1995; Shields, 1995; Ittner & Larcker, 1995; Sim & Killough, 1998). Furthermore, our results indicate that WCM practices enable plants to leverage the capabilities offered by ABC implementation and to significantly improve plant performance.

Our study has several limitations. First, the survey instrument measures beliefs about changes in plant performance over a five-year period. These measures need to be validated through archival and field data collection in future research. Second, it is possible that ABC may have been in place beforehand or implemented sometime during the five-year period. The secondary nature of the data did not allow us to separate the implications of these possibilities. Future studies must be designed to gather more detailed data, about the timeline of ABC implementation to better understand its impact on plant performance especially since users may need training to adapt to new types of costing procedures. ABC implementation was measured as a 0–1 variable in our study. It is possible that using a more granular scale to measure the extent of ABC implementation, including the level of ABC integration and the time lag since ABC implementation, may provide greater insights on the relationship between ABC and plant performance.

Our focus on plants that employ a minimum of 100 employees limits the generalizability of our results to industries with relatively large or very small manufacturing plants. We also did not account for country or cultural differences in manufacturing characteristics since the scope of the survey was limited to US plants. Our findings must also be validated with additional data collected in industry-specific settings to examine the impact of industry characteristics and differences in manufacturing strategies. Future research may also include evaluation of other contextual factors that are associated with the success of ABC implementation, such as process infrastructure, and the extent of human resource support and outsourcing.

Our study enhances the quality of the extant body of knowledge on ABC effectiveness in several ways. First, our survey responses were data provided by plant managers who may represent a more objective and knowledgeable source of plant-wide operations compared to many previous studies, that relied on respondents (such as ABC project managers) with a personal stake in ABC success (Shields, 1995; Swenson, 1995). Second, ABC non-adopters were identified based on the responses provided by plant managers, unlike prior studies where non-adopters were identified based on the lack of public information on ABC implementation (Balakrishnan, Linsmeier, & Venkatachalam, 1996; Gordon & Silvester, 1999). Third, we treated the manufacturing plant (instead of the firm) as the unit of analysis, which allowed us to observe the impact of ABC implementation on changes in process-level performance metrics

[11] We also extended our research model to study the indirect impact of ABC on change in plant-level return on assets (ROA), a key financial performance measure. We found that ABC has a significant, positive impact on ΔROA which is mediated through its impact on WCM. Our ROA results are consistent with our results on the inter-relationships between ABC, WCM, and plant operational performance reported here.

and avoid the confounding potential when only firm-level financial measures are used.

Conclusion

In contrast to prior studies (Ittner et al., 2002) that have typically focused on the direct impact of ABC on plant performance, we study the role of world-class manufacturing practices in mediating the impact of ABC on plant performance. We draw on prior research on the relationship between management accounting systems and business processes to better understand how ABC may support implementation of WCM practices. Analyzing data from a large cross-sectional sample of US manufacturing plants, we find evidence supporting our model emphasizing the role of advanced manufacturing practices in improving plant performance.

Our findings emphasize the need for firms to strengthen their manufacturing capabilities when making an investment to implement ABC systems, as ABC is unlikely to result in improved manufacturing performance by itself. Our evidence also suggests that plants can reap significant benefits by combining ABC implementation with the deployment of advanced manufacturing practices. Using a conceptual lens that focuses on the indirect impact of ABC, the evidence supports our alternative theoretical perspective to prior research. We conceptualize ABC as only an enabler of world-class manufacturing practices, which in turn is associated with improvements in plant performance. Our "complete mediation" model stands in contrast with earlier models proposed by Ittner et al. (2002) who focus primarily on the direct impact of ABC on plant performance. The results indicate that our alternative conceptualization is superior in terms of its ability to explain variations in plant performance based on cross-sectional data of a large sample of plants that have implemented ABC. Furthermore, our proposed model may provide an avenue for future researchers using different methodologies to explain differences in performance improvements following ABC implementations. It may also explain the weak or ambiguous results in prior research on ABC impact because ABC adoption may not be a sufficient statistic for WCM.

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Appendix: Survey questions

I. Plant characteristics

Variable	Question
SIZE	How many employees are at this plant location? 1 = Less than 100; 2 = 100–249; 3 = 250–499; 4 = 500–999; 5 = >1000 employees
PLANTAGE	How many years has it been since plant start-up? 1 = Less than 5 years; 2 = 5–10 years; 3 = 11–20 years; 4 = >20 years
MIX, VOLUME[12]	How would you describe the primary product mix at this plant? 1 = High volume, high mix; 2 = High volume, low mix 3 = Low volume, high mix; 4 = Low volume, low mix
DISCRETE	What is the nature of manufacturing operations for primary products at this plant? 1 = Discrete; 0 = Otherwise (hybrid or process)
DOWNSIZE	What is the extent of downsizing at the plant in the past five years? 1 = no change, 2 = extent of downsizing increased 1–10%, 3 = increased 11–20%, 4 = increased 21–50%, 5 = increased 51–75%, and 6 = increased >75%

[12] For our analysis, we split the data into two variables such that MIX = 1 if high mix; 0 = otherwise, and VOLUME = 1 if high volume; 0 = otherwise.

II. Activity-based costing (ABC): Please indicate the status of implementation of activity-based costing or activity-based costing systems in your plant[13]

Scale	0 = No implementation	1 = Plan to implement	2 = Extensive implementation

III. World-class manufacturing (WCM): Please indicate the extent to which each of the listed manufacturing practices has been adopted at your plant

Scale	0 = No implementation	1 = Some implementation	2 = Extensive implementation[14]
1	Just-in-time (JIT)/continuous-flow production		
2	Total quality management (TQM)		
3	Pull system/Kanban		
4	Formal continuous process improvement		
5	Competitive benchmarking		
6	Self-directed teams		

IV. Plant performance[15]

1. Δ(QUALITY): How has finished product first-pass quality yield changed over the last five years?
   1 = Declined more than 20%, 2 = declined 1–20%, 3 = stayed the same, 4 = improved 1–20%, 5 = improved more than 20%.

2. Δ(TIME)
   Δ(Cycle time): By what percentage has manufacturing cycle time changed over the last five years?
   1 = No reduction, 2 = decreased 1–10%, 3 = decreased 11–20%, 4 = decreased 21–50%, 5 = decreased more than 50%.
   Δ(Lead time): How has customer lead time changed over the last five years?
   1 = Increased more than 20%, 2 = increased 1–20%, 3 = stayed the same, 4 = decreased 1–20%, 5 = decreased more than 20%.

3. Δ(COST): How have unit manufacturing costs at this plant, excluding purchased materials, changed over the last five years?
   1 = Increased more than 20%, 2 = increased 11–20%, 3 = increased 1–10%, 4 = no change, 5 = decreased 1–10%, 6 = decreased 11–20%, 7 = decreased more than 20%.

[13] We combined the first two categories into one. Therefore, 0 = no ABC implementation, while 1 = extensive implementation.

[14] For ease of analyses, we combined the second and third categories into one. Hence, 0 = none or some implementation, while 1 = extensive implementation.

[15] To facilitate analyses, we grouped the plant performance categories in the original survey into a five- or seven-point Likert scale.

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