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The information systems environment of time-based competitors

Patrick Rondeau
Butler University, prondeau@butler.edu

T. S. Ragu-Nathan

M. A. Vonderembse

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Rondeau, P.J., Ragu-Nathan, T.S., and Vonderembse, M.A.

Abstract:

Time-based competitors create product development and manufacturing practices that reduce response-time and enhance customization capabilities. These practices require an information-rich, internal environment capable of flexible resource deployment and direct and continuous feedback. These firms should have enhanced information systems planning capabilities, cross-functional involvement in information systems related activities, responsiveness to organizational computing demands, high levels of end-user development, and high levels of information systems performance. Data were collected from 265 manufacturers to develop measures for these information systems variables and to determine if there are relationships between the use of time-based practices and the levels of these variables. Results indicate that firms with high levels of time-based product development practices and time-based manufacturing practices have significantly higher scores across these information systems variables than firms with low levels of these time-based practices.

Keywords: Information systems; Product design and planning; Survey research; Time-based competition

1. Introduction

Increasing global competition and changing markets and technology are causing manufacturers to reinvent their products and reexamine their organizational structure and operational controls [1-3]. These phenomena closely follow and may be explained by a shift from an industrial to a postindustrial model of manufacturing [4-9]. Industrial-era firms are characterized by dominant products and longlinked production technologies where manufacturing operations occur in a fixed sequence by specialized functions [10]. Post-industrial firms possess high customer orientation; they are characterized by expansive product variety and information intensive technology. They use flexible resource deployment and a rich information environment to achieve competitive advantage by designing, producing, and delivering a variety of superior products [2, 11].

As organizations shifted from industrial to post-industrial operations, competitive thrusts changed [12]. In the first half of the 20th century, competitive thrusts were marketing competence and low cost mass production capability [13]. In the 1970s and 1980s, quality became a key competitive thrust. In the 1990s, competitive dimensions expanded to include time [14]. In this post-industrial environment, time-based competitors seek to achieve significant reductions in response time [4, 9, 15]. They implement time-based product development and manufacturing practices to meet customer needs for an increasing array of high-quality, cost-effective products [16, 17]. As a result, time-based competitors (post-industrial firms) become more process oriented, responsive, and information rich than industrial firms [14, 18]. They support a growing need for intellectual work with information systems (I.S.) that are designed for knowledge sharing and integration [5].

While these propositions seem logical, empirical evidence does not exist to support the claims that implementing time-based product development and time-based manufacturing practices influence the creation of an effective I.S. environment. The central tenet of this study is that firms exhibiting strong time-based practices have (1) enhanced I.S. planning effectiveness, (2) improved cross-functional involvement in I.S. related activities, (3) responsiveness to organizational computing demands, and (4) strong end-user development. These I.S. practices facilitate the implementation of time-based practices and increase I.S. performance.

This study defines a framework to explain the relationships between time-based practices and the I.S. variables. It classifies firms into high versus low time-based practices, and it analyzes the variance of the I.S. variables across these groups. Valid and reliable instruments exist to measure time-based product development practices [16] and time-based manufacturing practices [17]. Data collected from 265 senior managers were used to develop valid and reliable measures of the I.S. variables and to test the research questions.

2. Time-based competition and the information systems environment

To design, produce, and deliver quickly a wide variety of products that meet specific customer needs, firms seek to reduce time from all facets of their value-delivery system [4, 9] by creating responsive and integrated product development and manufacturing processes [5]. These processes require firms to acquire and organize knowledge rapidly, process it promptly, and share it across functional boundaries seamlessly. The fit between the manufacturing function and the IS function can be achieved through a top-down, strategic view of I.S. planning, which links I.S. development to manufacturing and builds an I.S. group that is responsive to their computing demands. To achieve this fit, organizations need a clear I.S. mission statement, a well defined set of I.S. strategies and objectives, and a set of policies and procedures that define the scope of I.S. responsibilities with respect to the requirements of manufacturing [18-21]. In addition, the I.S. function should promptly respond to requests for software applications, upgrades, networking concerns, and end-user questions [22-24].

Involving product development managers, manufacturing managers, and end-users in I.S. related activities enables firms to build an I.S. infrastructure that supports cross-functional decision-making. The early involvement of manufacturing managers and engineers in product development reduces the time and cost of designing new products and increases performance and quality [2, 25]. Employee involvement programs and the integration of I.S. across business functions are considered important for improving manufacturing performance [26]. Firms like IBM assign representatives from product development and manufacturing to cross-functional teams that interact significantly. This sensitizes design engineers to the realities of manufacturing by creating an environment where knowledge is shared and learning is expected [14].

In this environment, enhancing communications facilitates the cooperative exchange and analysis of data [15]. This exchange often occurs via electronic interaction among team members and through the application of information technologies by end-users. High levels of organizational involvement in I.S. related activities and increased I.S. performance go hand-in-hand when users determine the type and level of services available [27, 28]. The speed and quality of I.S.'s response to requests from users impact I.S. performance [29].

While the literature suggests that the I.S. environment of time-based competitors is more effective than the I.S. environment of traditional firms, there are no empirical studies that support this claim. Specifically, it is important to determine whether time-based product development practices (TBPDP) or time-based manufacturing practices (TBMP) or both are associated with improvements in I.S. practices and I.S. performance.

The matrix in Fig. 1 shows that organizations with low levels of TBPDP and TBMP are classified as industrial, Cell 1. These firms have less need for information processing because their environment changes slowly, and their product demand is concentrated in a few high-volume products or product lines. These firms may not face the same competitive forces (i.e., intense global competition, rapidly changing products and markets, and burgeoning technology) that post-industrial firm face. These firms may have a different I.S. environment with lower I.S. requirement than post-industrial firms. Examples of these types of firms would be manufacturers that produce commodity-like products such as threaded fasteners or basic electrical components.

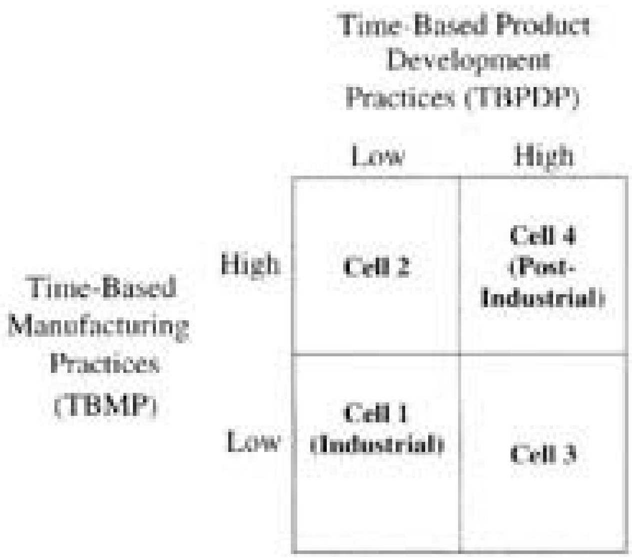

Fig. 1. Research model.

Firms in Cell 2 have low TBPDP and high TBMP. These firms may manufacture component parts or subassemblies as part of a supply chain that feeds firms operating in a post-industrial environment. In this cell, product variety and uncertainty tend to be high, response time short, and delivery reliability critical, so TBMP are important, but they may have no or very limited product design responsibility. Their production follows designs and specifications provided by their customers. Second-tier suppliers to the automotive or aircraft industry may be good examples for this cell. These firms should have an I.S. environment rated between Cells 1 and 4.

Firms in Cell 3 have high TBPDP and low TBMP. These firms may be experiencing increasing turbulence in their external environment and are responding by redesigning the product design process to focus on speed and flexibility. They may be in transition as they focus first on TBPDP before addressing these issues in the manufacturing system. This cell may also hold firms that are primarily focused on design and have outsourced manufacturing. These virtual manufacturing firms need TBPDP, but they have limited use for time-based manufacturing practices. They should have an I.S. environment rated between Cells 1 and 4.

Organizations with a high TBPDP and TBMP are classified as post-industrial, Cell 4. These firms should have an information-rich, internal environment that is capable of flexible resource deployment. The I.S. environment supports the design and successful implementation of product development and manufacturing practices. These firms tend to operate in a globally competitive external environment with rapid changes in markets and technologies. To achieve high levels of TBPDP and TBMP, they should have an internal environment that is high in I.S. strategic planning effectiveness, cross-functional involvement (in I.S. related activities), I.S. responsiveness to organizational computer demands, and end-user computing. Firms in this cell would have a strong international presence and broad products lines.

To further develop the research framework, TBPDP, TBMP, and key elements of the I.S. environment are defined, and a set of hypotheses is constructed.

2.1. Time-based product development practices (TBPDP)

Koufteros [16], Koufteros et al. [30, 31] developed valid and reliable measures for six TBPDP, which are discussed later in this section. He provided assurance that the domain of the construct was adequately covered through a rigorous process that included theory development, literature reviews, structured interview with manufacturing executives, pre-testing with academic and industry experts, and pilot testing with target respondents. These methods as well as the sampling plan and data analysis followed generally accepted psychometric principles [32].

Heavy-weight product development managers. They are important throughout the product development process because they have sufficient status and clout to champion, guide, and drive innovation throughout the firm. They are often highly effective at overcoming internal opposition to new product development programs and bypassing traditional functional structures that may limit creativity and thwart the effective allocation of resources [11, 33]. Such managers are in a favorable position to drive the evaluation, selection, and implementation of information technologies essential for product development.

Concurrent engineering. Firms engaged in TBPDP employ concurrent engineering to integrate product and process design efforts and achieve concurrent work flows. Firms conduct parallel product and process design efforts that simultaneously consider the features, performance, and function of the product as well as its manufacturability [2]. These efforts are greatly enhanced through the effective application of information technology [30].

Platform products. Firms create a core product that can be altered and enhanced to produce multiple variants with different features and appearances. Each product platform can be optimized to achieve a particular design goal while allowing for small but frequent design changes that incorporate the latest technologies and customer requirements [2, 34].

Computer usage. Product and process designs are better, and the results are achieved more quickly when computer-based tools such as computer-aided design (CAD) and computer-aided manufacturing (CAM) are used extensively [35]. The use of computers greatly enhances concurrent engineering and platform product development efforts through the automation, simplification, coordination, and integration of work [36]. Successful computer usage also requires individual functions to conform to standards, share information, and cooperate together to insure its full diffusion and adoption within the firm [37].

Customer involvement. Customers should be involved extensively and early in product development activities because customers contribute valuable feedback about designs. As the interaction between the organization an its customers increase, both the organization and the customers learn more about how a particular design meets their needs [14]. This involvement is facilitated and enhanced through effective I.S. applications.

Supplier involvement. Suppliers contribute valuable design suggestions, technical contributions, and quality improvement actions that improve manufacturability and minimize design to market cycle time [16]. Laudon and Laudon [38] state that increasing real-time involvement of suppliers in product development efforts greatly enhanced the demand for advanced internet-based technologies.

2.2. Time-based manufacturing practices (TBMP)

Koufteros et al. [17] developed valid and reliable instruments for seven TBMP, which are discussed here. The creation of these practices was part of the research study that developed TBPDP so the same methods and procedures were used.

Shop-floor employee involvement in problem solving. Employee involvement is an antecedent to other time-based changes such as setup time reduction and quality improvement efforts, [39, 40]. In today's factories, work has a higher intellectual content than it had in the past. As a result, shop-floor employees create, share, and manage information and information systems in order to plan and do their work [39].

Reengineering setups. Shingo [41] stresses that reducing setup time is essential for cutting throughput time because it increases flexibility, thus enabling firms to switch between products, quickly. Compressing setup time enables small batch production and reduces the need for inventory. Monden [42] argues that setup time is an inherent component of throughput time and a determinant of shop-floor responsiveness.

Cellular manufacturing. Cellular manufacturing allows firms to use product-oriented layouts, which enable families of products to be produced by general-purpose machines located close together. Because all the parts produced in a cell have similar design and/or manufacturing process characteristics, a minimal amount of setup time is required when switching between products [43, 44]. The successful application of group technology to create families of parts is heavily dependent on information processing capabilities.

Preventive maintenance. Throughput time may be reduced through increased preventative maintenance efforts. When preventive maintenance is tracked via computer-based systems and executed properly, the machines, tools, and other equipment will be more reliable, yield fewer defects, be more productive, and operate at a lower cost [25, 45, 46].

Quality improvement efforts. The ultimate goal of quality improvement efforts are improving customer satisfaction, reducing throughput time, and lowering costs. The major focus of quality improvement efforts should be the prevention of defects and the elimination of non-value added rework [47-50]. These efforts include the use of computerized statistical quality control and databases containing written procedures and methods.

Dependable suppliers. Supplier dependability in meeting performance measures is critically important in reducing throughput time and improving manufacturing capabilities [4, 51-53]. Supply chain management is heavily dependent on the flow of accurate information along the value chain.

Pull production. Pull systems employ signals, which are ultimately triggered by customer demand, to control material movement and machine processing within the factory. This requires a tightly linked flow of information and substantial equipment flexibility. This enables firms to respond to changing customer demand [39, 41, 46].

2.3. The information systems environment

In this study, five dimensions of the I.S. environment are examined. The effectiveness of the I.S. strategic planning process is important because it generates appropriate I.S. mission and vision statements, defines specific I.S. objectives, and identifies a clear scope of operating responsibility [18, 24, 54-56]. Second, cross-functional involvement in I.S. related activities creates an environment where teamwork and knowledge are essential. Time-based competitors use cross-functional teams to ensure organizational success [4, 9]. In addition, the I.S. literature emphasizes the importance of cross-functional involvement to insure the effective development and timely delivery of I.S. solutions [28]. Third, I.S. responsiveness to organizational computing demands supports time-based competition by promptly and effectively resolving questions and issues so the organization can satisfy customer needs [29, 57-59]. Fourth, end-user computing provides users with hands-on involvement in decision-making that makes employee participation and empowerment a reality. These dimensions should lead to enhanced I.S. performance.

2.3.1. I.S. strategic planning effectiveness

Formal I.S. planning is critical because it links I.S. strategies to corporate and functional strategies. This is consistent with Parson's [20] contention that the firm's business strategy should lead to the development and adoption of new information and automation technologies. Specific I.S. goals and objectives emerge, technologies are chosen, and policies and procedures adopted during the I.S. strategic planning process. [19, 21, 60, 61].

Better performing organizations have more key personnel involved in strategic planning [62]. Effective I.S. planning involves end-users on an individual and cross-functional basis, and it explores multiple scenarios, which integrate complex business, technical, and cost issues [63]. The integrative nature of the I.S. planning process requires it to reach beyond these issues to incorporate the politics and personalities of the enterprise in the final solution [64]. Thus, the final I.S. plan projects a clear vision of the future of business, the I.S. organization, and the ways the firm should operate these systems to be effective [18].

H1: Firms scoring high in both TBPDP and TBMP (i.e., Cell 4) will score higher in I.S. strategic planning effectiveness than firms scoring low in both TBPDP and TBMP (i.e., Cell 1).

As a corollary to H1, it is expected that firms scoring high in one dimension of time-based competition and low in the other (i.e., Cells 2 and 3) will have a score in I.S. Strategic Planning Effectiveness that is between Cells 4 and 1.

2.3.2. Cross-functional involvement (in I.S. related activities)

The uses and consequences of information technology often emerge unpredictably to form complex social interactions. Decisions related to the computing infrastructure of the firm may be segmented and discontinuous in nature because of conflicting organizational objectives and preferences [65]. The diffusion of technology is moderated by the organizational context in which it is deployed. Therefore, management's role in the implementation of new technologies is to modify or alter organizational context to minimize resistance [66].

As firms seek to better integrate organizational processes, more interactive and highly collaborative work tools are required to better support these processes. Sophisticated I.S. applications that allow end-users to simultaneously create, share, and manage large amounts of information have become increasingly important [67]. Within such an environment, greater cross-functional involvement in I.S. activities is also required to reduce functional isolation and to stimulate organizational process improvements [68].

From an information technology perspective, the diverse interests of information technology stakeholders are managed jointly for the successful implementation and administration of a portfolio of I.S. applications. Cross-functional involvement is thought to be a critical component of implementation success, especially during the initiation, adoption, and adaption stages of information technology [69]. Once implemented, the informating power of technology is unleashed as workers "act-with" co-workers to process information, make decisions, and create solutions to problems [70]. Thus, an organization's capacity to learn and innovate is significantly enhanced through higher levels of cross-functional involvement, allowing it to more fully realize the potential of intelligent technologies [71].

H2: Firms scoring high in both TBPDP and TBMP (i.e., Cell 4) will score higher in cross-functional involvement (in I.S. related activities) than firms scoring low in both TBPDP and TBMP (i.e., Cell 1).

As a corollary to H2, it is expected that firms scoring high in one dimension of time-based competition and low in the other (i.e., Cells 2 and 3) will have a score in cross-functional involvement (in I.S. related activities) that is between Cells 4 and 1.

2.3.3. I.S. responsiveness to organizational computing demands

A lack of responsiveness to end-user issues, questions, and concerns by the I.S. function is commonly cited as one of the primary reasons behind I.S. downsizing and outsourcing initiatives. Many end-users are frustrated by the inability of their I.S. departments to deliver useful project results within budget and on time. They are further frustrated by these same I.S. departments' delays in fixing computer hardware and software problems and in supporting special information reporting requests. As such, these I.S. departments are often the focus of intense end-user dissatisfaction and the target of poor end-user performance evaluations [22-24, 29, 54].

H3: Firms scoring high in both TBPDP and TBMP (i.e., Cell 4) will score higher in I.S. responsiveness to organizational computing demands than firms scoring low in both TBPDP and TBMP (i.e., Cell 1).

As a corollary to H3, it is expected that firms scoring high in one dimension of time-based competition and low in the other (i.e., Cells 2 and 3) will have a score in I.S Responsiveness to Organizational Computing Demands that is between Cells 4 and 1.

2.3.4. End-user computing

Modern information technologies must be flexible, adaptable, reliable, and widely deployed to support changing business requirements. To achieve these goals, end-users and line managers should work in partnership with the I.S. function to create joint ownership of new applications for rapid development and implementation [72]. The growth of personal computers and network technologies has placed powerful tools in the hand of managers and workers throughout the organization [18]. This requires high-level computer skills and comprehensive I.S. training for end-users [55, 73, 74].

End-user involvement (in I.S. related activities,). Developing successful I.S. applications is becoming more difficult as the degree of intellectual content associated with end-user tasks expands [67]. This specialized usage often requires greater levels of end-user involvement to develop and implement new applications, successfully. Greater levels of end-user involvement, in mm, are associated with improved I.S. management practices, greater end-user satisfaction, and improved I.S. performance [75, 76].

End-user involvement is vital because it helps to ensure accurate requirements specifications, to facilitate the development of relevant application designs, and to foster a greater sense of empowerment and ownership among users of I.S. services. By providing end-users additional opportunities to influence I.S. decisions, end-user involvement is thought to cultivate a greater sense of control, increase motivation and satisfaction, and reduce resistance to organizational change [77, 78].

H4: Firms scoring high in both TBPDP and TBMP (i.e., Cell 4) will score higher in end-user involvement (in I.S. related activities) than firms scoring low in both TBPDP and TBMP (i.e., Cell 1).

As a corollary to H4, it is expected that firms scoring high in one dimension of time-based competition and low in the other (i.e., Cells 2 and 3) will have a score in end-user involvement (in I.S. related activities) that is between Cells 4 and 1.

End-user training effectiveness. Effective end-user education and training involves teaching general problem solving approaches, including abstract reasoning and specific technical skills [79]. Attaining this is critical in an I.S. environment where cognitive skills, that are necessary for continued learning, vary greatly among participants and may, on-the-average, be less than desired [73].

Effective end-user education and training can deliver many benefits that extend beyond the improvement of computing knowledge or the development of application specific skills. It can enable the rapid acceptance of new technologies and software applications, empower users to experiment more freely, and motivate them to deploy new technologies more quickly. It can foster more positive attitudes toward the I.S. function, thus resulting in improved levels of end-user satisfaction [78].

H5: Firms scoring high in both TBPDP and TBMP (i.e., Cell 4) will score higher in end-user training effectiveness than firms scoring low in both TBPDP and TBMP (i.e., Cell 1).

As a corollary to H5, it is expected that firms scoring high in one dimension of time-based competition and low in the other (i.e., Cells 2 and 3) will have a score in end-user training effectiveness that is between Cells 4 and 1.

End-user computing skill. The level of end-users' computer literacy and experience is recognized as an important enabler of I.S. implementation success [80]. Since the advent of the personal computer, the availability of PC-based educational and training programs have enabled end-users to enhance their cognitive computing skills [74]. Network and computing technologies offer many exciting opportunities to develop new software applications or explore databases via data mining techniques.

H6: Firms scoring high in both TBPDP and TBMP (i.e., Cell 4) will score higher in end-user computing skills than firms scoring low in both TBPDP and TBMP (i.e., Cell 1).

As a corollary to H6, it is expected that firms scoring high in one dimension of time-based competition and low in the other (i.e., Cells 2 and 3) will have a score in end-user computing skills that is between Cells 4 and 1.

2.3.5. I.S. performance

Management's satisfaction with I.S. performance depends on the ability of I.S. to facilitate better decision-making [81]. End-users in product development and manufacturing recognize the benefits of the services provided by I.S., and they recognized how these services lead to faster and better decisions in highly competitive situations. Firms with high levels of TBPDP and TBMP have high levels of I.S. performance. The challenge faced by the I.S. function is to develop clear, objective measures of I.S. performance [82].

H7: Firms scoring high in both TBPDP and TBMP (i.e., Cell 4) will score higher in I.S. performance than firms scoring low in both TBPDP and TBMP (i.e., Cell 1).

As a corollary to H7, it is expected that firms scoring high in one dimension of time-based competition and low in the other (i.e., Cells 2 and 3) will have a score in I.S performance that is between Cells 4 and 1.

3. Research methodology

This section describes the data collection procedure and characteristics of the respondents, and it also discusses instrument development methods for the I.S. variables.

3.1. Data collection

Data for the study were gathered as part of a larger survey. A cover letter, the survey instrument, and postage-paid return envelope were mailed to 6269 senior manufacturing managers. The mailing list, purchased from Manufacturers' News, contained SIC codes: #25--furniture & fixtures, #34--fabricated metals, #35--industrial machinery & equipment, #36---electronic & other equipment, #37-transportation equipment, and #38--instruments & related products. All firms selected had at least 250 employees.

There were 265 usable responses for a response rate of 4.3%. The split by SIC code was: #25--8.4%, #34--20.1%, #35--25.7%, #36--23.4%, #37--13.1%, and #38--9.3%. The split by company size was 250 to 499 employees--56.0%, 500 to 999--28.0%, and 1,000 or more--16.0%. Even though the response rate was low, the makeup of the respondent pool was considered good. In the sample, 44.9% reported a job title of president, CEO, vice president, or general manager, 15.5% reported plant manager, 15.1% reported director or senior manager, 20.4% reported manager, and 4.1% did not provide job title information. A significant problem with organizational-level research is that senior managers receive many requests to participate and have limited time. Because this interdisciplinary research collected information form several functional areas, the size and scope of the instruments must be large and time consuming to complete. These factors contribute to the low response rate. Statistical tests were done to determine if significant differences exist between responding firms and firms on the mailing list. Using chi square goodness of fit test ($p < 0.05$), no statistically significant differences were found when SIC codes ([chi square] of 4.667 versus a critical value [chi square] of 5.991) and firm size as measured by the number of employees ([chi square] of 5.782 versus a critical value [chi square] of 5.991) were examined. This supports the claim that characteristics of the respondents and non-respondents are not significantly different [83].

3.2. Instrument development methods for the information systems variables

The instrument development process included an extensive review of the relevant literature. This review facilitated theory development, construct definition, and the identification of existing measures. Items designed to measure I.S. strategic planning effectiveness, I.S. responsiveness to organizational computing demands, end-user training effectiveness, and end-user computing skill were developed from the I.S. strategic planning literature (e.g., [19, 20, 60, 61], the I.S.

downsizing and outsourcing literatures (e.g., [54, 56, 57, 84, 85], and the end-user training literature (e.g., [74, 79, 80]). Items designed to measure I.S. performance were adapted from an instrument by Ragunathan and Ragunathan [81]. For these variables, respondents were asked to indicate the strength of their agreement related to each survey item. The possible responses included: 1 = strongly disagree, 2 = mildly disagree, 3 = neutral, 4 = mildly agree, 5 = strongly agree, and NA = not applicable or do not know.

Potential items designed to measure end-user involvement and cross-functional involvement in I.S. were developed from a review of the I.S. involvement literature (e.g., [27, 28, 76, 78]) and the I.S. implementation literature (e.g., [37, 66, 69, 70]). A five-point Likert scale was used to ask respondents to indicate their existing level of 1) end-user involvement in software application development and 2) cross-functional involvement in the development and administration of software applications. For both of these variables the possible responses included: 1 = none, 2 = low, 3 = moderate, 4 = high, 5 = very high, and NA = not applicable or do not know.

To enhance content validity, refine definitions, and improve item generation for these I.S. constructs, structured interviews were conducted with four managers from manufacturing firms (three production managers and one product development manager). A pre-pilot test was completed that involved three production managers and eight academic experts. They were asked to comment on the appropriateness of the research constructs, including the methods and measures to be used. The final step involved conducting a pilot study targeted at senior manufacturing managers.

4. Results

Results are provided for testing the measurement model for the I.S. variables and for testing the hypotheses.

4.1. Results of the measurement model

The items for all seven I.S. dimensions were submitted to exploratory factor analysis, simultaneously, to assess the variable's internal consistency. Principal component was selected for the extraction procedure with the varimax method used for factor rotation. Results of the factor analysis are given in Table 1. Factor loads below 0.40 are not shown, there are no significant cross loads, and the minimum load exceeds 0.6 for all items, implying convergent and discriminant validity for the constructs.

Table 2 gives the means, standard deviations, and reliability estimates [86] for the I.S. dimensions. All the reliabilities are above 0.80 except for end-user computing skills, which is 0.77. The final instruments, listed in Appendix A, are short and easy to use. Each scale has seven or fewer items, and the total number of items across all scales is only 34. The factor structure is simple and has high loadings. The instruments exceed generally accepted validity and reliability standards for basic research.

4.2. Approach to hypothesis testing

The division of the sample into the cells shown in Fig. 1 depends on the overall construct means for TBPDP and TBMP, which were calculated by averaging the factor means for the dimensions listed in Tables 3 and 4, respectively. (Reliabilities are also provided.) The distributions of TBPDP and TBMP are symmetrical so using the mean or the median would lead to the same result. Individual responses were then classified into the four cells shown in Fig. 1 by comparing the mean of TBPDP and TBMP for a response to the overall construct mean. If a respondent's TBPDP or TBMP score was above the construct mean, the firm was considered an above average practitioner of time-based product development or time-based manufacturing techniques. If a respondent's TBPDP or TBMP score was below the construct mean, the firm was considered a below average practitioner of time-based manufacturing or product development techniques. Fig. 2 shows the final classification of firms into four cells.

After the classification of firms was complete, analysis of variance (ANOVA) was used to test whether the dimensions of the I.S. environment varied significantly among the four cells. ANOVA is a tests of mean responses, and the F-value is used to accept or reject the null hypothesis that all the group means are equal. Rejection of the null hypotheses indicates that some of the group means are different. A significant value of F indicates that at least one of the pair-wise differences is significant. It is preferable to conduct one F-test rather than separate t-tests for each pair-wise group because a series of t-test tends to inflate the alpha risk [87].

4.3. Results of hypothesis testing

The results shown in Table 5 support all seven hypotheses discussed earlier as well as the corollaries to these hypotheses. Firms that are high in both TBPDP and TBMP have higher levels of the seven I.S. variables than firms that are low in both TBPDP and TBMP. The F values for the main effects for each I.S. dimensions indicates statistically significant differences in the group means at the $p < 0.01$ level. There are no significant interaction effects found in all the analyses. This result indicates general support for the argument that time-based competitors tend to have high levels of these information systems variables, including I.S. performance. For each IS variable, the mean values for the four cells, namely high-high, high-low, low-high, low-low, are also shown in Table 5. These mean values illustrate that organizations high in only one dimension of time-based competition (either TBPDP--Cell 3 or TBMP--Cell 2) have higher levels of the I.S. variables than firms that are low in both dimensions. These results are statistically significant at $p < 0.01$ or 0.05 in all cases except end-user involvement in I.S. related activities. In this case, TBPDP generates a significant difference at the $p < 0.05$, but TBMP does not.

One explanation for this exception may be that end-users involved in product development activities become more closely involved with I.S. professional in evaluating software than their manufacturing counterparts. End-users in product development may position themselves to influence the selection, implementation, and diffusion of information technologies. In contrast, end-users involved in manufacturing may use information technologies that are general purpose. They may view information technologies as tools to assist them in performing work. For example, manufacturing resource planning has been around for decades. It has evolved at a much slower pace and in more predictable ways than engineering technologies such as computer-aided design, which is used extensively in product development. As a result, manufacturing end-users may see less need to become involved in I.S. related activities than end-users in product development.

5. Implications for managers

Faced with the task of becoming time-based competitors, organizations should prepare an I.S. foundation and nurture effective working relationships between I.S. managers and the professionals involved in product development and manufacturing. These professional should be represented in the I.S. strategic planning process, which defines a clear vision for developing and deploying I.S. resources to shape the company's future and enhance organizational effectiveness. The I.S. strategic plan should be effectively linked with plans for marketing, engineering, manufacturing, supply, and distribution.

Table 2
Information Systems variable characteristics

	Scale	No of items	Mean	Standard deviation	Reliability
SP	I.S. strategic planning effectiveness	5	3.14	0.99	0.93
CI	Cross-functional involvement (in I.S. related activities	6	2.48	0.86	0.95
RD	I.S. responsiveness to organizational computing Demands	5	3.34	0.91	0.90
EI	End-user involvement (in I.S. related activities)	7	2.92	0.96	0.95
ET	End-user training effectiveness	2	3.05	1.03	0.81
ES	End-user computing skill	4	3.24	0.76	0.77
IP	I.S. performance	5	3.16	0.99	0.90

To follow through on these efforts at the strategic business level, firms should enhance integration at the operating level by increasing cross-functional involvement in I.S. related activities. This may be accomplished by including product development and manufacturing managers in efforts that define operating policies and procedures. These inputs may also help organizations to prioritize I.S. projects and designing user-friendly enterprise-wide data management systems. With this level of input, firms can create I.S. capabilities that add value to product development and manufacturing activities, support time reduction efforts, and enhance the firm's ability to deliver a variety of products.

As firms seek to implement complex activities such as TBPDP and TBMP, they should implement collaborative work tools to support integrative organizational processes. These tools, which are usually based on the application of information technology, allow end-users to simultaneously create, share, and manage large amounts of information. The ability to transcend functional boundaries enhances the ability of organizations to learn and innovate. Trust and cooperation is built through cross-functional involvement in selecting software and coping with enterprise-wide data management problems.

Table 3
Time-based product development practices variable characteristics

	Scale	No of items	Mean	Standard deviation	Reliability
HW	Heavy-weight product development managers	4	3.22	0.75	0.86
CE	Concurrent engineering	4	3.69	0.91	0.90
PL	Platform products	4	3.46	0.75	0.91
CO	Computer usage	4	3.92	0.86	0.91
CU	Customer involvement	4	3.98	0.71	0.87
SU	Supplier involvement	4	2.72	0.82	0.83

To maintain this trust and cooperation, I.S. must respond quickly and effectively to organizational computing demands. While this activity may not provide significant positive benefits, a lack of response to questions and concerns has a very negative impact on relationships between I.S. managers and the professionals in product development and manufacturing. Specifically, relationships deteriorate when software problems are not resolved promptly, software enhancements are not provided or are consistently late, or the network has significant downtime.

End user training effectiveness, computer skills, and involvement in I.S. related activities are essential in distributed data processing activities like TBPDP and TBMP. End-users should receive classroom training as well as on-the-job training that allow them to think openly about problem solving and customer expectations. This learning climate forms an environment that enhances creativity, knowledge sharing, and continuous learning. In this environment, end-users should be highly productive and skilled users of computer-based technologies that relate to product development and manufacturing. End-users should be extensively involved with specifying, analyzing, designing, developing, and testing software applications. The end-user becomes the decision-maker, and the I.S. professional is a source of knowledge.

Table 4
Time-based manufacturing practices variable characteristics

	Scale	No of items	Mean	Standard deviation	Reliability
EM	Employee involvement	4	3.65	0.89	0.90
RS	Reengineering setup	4	3.29	0.89	0.89
CM	Cellular manufacturing	4	3.99	0.76	0.83
PM	Preventive maintenance	4	3.95	0.92	0.93
QI	Quality improvement Efforts	4	3.01	1.00	0.82
DS	Dependable suppliers	4	4.01	0.60	0.88
PP	Pull Production	4	3.27	0.99	0.86

As an organization is able to develop effective I.S. strategic plans, involve other disciplines in I.S. related activities, increase responsiveness to organizational computing demands, and serve the needs of end-users, the ability of professionals in TBPDP and TBMP should be enhanced. This should lead to better organizational performance, which, in turn, should lead to increased satisfaction with I.S. performance.

6. Conclusion, limitations, and future research

This study explores the contingent nature of a firm's I.S. environmental variables in the context of TBPDP and TBMP. The highly cross-functional, team-based nature of time-based competitors is a requisite requirement for the acceleration of product development and manufacturing processes. Both TBPDP and TBMP activities are information intensive, requiring the rapid processing, exchange, and interpretation of organizational data. The benefit from these enhancements is a more effective I.S. functions that enables a firm to respond to competitive threats and opportunities.

The I.S. management practices explored in this study are positively related to the adoption of TBPDP and TBMP, which indicates the existence of a favorable business environment for developing effective I.S. strategic planning, I.S. responsiveness to end-users, and end-user training. One possible reason for this is that the high degree of cross-functional involvement inherent in time-based manufacturing creates a more stable work system environment. While products and processes may change frequently, the integration of work teams provides opportunities to better identify and prioritize I.S. objectives and requirements on a company-level basis. This removes the I.S. department from individual functional battles, freeing it to pursue those projects and services that create the greatest overall value to the firm.

The existence of strong cross-functional involvement, a more stable business environment, and clear I.S. objectives and priorities all enable I.S. department success. As it becomes more focused, targeting the delivery of projects and services that yield the greatest value to the firm, opportunities for improvements in management perceptions of I.S. performance are created. The development of greater end-user computing skill further extends the I.S. departments capabilities, allowing it to gain greater user commitment through the utilization and integration of skilled end-users into major application development projects.

This study supports the claim that time-based competitors have higher levels of these I.S. dimensions than non-time-based competitors. However, this does not imply that non-time-based competitors are prohibited from achieving high levels of these I.S. dimensions. Non-time-based competitors could invest resources to enhance their I.S. capabilities, but this study indicates that they have not. One plausible argument is that firms with low levels of time-based practices do not have a high level of need for I.S. capabilities. When product life cycles are long and production operates with few changeovers, the number of decisions and the need for information is greatly reduced. In essence, it is less complex for these firms to produce and deliver low-cost, high-quality products to customers in a timely manner. Another explanation may be that some firms, faced with a rapidly changing environment, do not perceive the need for time-based practices and do not invest in the I.S. capabilities to support them.

Note: A total of 265 respondents were split into High or Low cells by TBPDP and TBMP construct means.

		Time-Based Product Development Practices (TBPDP)	
		Low	High
Time-Based Manufacturing Practices (TBMP)	High	42 (16%)	97 (37%)
	Low	96 (36%)	30 (11%)

Fig. 2. Respondents classified by cell.

6.1. Limitations

The results of any research study and its generalizability have to consider limitations. Though precautions have been taken to avoid obvious limitations, it is impossible to avoid all such concerns. Both the dependent and independent variables in this study have been measured through a single respondent, which may introduced response bias. The measurement process for TBPDP, TBMP, and I.S. practices targeted manufacturing managers. The assumption is that senior manufacturing managers have knowledge of TBPDP and I.S. practices as well as TBMP.

The amount of data captured in this study and the need to collect data from top managers have created a low response rate. To ensure that response/non-response basis is not an issue, tests were done to compare attributes of these groups. The IS variables measured in this research are not exhaustive. In addition, they focus mainly on the internal aspects of the organization and not on the external links with suppliers and customers. Finally, one factor, end-user training effectiveness has only two items, which casts doubt on the reliability of this measure.

6.2. Future research

Clearly, future research can attempt to address each of the procedural problems identified in the limitations section. In addition, the inclusion of I.S. variable that focus on the relationship between an organizations and its customers and suppliers could be important. Supply chain management and customer relationship management are strongly dependent on I.S. capabilities. Future studies could examine the impact of I.S. variables on other innovative and or cross-functional practices such as creating strategic partnerships with suppliers or managing research and development activities. How do I.S. variables impact mass customization efforts. Future efforts could also attempt to determine what other factors help to facilitate TBPDP and TBMP. Do certain types of organizational structure or culture impact the implementation of time-based practices.

Appendix A. Questionnaire items

The following statements measure typical information systems practices within a firm. Please circle the appropriate number which best indicates the strength of your agreement with each of the following statements as they relate to your firm's manufacturing function.

1 = Strongly Disagree, 2 = Mildly Disagree, 3 = Neutral, 4 = Mildly Agree, 5 = Strongly Agree
NA = Not Applicable, or Do Not Know

I.S. Strategic Planning Effectiveness (SP)

My firm's I.S. function ...

SP1 Has developed a well defined set of I.S. strategies.

SP2 Has developed a well defined set of I.S. objectives.

SP3 Has developed policies and procedures that clearly define the scope of I.S. functional activities within this organization.

SP4 Has developed a well defined mission statement.

SP5 Has developed policies and procedures that clearly define the scope of I.S. responsibility within this organization.

I.S. Responsiveness to Organizational Computing Demands (RD)

My firm's I. S. function ...

RD1 Promptly resolves software application problems.

RD2 Promptly responds to special software programming requests.

RD3 Promptly responds to end-user questions and concerns.

RD4 Promptly resolves computer network problems.

RD5 Promptly implements software application upgrades.

End-User Training Effectiveness (ET)

Within this manufacturing facility ...

ET1 End-users receive formal classroom training on how to use our existing Manufacturing information systems.

ET2 End-users receive extensive on-the-job training on how to use our existing Manufacturing information systems.

End-User Computing Skill (ES)

Within this manufacturing facility ...

ES1 End-users are highly productive when using our existing manufacturing information systems.

ES2 End-users are highly skilled in the use of manufacturing information technologies.

ES3 End-users are highly skilled in the use of computer based technologies.

ES4 End-users are capable of completing routine work assignments requiring the use of our existing manufacturing information systems.

Cross-Functional Involvement (in I.S. Related Activities) (CI)

Please circle the appropriate number which best indicates your existing level of cross-functional involvement in the development and administration of software applications.

Table 5
Analysis of variance results

Time-based manufacturing practices (TBMP)	Time-based product development practices (TBPDP)		Source of variation	*F*-value	Significance of *F*
	Low	High			
I.S. strategic planning effectiveness (SP)					
			Main effect	29.347	0.000
High	3.20	3.64	TBMP	22.740	0.000
			TBPDP	9.622	0.002
Low	2.60	2.96	Two-way interaction	0.094	0.760
Cross-functional involvement in I.S. related activities (CI)					
			Main effect	11.884	0.000
High	2.42	2.81	TBMP	4.900	0.028
			TBPDP	8.410	0.004
Low	2.19	2.49	Two-way interaction	0.150	0.699
I.S. responsiveness to organizational computing demands (RD)					
			Main effect	17.385	0.000
High	3.45	3.68	TBMP	14.237	0.000
			TBPDP	5.337	0.022
Low	2.92	3.29	Two-way interaction	0.330	0.566
End-user involvement in I.S. related activities (EI)					
			Main effect	4.830	0.009
High	2.87	3.11	TBMP	0.890	0.346
			TBPDP	5.019	0.026
Low	2.66	3.08	Two-way interaction	0.450	0.503
End-user training effectiveness (ET)					
			Main effect	17.983	0.000
High	2.91	3.45	TBMP	4.116	0.044
			TBPDP	16.742	0.000
Low	2.60	3.21	Two-way interaction	0.058	0.811
End-user computing skill (ES)					
			Main effect	31.195	0.000
High	3.26	3.65	TBMP	24.478	0.000
			TBPDP	10.266	0.002
Low	2.87	3.06	Two-way interaction	1.083	0.299
Information systems performance (IP)					
			Main effect	14.120	0.000
High	3.20	3.52	TBMP	12.032	0.001
			TBPDP	3.998	0.047
Low	2.78	2.99	Two-way interaction	0.177	0.674

Note: TBPDP and TBMP cell means are provided on the left-hand side of this table.

1 = None, 2 = Low, 3 = Moderate, 4 = High, 5 = Very High, NA = Not Applicable, or Do Not Know

CI1 Development of I.S. policies/procedures.

CI2 Integration of I.S. planning activities.

CI3 Prioritization of I.S. related activities.

CI4 Enterprise-wide data management.

CI5 Integration of software applications.

CI6 Resolution of software application problems.

End-User Involvement (in I.S. Related Activities) (EI)

Please circle the appropriate number which best indicates your existing level of end-user involvement in software application development.

1 = None, 2 = Low, 3 = Moderate, 4 = High, 5 = Very High, NA = Not Applicable, or Do Not Know

EI1 Development of manufacturing software applications.

EI2 Design of manufacturing software applications.

EI3 Analysis of manufacturing software application problems and opportunities.

EI4 Testing of manufacturing software applications.

EI5 Specification of manufacturing software application requirements.

EI6 Management of manufacturing software application development projects.

EI7 Implementation of manufacturing software applications.

Information Systems Performance (IP)

The following statements measure typical perceptions about information systems performance within a firm. Please circle the appropriate number, which best indicates the strength of your agreement with these statements as they relate to your firm.

1 = Strongly Disagree, 2 = Mildly Disagree, 3 = Neutral, 4 = Mildly Agree, 5 = Strongly Agree, NA = Not Applicable, or Do Not Know

IP1 End-users are generally satisfied with the services of the I.S. function.

IP2 Our I.S. function is perceived as facilitating better decision making.

IP3 End-users recognize the benefits of our I.S. function's services.

IP4 The use of I.S. services has led to better management of manufacturing activities.

IP5 Our I.S. function has failed to meet end-user performance expectations. (1)

Table 1

Factor analysis for the I.S. scales (excluding I.S. performance)

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy = 0.90.
Only factor loadings of 0.40 and above are shown

Item no.	End-user involvement in I.S. (EI)	I.S. strategic planning effectiveness (SP)	Cross-functional involvement in I.S. (CI)	I.S. responsiveness to organizational computing demands (RD)
EI1	0.84			
EI2	0.83			
EI3	0.83			
EI4	0.81			
EI5	0.79			
EI6	0.78			
EI7	0.77			
SP1		0.83		
SP2		0.82		
SP3		0.81		
SP4		0.78		
SP5		0.78		
CI1			0.84	
CI2			0.80	
CI3			0.79	
CI4			0.74	
CI5			0.69	
CI6			0.68	
RD1				0.85
RD2				0.83
RD3				0.83
RD4				0.69
RD5				0.68
IP1				
IP2				
IP3				
IP4				
IP5				
ES1				
ES2				
ES3				
ES4				
ET1				
ET2				
EV (a)	11.65	5.19	2.04	1.74

% (b)	34.30	15.26	6.00	5.12
CP (c)	34.30	49.56	55.56	60.68

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy = 0.90. Only factor loadings of 0.40 and above are shown

Item no.	I.S. performance (IP)	End-user computing skill (ES)	I.S. end-user training effectiveness (ET)
EI1			
EI2			
EI3			
EI4			
EI5			
EI6			
EI7			
SP1			
SP2			
SP3			
SP4			
SP5			
CI1			
CI2			
CI3			
CI4			
CI5			
CI6			
RD1			
RD2			
RD3			
RD4			
RD5			
IP1	0.89		
IP2	0.87		
IP3	0.82		
IP4	0.81		
IP5	0.81		
ES1		0.76	
ES2		0.74	
ES3		0.72	
ES4		0.66	
ET1			0.79
ET2			0.74
EV (a)	1.52	1.34	0.91
% (b)	4.47	3.93	2.70
CP (c)	65.15	69.08	71.78

(a) Factor eigenvalues.

(b) percent of total variance.

(c) Cumulative percent of total variance.

Table 2

Information Systems variable characteristics

	Scale	No of items	Mean	Standard deviation
SP	I.S. strategic planning effectiveness	5	3.14	0.99
CI	Cross-functional involvement (in I.S. related activities	6	2.48	0.86
RD	I.S. responsiveness to organizational computing Demands	5	3.34	0.91
EI	End-user involvement (in I.S. related activities)	7	2.92	0.96
ET	End-user training effectiveness	2	3.05	1.03
ES	End-user computing skill	4	3.24	0.76
IP	I.S. performance	5	3.16	0.99

	Reliability
SP	0.93
CI	0.95
RD	0.90
EI	0.95
ET	0.81
ES	0.77
IP	0.90

Table 3

Time-based product development practices variable characteristics

	Scale	No of items	Mean	Standard deviation
HW	Heavy-weight product development managers	4	3.22	0.75
CE	Concurrent engineering	4	3.69	0.91
PL	Platform products	4	3.46	0.75
CO	Computer usage	4	3.92	0.86
CU	Customer involvement	4	3.98	0.71
SU	Supplier involvement	4	2.72	0.82

	Reliability
HW	0.86
CE	0.90
PL	0.91
CO	0.91
CU	0.87
SU	0.83

Table 4

Time-based manufacturing practices variable characteristics

Scale	No of	Mean	Standard

		items		deviation
EM	Employee involvement	4	3.65	0.89
RS	Reengineering setup	4	3.29	0.89
CM	Cellular manufacturing	4	3.99	0.76
PM	Preventive maintenance	4	3.95	0.92
QI	Quality improvement Efforts	4	3.01	1.00
DS	Dependable suppliers	4	4.01	0.60
PP	Pull Production	4	3.27	0.99

	Reliability
EM	0.90
RS	0.89
CM	0.83
PM	0.93
QI	0.82
DS	0.88
PP	0.86

Table 5

Analysis of variance results

Time-based manufacturing practices (TBMP)	Time-based product development practices (TBPDP)	
	Low	High
I.S. strategic planning effectiveness (SP)		
High	3.20	3.64
Low	2.60	2.96
Cross-junctional involvement in I.S. related activities (CI)		
High	2.42	2.81
Low	2.19	2.49
I.S. responsiveness to organizational computing demands (RD)		
High	3.45	3.68
Low	2.92	3.29
End-user involvement in I.S. related activities (EI)		
High	2.87	3.11
Low	2.66	3.08
End-user training effectiveness (ET)		
High	2.91	3.45

Low	2.60	3.21
End-user computing skill (ES)		
High	3.26	3.65
Low	2.87	3.06
Information systems performance (IP)		
High	3.20	3.52
Low	2.78	2.99

Time-based manufacturing practices (TBMP)	Source of variation	F-value	Significance of F
I.S. strategic planning effectiveness (SP)			
	Main effect	29.347	0.000
High	TBMP	22.740	0.000
	TBPDP	9.622	0.002
Low	Two-way interaction	0.094	0.760
Cross-junctional involvement in I.S. related activities (CI)			
	Main effect	11.884	0.000
High	TBMP	4.900	0.028
	TBPDP	8.410	0.004
Low	Two-way interaction	0.150	0.699
I.S. responsiveness to organizational computing demands (RD)			
	Main effect	17.385	0.000
High	TBMP	14.237	0.000
	TBPDP	5.337	0.022
Low	Two-way interaction	0.330	0.566
End-user involvement in I.S. related activities (EI)			
	Main effect	4.830	0.009
High	TBMP	0.890	0.346
	TBPDP	5.019	0.026
Low	Two-way interaction	0.450	0.503
End-user training effectiveness (ET)			
	Main effect	17.983	0.000
High	TBMP	4.116	0.044
	TBPDP	16.742	0.000
Low	Two-way interaction	0.058	0.811
End-user computing skill (ES)			
	Main effect	31.195	0.000
High	TBMP	24.478	0.000
	TBPDP	10.266	0.002
Low	Two-way interaction	1.083	0.299
Information systems performance (IP)			

	Main effect	14.120	0.000
High	TBMP	12.032	0.001
	TBPDP	3.998	0.047
Low	Two-way interaction	0.177	0.674

Note: TBPDP and TBMP cell means are provided on the left-hand side of this table.

Fig. 1. Research model.

Time-Based Manufacturing Practices (TBMP)

	Low	High
High	Cell 2	Cell 4 (Post-Industrial)
Low	Cell 1 (Industrial)	Cell 3

Fig. 2 Respondents classified by cell.

	Time-based Product Development Practices (TBPDP)	
Time-Based Manufacturing Practices (TBMP)	Low	High
High	42 (16%)	97 (37%)
Low	96 (36%)	30 (11%)

Note: A total of 265 respondents were split into High or Low cells by TBPDP and TBMP construct means.

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(1) This question is reverse scaled.