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The role of infrastructure practices in the effectiveness of JIT practices: implications for plant competitiveness

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Abstract

Previous research on JIT provides very little insight as to why the same JIT practices are able to foster competitiveness in one plant but fail to do the same in another plant. The premise of this research is that such failures are due to a lack of managerial concern regarding infrastructure practices needed for JIT. The current JIT literature on infrastructure design is largely prescriptive, but the prescriptions are not founded on systematic empirical investigation. In this paper, we examine the role of infrastructure practices in the effectiveness of JIT practices from three perspectives—universal, contingency, and configurational—with data from a study sample of 110 plants. The plants in the study sample belong to three industries—electronics, machinery, and transportation—and are located in three countries—US, Italy, and Japan. Our results support the contingency and the configurational perspectives. Specifically, the analyses based on the contingency perspective indicate that with the exception of manufacturing strategy, all other infrastructure practices—quality management, product technology, work integration system, and human resource management (HRM) policies—individually moderate the relationship between JIT practices and plant competitiveness. The analyses based on the configurational perspective indicate that synergy between JIT practices and infrastructure practices needs to be exploited to attain superior plant competitiveness.

Keywords: Just-in-time; Quality management; Plant competitiveness; Manufacturing strategy; Integrated competitive strategy

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1. Introduction

The primary motivation for adopting JIT practices has been to reduce and ultimately eliminate waste, enhance the quality of the product, and improve delivery efficiency. While many JIT implementations have been successful, many have failed to improve plant performance (Inman and Brandon, 1992; Safayeni and Purdy, 1991; Crawford et al., 1988). Previous research on JIT provides very little insight as to why the same managerial practice is a success in one plant and a failure in another. The premise of this research is that failures are due to a lack of managerial concern regarding infrastructure practices needed for JIT. We propose that effectiveness of JIT practices to enhance plant competitiveness will be minimized without developing and instituting these infrastructure practices. Additionally, we posit that infrastructure practices must fit the core requirements of JIT practices for them to be effective.

The current literature on infrastructure design for JIT is largely prescriptive. The prescriptions are not backed by systematic empirical investigations. In this paper, we examine the relationship between JIT practices and infrastructure practices through theory-driven empirical research. First, we identify the infrastructure practices. Next, we assess the individual and combined effects of the infrastructure practices on the effectiveness of JIT.

In reviewing the literature, we found that infrastructure for JIT is composed of initiatives, practices, procedures, and competencies that create an environment conducive for JIT practices to be effective. After identifying the infrastructure practices, we examine the relationship between these infrastructure practices, JIT practices, and plant competitiveness. Following Delery and Doty (1996), we examine this relationship from three perspectives: universal, contingency, and configurational. A *universal* perspective posits a direct relationship between JIT practices and plant competitiveness. A *contingency* perspective posits that the relationship between JIT practices and plant competitiveness is contingent on the infrastructure practices in a plant. A *configurational* perspective posits that synergy between the infrastructure practices and JIT practices determine plant competitiveness. The configurational perspective is founded on the holistic principle of inquiry aimed at identifying maximally effective patterns of JIT practices and infrastructure practices.

The unit of analysis for this study is a plant. The study sample contains 110 plants from three industries—electronics, machinery, and transportation—located in three countries—US, Japan, and Italy. The remainder of the paper is organized as follows. In the ensuing section, we provide the theoretical background of this study and present the relevant hypotheses. Next, we describe the research setting and discuss research methods. In the penultimate section, we present the results. The last section contains our concluding remarks, implications, and directions for future research.

2. Theoretical background and hypotheses

2.1. JIT practices

Ohno (1982), the originator of JIT, defines JIT as having the right part at precisely the right time, and in the right quantity, to go into assembly. JIT strives to eliminate waste and reduce inventory (Brown and Mitchell, 1991; Sugimori et al., 1977) by simplifying the production process (Schonberger, 1986). Monden is credited with being the first to provide a thorough overview of JIT in a series of articles describing JIT philosophy, the kanban system, production smoothing in JIT, and setup time reduction (Monden, 1981a,b,c,d). Schonberger, another JIT pioneer, projected simplicity as the guiding theme for JIT manufacturing (Schonberger, 1982). Davy et al. (1992) have empirically derived three theoretical constructs underlying the JIT manufacturing system. In another study, Sakakibara et al. (1993) have empirically shown that the dimensions of JIT can be collapsed into three independent factors: (i) management of people and schedules; (ii) simplified physical flow; and (iii) supplier management.

The studies mentioned above show that the definition of JIT varies widely. Review of the literature also reveals that a certain amount of confusion exists over what exactly constitutes a JIT manufacturing system (Groenevelt, 1993). We, therefore, use the following definition throughout this paper. We define JIT practices as practices instituted in a plant to eliminate waste. As noted earlier, the infrastructure practices are activities and mechanisms that provide support for JIT practices to be effective in a plant. Hereafter, we refer to JIT practices and infrastructure practices collectively as JIT manufacturing system, or JIT for short.

Following the above definition, the primary objective of JIT practices is to eliminate waste. Examples of waste include keeping more inventory than necessary, making products before they are demanded by customers, and using long setup times. Elimination of waste is achieved through streamlining the production process with proper equipment layout, and reducing setup time to adhere to the daily schedule made possible by a pull system. Ideally, a pull system extends from suppliers to manufacturers and ultimately to customers—i.e. the supply chain. This definition of JIT practices includes the physical elements of JIT extending from the supplier to the shop floor to the customer, but does not include the supporting infrastructure such as training and teamwork.

Based on the above literature review and focusing on the physical elements of JIT, we conceptualize JIT practices along the following dimensions.

2.1.1. Daily schedule adherence

The ability to meet the schedule for production during each day.

2.1.2. Equipment layout

The extent of use of manufacturing cells, elimination of long conveyers, and use of smaller movable equipment suited for flexible floor layout.

2.1.3. JIT delivery by suppliers

The degree to which vendors are integrated into the production system by a pull system making frequent deliveries as needed.

2.1.4. JIT links with customers

The extent of pull type links with the customer and ability of the production system to respond to changes in customer needs.

2.1.5. The kanban system

The existence and use of the physical elements of a pull system such as a kanban system.

2.1.6. Setup time reduction

The efforts of management and the workers to continually reduce setup time.

Our study is aimed at examining the linkage between JIT practices and plant competitiveness. Plant competitiveness is represented by a composite measure which reflects the performance of a plant relative to other comparable plants in the industry along the following four dimensions: (i) unit cost of manufacturing; (ii) quality of product conformance; (iii) on-time delivery performance; and (iv) flexibility to change product mix (Ward et al., 1998; Hayes and Wheelwright, 1984). JIT practices minimize the use of costly buffers (e.g. work-in-process) and eliminate waste in all stages of production. Thus, unit cost of production is expected to decrease. Reduction in buffer size also provides early warning of potential quality problems in the production process so that the root causes of the quality problems can be identified and fixed. This enhances conformance quality of the product. Reduced setup time enables a plant to run mixed-model production, where a small number of different types of products are produced each day, which in turn helps a plant attain product mix flexibility. Mixed-model production also increases the availability of each type of product. Furthermore, pull type links with suppliers and customers enable a plant to be agile and responsive and, therefore, enhance delivery reliability. Thus, based on the universal perspective, we posit the following hypothesis.

H1. JIT practices will be positively associated with plant competitiveness.

2.2. Infrastructure practices

Infrastructure practices are conceptualized as practices that create an environment that is conducive for JIT practices to be effective in a plant. Mehra and Inman (1992) identified 20 elements that are crucial to JIT implementation. They group these elements into four key factors: (i) JIT production strategy; (ii) JIT vendor strategy; (iii) JIT education strategy; and (iv) management commitment. Golhar and Stamm (1991) argue that the success of JIT manufacturing depends on the implementation of four basic tenets: (i) elimination of waste; (ii) employee involvement in decision-making; (iii) supplier participation; and (iv) total quality control. Lee and Ebrahimpour (1984) point out that implementation of JIT in an organization requires many changes. Management has control over some of these changes such as management understanding and support of the system, management and labor responsibilities, training programs, layout planning and production flow, long-term implementation planning, and supplier management.

In a review of research on JIT implementation, Ramarapu et al. (1995) identified elements that are crucial to the JIT implementation process and grouped these elements into the following categories: (i) elimination of waste; (ii) production strategy; (iii) quality control and quality improvement; (iv) management commitment and employee participation; and (v) vendor/supplier participation. Other authors and researchers have proposed similar critical elements for successful JIT implementation (White and Ruch, 1990; Im and Lee, 1989; Hall, 1987; Suzaki, 1987; Schonberger, 1986; Heard, 1986).

The results of an empirical study by Flynn et al. (1995) suggest that, although TQM and JIT practices function effectively in isolation, their combination further improves plant performance. In the same study, Flynn et al. found that common infrastructure practices alone were significantly related to plant performance. The common infrastructure practices consisted of plant environment, management support, and supplier relationship.

A study conducted by Sakakibara et al. (1997) was the first to emphasize the need for separating infrastructure practices from JIT practices. This study investigated the effect of JIT practices and infrastructure practices on plant performance. Using canonical correlations, this study showed that infrastructure practices as a whole impact plant performance and, therefore, these practices need to be given careful consideration when implementing JIT. This finding leads us to investigate how infrastructure practices interact with JIT practices. More specifically, the research question is: How do infrastructure practices—individually and together—affect the relationship between JIT practices and plant competitiveness? This question guides our current investigations.

As mentioned earlier, a number of practices have been frequently cited as contributing to JIT effectiveness in the literature (Ramarapu et al., 1995; Mehra and Inman, 1992; Golhar and Stamm, 1991; Lee and Ebrahimpour, 1984). We combine these practices into five coherent sets of infrastructure practices. Starting with *quality management* as one of the key practices, we note that researchers have strongly emphasized the need for quality management efforts for JIT to be successful. Other practices also emphasized as critical can be broadly classified as the existence and implementation of *manufacturing strategy* and *product technology*. Also emphasized are several human resource practices that are purported to be crucial for the effectiveness of JIT. The individual HR practices are grouped into two *bundles* of interrelated and internally consistent HR practices: *work integration system* and *human resource management* (*HRM*) *policies* (MacDuffie, 1995). In the following sections, we describe each of these five sets of infrastructure practices and relate them to plant competitiveness using the concept of fit.

2.3. The concept of fit

Fit, in general, means consistency between two or more factors that leads to better performance. To illustrate the concept of fit, let us consider two factors: type of task and type of skill. In a production facility, the types of tasks that need to be performed can be pre-defined (e.g. mass production) or they can be uncertain (e.g. job shop) depending on the kinds of products being produced. The skills that workers need for these two scenarios are different. Specialized workers would best suit the environment in which tasks are pre-defined. On the other hand, multiskilled workers would be appropriate to improve and maintain the efficiency of a job shop. We have used two factors for simplicity in the above illustration; however, fit among several factors (e.g. type of task, type of skill, and type of incentives) can be investigated.

Organizational researchers were among the first to operationalize the concept of fit (see for example, Van de Ven and Drazin, 1985; Aldrich, 1979; Chandler, 1962). The organizational researchers have argued that the fit among strategy, technology, and context improves organizational performance. Examples of context are external environment (Hambrick, 1988; Hofer, 1975), organizational structure (Rumelt, 1974; Chandler, 1962), administrative systems (Galbraith and Nathanson, 1978), managerial characteristics (Gupta and Govindarajan, 1984), and entrepreneurial style (Naman and Slevin, 1993). The concept of fit has also been referred to by other names. For example, in economics, fit has been referred to as "complementarity" (Milgrom and Roberts, 1995, 1990). In the area of innovation and technology management, "synchronous innovation" (Georgantzas and Shapiro, 1993; Ettlie, 1988; Gerwin, 1988; Cohen and Zysman, 1988) and "cooperative competencies" (Tyler, 2001; Chi, 1994) operationalize the concept of fit. In the human resource management literature, "organizational logic" (MacDuffie, 1995) operationalizes the concept of fit.

In this study, we conceptualize fit from two perspectives: the contingency perspective and the configurational perspective. First, we will describe the contingency perspective in the context of JIT practices. Then, we will describe each infrastructure practice and present hypotheses based on the contingency perspective. Finally, we will describe the configurational perspective and state a hypothesis based on this perspective.

2.4. *Contingency perspective*

The contingency perspective is an important theme in organization theory (Galunic and Eisenhardt, 1994). Generally speaking, contingency theory asserts that the effect of a factor cannot be universally superior in all environmental and organizational contexts. When the impact that a predictor variable has on a criterion variable is dependent on the level of a third variable, then the third variable is said to be the moderator of the relationship between the first two variables. The hypotheses based on the contingency perspective are tested by checking for the presence of moderation effects. In the following sections, we explain why the impact of JIT practices (the predictor) is expected to vary across different levels of the infrastructure practices (the moderators). We consider the infrastructure practices one at a time, describing them first, and then arguing for the contingent relationship between the infrastructure practices and JIT practices.

2.4.1. *Quality management*

A quality management program mobilizes the entire organization along with customers and suppliers toward meeting customers' needs. Quality management and JIT practices are mutually reinforcing. Schonberger describes it thus: "Someone asked me once what the connection is between quality and JIT. I said, two peas in a pod. It was a dumb thing to say. I should have said one pea in a pod" (1986, p. 135). This indicates that the need for quality management in a JIT environment cannot be overemphasized. JIT is a *hand-to-mouth* mode of operation due to a minimum buffer between processes. Thus, quality management is of utmost importance since WIP level is very small and a defective unit can cause stoppage in the production line (Lee and Ebrahimpour, 1984). Groenvelt reiterates this notion as follows: "Only when quality of production and reliability of equipment are sufficiently improved is it possible to run [production] smoothly with drastically reduced inventory" (1993, p. 638). Crawford et al. (1988) conclude from their survey of 39 early implementers of JIT manufacturing systems that JIT implementation requires the company to focus on quality in the early stages of the implementation process.

Quality management is a multifaceted concept that emphasizes quality improvement principles throughout the organization. Supplier involvement plays an important role in quality management. Garvin (1983) emphasizes that supplier selection should be based on quality and time, not only on cost criteria. In the same vein, Ansari and Modarress (1986) conclude that a mutually supportive long-term supplier relationship is the best way to achieve quality improvement. Hall (1987) argues that workers, when provided with process and performance feedback in a timely fashion, can make a significant contribution to process improvement and variance reduction. Consistent with the literature, quality management is conceptualized in this study along the following dimensions.

2.4.1.1. Customer focus. The extent of customer involvement and responsiveness, i.e. whether the quality initiatives are customer driven or not.

2.4.1.2. Feedback. Timely feedback about performance in both graphical and verbal forms to the shop-floor personnel.

2.4.1.3. Process control. The extent of use of statistical process control in production to monitor and reduce variation.

2.4.1.4. Supplier involvement. The degree of interaction with the supplier regarding quality concerns in terms of long-term relationships, number of suppliers, and supplier certification.

Variability in quality is one of the main reasons for keeping a buffer stock to prevent downstream machines from being idle. With improvement in quality, buffer stocks can be reduced or eliminated, thereby achieving one of the goals of JIT–WIP reduction. With regard to day-to-day implementation on the shop floor, JIT needs a predictable process. Quality management activities strive to establish a process which is in control, and thus provide support for JIT practices (Hayes, 1981). A predictable process enables a smooth flow of goods through the process with little or no buffer inventory (Takeuchi and Quelch, 1983). Thus, quality management is expected to have a positive effect on the effectiveness of JIT practices.

H2a. The effect of JIT practices on plant competitiveness is moderated by quality management.

2.4.2. Manufacturing strategy

Manufacturing strategy is a long-range vision for the manufacturing function, aligned with the business strategy that sets an overall direction for consistent decision making in manufacturing, in order to gain competitive advantage (Schroeder, 1993). It sets the objectives for manufacturing and mobilizes all the resources toward achieving those objectives. Manufacturing strategy should be clearly defined and communicated throughout the plant.

There is a close connection between the manufacturing strategy of a plant and the managerial practices that are employed in the plant. Sakakibara et al. (1997) point out that this connection is rarely discussed in studies relating to JIT. In a seminal paper, Skinner (1969) stressed the need for the link between an organization's competitive strategy and its production operations. He explains, “The notion is simple enough—namely, that a company’s competitive strategy at a given time places particular demands on its manufacturing function, and, conversely, that the company’s manufacturing posture and operations should be specifically designed to fulfill the task demanded by strategic plans” (Skinner, 1969, p. 138). Thus, for a managerial practice to be effective, the manufacturing strategy must be consistent with the business strategy. Also, a plant with a well-defined manufacturing strategy will be more focused than a plant without a manufacturing strategy, and thus will provide support for JIT. In this study, a well-defined manufacturing strategy is conceptualized along the following dimensions.

2.4.2.1. Manufacturing strategy strength. The efforts to develop a manufacturing strategy and the extent of plant focus.

2.4.2.2. Communication of manufacturing strategy. Management’s efforts to communicate competitive strategy, goals, and objectives throughout the plant.

2.4.2.3. Formal strategic planning. The extent of formalization of the strategic plan as exercised by management which is evidenced by the existence of a written mission, long-range goals and strategies for implementation.

2.4.2.4. Manufacturing–business strategy link. The consistency between the manufacturing strategy and the business strategy, i.e. whether business strategy is translated into manufacturing terms.

Manufacturing strategy sets a long-term goal for the production function. Any managerial practice being employed in an organization should be consistent with the manufacturing strategy. An organization that has a well-defined manufacturing strategy allocates pertinent resources (the workforce, equipment, capital, and so on) and aligns its managerial practices with the manufacturing strategy so that these resources can be efficiently used to meet its objectives. The effectiveness of JIT practices is expected to be higher in an organization that has a well-defined manufacturing strategy than in an organization with one that is not so well defined.

H2b. The effect of JIT practices on plant competitiveness is moderated by manufacturing strategy.

2.4.3. Product technology

JIT manufacturing system is based on the principle of simplicity (Schonberger, 1986). Design principles specifically geared to JIT include simplification and reduction of number of parts (Ettlie and Stoll, 1990). Simultaneous use of quality engineering techniques (Taguchi techniques) and design for manufacturability (DFM) can lead to simple yet robust products that customers value. Elimination of unnecessary parts simplifies the assembly process and enhances product reliability. Some of the elements of JIT practices, such as quick machine setup, can be facilitated through design of the product. In this study, product technology of a plant is conceptualized on the following terms.

2.4.3.1. Simplicity in product design. The efforts to simplify product design and to minimize the number of parts in a product to ease manufacturability and assembly.

2.4.3.2. Customer focus in product design. The efforts to design products that are customer driven.

In a JIT environment, product design that emphasizes fewer parts and ease of manufacturability can significantly simplify the production process (Sakakibara et al., 1997). Thus, product technology is expected to have a positive impact on the effectiveness of JIT practices.

H2c. The effect of JIT practices on plant competitiveness is moderated by product technology.

2.4.4. Work integration system

This is the first of the two human resource bundles in the infrastructure practices. The concept of *bundling* states that bundles of related practices rather than individual practices are more effective because of their overlapping and mutually reinforcing effect (MacDuffie, 1995). Thus, it is possible for a research study, investigating the impact of individual HR practices on performance, to produce misleading results (Ichniowski et al., 1993). The resource-based view of the firm also reinforces the concept of bundling by emphasizing that individual practices have limited ability to generate competitive advantage in isolation, but in combination, these complementary resources help a firm realize competitive advantage to a greater extent (Barney, 1995). Hence, we grouped HR practices into two bundles of interrelated and internally consistent HR practices.

The work integration system consists of those human resource practices that provide a cooperative and communicative atmosphere so that tasks within and across the functional units are coordinated. Such coordination transforms the organization of work into a focused, integrated, enhanced delivery system to gain competitive advantage. Sicotte and Langley (2000) emphasize the need for work integration system particularly in situations characterized by high uncertainty and high equivocality. For this study, the work integration system has been conceptualized along the following dimensions.

2.4.4.1. Interaction facilitation. The supervisors' efforts to encourage and assist workers to work as a team and urge them to express their opinions and cooperate with each other to improve production.

2.4.4.2. Coordination of decision making. The level of communication and coordination maintained among different functional units within the plant.

2.4.4.3. Job rotation. The degree to which managers are moved within and between plants to broaden their skills.

2.4.4.4. Management presence on the shop floor. The level of interaction among managers, engineers, and workers on the shop floor achieved through co-location, face-to-face contact, and frequent visits by managers.

JIT practices make the whole production system very interdependent due to minimal use of buffers between the stages of production. Instituting a work integration system serves a cybernetic or feedback function, providing management with the ability to react to production problems quickly and effectively. Thus, the work integration system is expected to positively impact the effectiveness of JIT practices.

H2d. The effect of JIT practices on plant competitiveness is moderated by work integration system.

2.4.5. HRM policies

The second human resource bundle in the infrastructure practices is human resource management policies. Following MacDuffie, we define HRM policies as “a set of policies that affects the ‘psychological contract’ between the employee and the organization, and hence employee motivation and commitment” (1995, p. 207). According to the behavioral perspective (Wright and McMahan, 1992; Jackson et al., 1989), a managerial practice such as JIT requires unique attitudes and role behaviors in order for it to be effective. HRM policies are the primary means employed to elicit and reinforce the requisite employee behaviors. This implies that if an employer knows what employee behaviors are needed, then the employer will enact HRM policies that elicit these behaviors so that the employer can achieve superior performance with the least amount of employee supervision.

In a similar vein, agency theory (Eisenhardt, 1988; Fama, 1980) explains the relationship between one party (the principal) delegating work to another party (the agent). In a plant, management assumes the role of principal, and a worker assumes the role of agent. The relationship between the principal and the agent is formally expressed in a contract. A contract can be based on the agent’s behavior or it can be based on outcome. In a behavior-based contract, an agent is compensated for what he or she does. On the other hand, in an outcome-based contract, an agent is compensated on the basis of a measurable outcome. While a substantial cost is involved in systematically aligning agents’ behavior that would support management’s goal, monitoring outcomes can also be expensive and difficult. However, the outcome-based contract is reactive which provides ex post control (Flamholtz, 1979). In situations where parties agree to abide by a contract based on outcome, mistakes are identified only after they occur, and there is no mechanism for preventing mistakes. This runs counter to JIT practices that emphasize prevention of all kinds of waste. Therefore, agency theory provides support for a contract based on behavior where JIT practices are used.

Control may be defined as a process that helps align the actions of individuals with the goals of their employer(s) (Tannenbaum, 1968). Snell (1992) categorizes all types of control systems into three categories: (i) behavior control; (ii) output control; and (iii) input control. Behavior control and output control correspond to the contracts based on behavior and output described earlier. Input control is another mechanism that can align the actions of agents with the goals of their principals through careful selection and training practices. The advantage of input control is that it helps *prevent* deficiencies in performance that might be impossible to fix later. Since this mode of control has the potential to prevent waste, it is also referred to as ex ante control (Flamholtz, 1979). We believe that simultaneous application of behavior and input control is best suited for a situation in which JIT practices are employed.

The above discussion demonstrates that implementing an appropriate bundle of mutually supporting HRM policies which is consistent with the core requirements of JIT practices and fosters the proper mode of control can be critical to JIT success. In this study, HRM policies have been conceptualized along the following dimensions.

2.4.5.1. Training. Efforts to upgrade employees' skills and knowledge on a regular basis.

2.4.5.2. Compensation for breadth of skill. Management's efforts to encourage workers and reward them for developing a broad skill base.

2.4.5.3. Multifunctional employees. Extent of cross training provided for employees to perform multiple tasks.

2.4.5.4. Recruiting and selection. Rigor of the recruiting and selection procedure in ascertaining a prospective employee's attitude towards teamwork and his/her problem solving aptitude.

The most consistent approach to HR in production systems that are purposely designed to minimize the impact of individual differences (e.g. mass production) is one based on the notions of command and control (Youndt et al., 1996). However, in an interdependent system such as JIT, employee motivation, commitment and involvement are crucial. Thus, HRM policies that harness these qualities in employees are expected to enhance the effectiveness of JIT practices.

H2e. The effect of JIT practices on plant competitiveness is moderated by HRM policies.

Fig. 1 depicts the operationalization of the universal (H1) and contingency (H2a–H2e) perspectives.

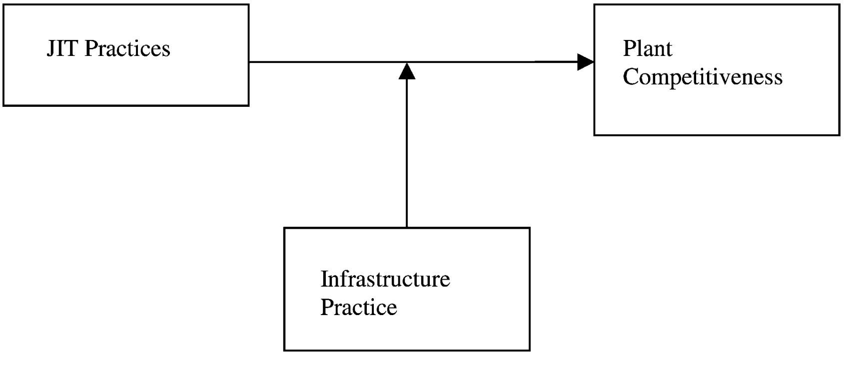

Fig. 1. The effect of an infrastructure practice on the relationship between JIT practices and plant competitiveness from a contingency perspective.

2.5. Configurational perspective

A natural extension of the universal and the contingency perspectives would be to address the research questions guiding this study from a configurational perspective. A configurational perspective draws on the holistic principle of inquiry to identify maximally effective patterns of JIT practices and the infrastructure practices. In the ensuing paragraphs, we distinguish the contingency perspective from the configurational perspective and explain the need for the configurational perspective.

The contingency perspective lets us separately examine how the impact of JIT practices on plant competitiveness is contingent upon each of the infrastructure practices. This mode of examination invokes *reductionism*, "an approach whereby researchers seek to understand the behavior of a social entity by separately analyzing its constituent parts" (Meyer et al., 1993b, p. 1177). The underlying assumption behind reductionism is that an organization consists of loosely coupled aggregates whose separate components can be fine-tuned incrementally to achieve better organizational performance (Meyer et al., 1993a).

In contrast, the configurational perspective is based on the systems view. The underlying assumption behind the configurational perspective is that "the parts of a social entity take their meaning from the whole and cannot be understood in isolation. Rather than trying to explain how order is designed into the parts of an organization, configurational theorists try to explain how order emerges from the interaction of those parts as a whole" (Meyer et al., 1993b, p. 1178). While contingency theorists consider a social system as loosely coupled aggregates, configurational theorists consider it to be tightly coupled amalgams. Thus, unlike the contingency perspective, it is assumed that separate components of a social entity cannot be individually fine-tuned to achieve better performance. Rather, collectively a certain state of the components defines a high performing system.

We believe that the configurational perspective can serve as a natural extension of the contingency perspective. This is consistent with Meyer et al., who observed that: "By synthesizing broad patterns from contingency theory's fragmented concepts and grounding them in rich, multivariate descriptions, the configurational approach may help consolidate the past gains of contingency theory" (1993b, p. 1177). Thus, researchers need to take both perspectives into account to develop an in-depth understanding of a social system.

To describe the relationship between JIT practices, the infrastructure practices and plant competitiveness, we define the *ideal type* which is used to operationalize fit from the configurational perspective. The performance of an organization depends on the compatibility of its practices and infrastructure. A compatible set of managerial practices and infrastructure practices is theoretically expected to yield higher performance. Such a compatible set is referred to as the ideal profile, and the organization having such a profile is said to be of the ideal type. Blalock Jr. (1969) conceptualizes the ideal type as an abstract model, deviation from which can be noted and explained. Any organization that does not fit the ideal profile(s)—i.e. a misfit with respect to the ideal type—is expected to have lower performance and hence be less competitive (see Fig. 2). Thus, the concept of fit provides a way to compare different managerial practice implementations and infrastructures with respect to deviation from the ideal type leading to the following hypothesis.

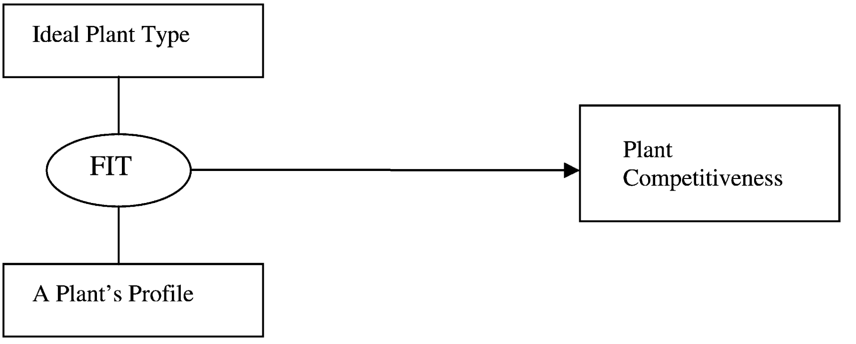

Fig. 2. The fit and its impact on plant competitiveness from a configurational perspective.

H3. The closer the fit of a plant's profile to the ideal type, the higher the plant's competitiveness.

Following Meyer et al. (1993b), this hypothesis will be tested twice—first, with respect to the "theoretical ideal profile," and then with respect to the "empirical ideal profile". While the first profile represents an ideal type based on theoretical assertions, the second one is derived from a subset of the sample representing high performing organizations. Both of these profiles will be described in detail later in the Section 4.

3. Research setting

3.1. Data collection

Plant is the unit of analysis for this study, which is a part of a larger ongoing project aimed at investigating differences in management practices across plants in different countries and industries (Sakakibara et al., 2001). Our study sample is comprised of 110 randomly chosen plants from three industries—transportation, electronics and machinery, in three countries—US, Italy, and Japan. Table 1 presents the distribution of plants across the three industries and the three countries. Managers of the selected plants were contacted by telephone and asked for their voluntary participation in exchange for detailed feedback regarding the status

Table 1
Distribution of the plants in the study sample—by industry and by country

Industry	Country			Total
	US	Japan	Italy	
Electronics	10	17	11	38
Machinery	10	14	13	37
Transportation	10	15	10	35
Total	30	46	34	110

of their practices and performance in comparison to the industry. Sixty percent of the plants contacted agreed to participate and returned the questionnaires. In this study, we used a subset of the data collected from the 110 plants. Surveys from 18 of the 110 plants indicated missing data and were not used for the empirical analysis.

In each plant that agreed to participate in the study, a plant research coordinator was appointed by the plant manager to serve as a liaison with the research team. The plant research coordinator, in consultation with the research team, selected respondents who were capable of providing accurate and unbiased data. Anonymity of responses was maintained by the collection of questionnaires in sealed envelopes. The respondents for the control variables, JIT practices and infrastructure practices variables included managers, engineers, supervisors and workers from the entire plant. The plant manager was asked to respond to the questions related to plant competitiveness (dependent variable). To avoid common respondent bias between the dependent and independent variables, we did not use responses obtained from plant managers on scales that measured the JIT practices and infrastructure practices (independent variables).

The data collection instrument was pre-tested at several plants. The pre-tests included structured interviews with the plant manager, quality manager, process engineer, human resources manager, several supervisors and workers. All of them were asked: (i) whether the right questions were being asked; (ii) whether these questions were easy to understand; (iii) whether there were any other questions that needed to be included; and (iv) who were the right people to respond to the questions. Feedback from the pilot study was used to clarify the language of some questions. Based on the feedback, some items in a few scales were dropped or added.

When the surveys were administered in Japan and Italy, the questionnaires were translated into Japanese and Italian by teams of production and operations management experts from those countries. The surveys were then translated back into English and compared with the original English version of the questionnaires. Any discrepancies were corrected before the surveys were administered in these two countries.

3.2. Characteristics of the plants in the study sample

Table 2 presents some of the key characteristics of the plants in the study sample. *Market share* of the plants' main product varied from 3 to 91% with an overall average of 36%. The common *production processes* in these plants are small batch (26%), and repetitive line processes (33%). One-of-a-kind, large batch, and continuous processes, together, accounted for 41% of the production processes. *Average age* of the 45% *equipment* used in the plants is 5 years or less, while only 11% of the equipment is more than 20 years old. Given that the average age of the plants is about 35 years, the average equipment age suggests that the plants in our study were proactive in their technological investments. Nineteen percent of the plants designed and built their equipment, and about 70% of them either used standard equipment purchased from the vendors or vendor equipment adapted to their specific needs. Direct labor is 17% of the *manufacturing costs* of the plants in the sample, while materials and overhead costs account for 63 and 20%, respectively. This breakdown is typical for manufacturing plants (Krajewski and Ritzman, 1996) and suggests the potential for significant savings if materials are managed effectively in a plant.

Table 2
Description of the plants in the study sample

Measures	Average
What is the market share (in %) held by the main product (or product line) produced at this plant?	36
What percent of product volume falls into each category?	
One-of-a kind (%)	13
Small batch (%)	26
Large batch (%)	13
Repetitive/line (%)	33
Continuous (%)	15
What percentage of the equipment in this plant falls into each of these age categories?	
<2 years old (%)	13
3–5 years old (%)	32
6–10 years old (%)	25
11–20 years old (%)	19
Over 20 years old (%)	11
What percentage of the equipment and processes that you currently use in manufacturing falls into each of the following categories?	
Standard equipment (%)	49
Modified equipment (%)	20
Designed equipment (%)	12
Designed and built (%)	19
What percentage of manufacturing costs falls into each of the following categories?	
Direct labor (%)	17
Materials (%)	63
Overhead (%)	20

Table 3 presents some salient characteristics of the plants organized by country and by industry. These characteristics include levels of management, plant size, and employee turnover rates. The number of levels of management did not differ widely (range = 4.4–3.9=0.5) across the three industries. However, they vary widely (range = 4.8–3.6=1.2) across the three countries.

At first we were surprised that Japan had the largest number of management levels because conventional wisdom is that Japanese plants have flatter organizational structures.

Table 3
Plant description—industry and country-wide differences

	All plants	Italy	Japan	US	Electronics	Machinery	Transportation
Levels of management	4.2	3.6	4.8	4.1	4.4	4.2	3.9
Hourly personnel	739.7	291.7	1277.9	385	489.3	305.3	1515.6
Salaried personnel	437.8	355.1	625.3	187	637.9	186.4	480.3
Number of employees	1177.5	646.8	1903.2	572	1127.2	491.7	1995.9
Turnover rate (hourly employee)	6.6	7.9	5.2	7.2	7.1	7	5.7
Turnover rate (salaried employee)	4.4	6.8	1.5	5.8	4.7	4.3	4.2

However, a closer look explains this apparent contradiction. Our sample contains some large size Japanese plants as evidenced by the number of employees. The average number of employees in Japanese plants is 1903. If we calculate the number of employees per level of management, we find that the Japanese plants have 397 (1903.2/4.8) employees while Italian and the US plants have 180 (646.8/3.6) and 140 (572/4.1) employees, respectively. This indicates that the Japanese plants indeed have flatter organizational structures.

The average annual turnover rate for the hourly employees is the lowest in the transportation industry. There are no significant differences between the average annual turnover rates for salaried employees across the three industries. The average annual turnover rate of the employees in Japanese plants seems to be significantly lower than that of Italian and American plants. Prevalence of a lifelong employment contract in Japan possibly plays an important role in the low rate of turnover.

3.3. Measurement

While some objective measures were used in this study, most of the measurements were performed using perceptual scales, each consisting of several questions (items). Each question was answered using the following five-point scale: strongly agree (5); agree (4); neutral (3); disagree (2); and strongly disagree (1). Reverse-worded items were reverse scored, so that a value of 1 indicated "strongly disagree" and a value of 5 indicated "strongly agree".

According to Nunnally (1967), *content validity* can be ensured through (i) a representative collection of items and (ii) method of test construction. The representative list of items for this study was identified based on a comprehensive review of the extant literature. The test construction method included questionnaire preparation, pilot testing, structured interviews, translation, and back translation when the questionnaires were administered in Japanese and Italian.

Reliability analysis, which evaluates internal consistency, was conducted for each scale at the plant level. Reliability was measured by Cronbach's alpha. Following Nunnally (1967), we used a score of 0.6 or more as a criterion for a reliable scale. All scales used in the analysis exceeded this criterion level.

Construct validity measures whether a scale is an appropriate operational definition of a construct (Flynn et al., 1990). The dimensionalities of the constructs used in this study were verified by performing within scale factor analysis. The items of each factor were checked to see if they loaded onto one factor. An item was deleted if it loaded onto a second factor. Therefore, the scales had to pass both the reliability and unidimensionality tests to be considered for subsequent analysis. The eigenvalue of each scale was required to be more than 1.00. Also, the loading of each item on any scale was required to be in excess of ± 0.40, showing that all the items contributed substantially to their respective scales (Hair et al., 1998). Detailed measures are available upon request.

With the exception of product technology, JIT practices, quality management, manufacturing strategy, and the two human resource bundles—work integration system and the HRM policies—are conceptualized and defined as multidimensional constructs. Each dimension (scale) represents one facet of these broad constructs (super scales) and all pertinent dimensions together define a super scale as a whole. After the scales were checked for reliability and validity, the next step was to aggregate (average) them into super scales or bundles to represent the five broader concepts mentioned above. A set of scales can be aggregated to represent a super scale if these scales load onto a single factor. Therefore, following Hunter and Gerbing (1982), we performed a second-order factor analyses for each of the super scales to ascertain that the set of scales form corresponding unidimensional measures as follows.

3.3.1. *JIT practices*

Six scales were used to measure JIT practices according to the definition of JIT practices described earlier. These six scales were factor analyzed to ascertain that they were measuring a common construct as shown in Table 4. The eigenvalue was greater than 1.00, and the factor loadings of the scales were much above the cut-off value of ±0.40. Also, the reliability of the super scale was found to be 0.86, as shown in Table 4. Thus, the super scale that

Table 4
Reliability and unidimensionality analyses for the super scales, the bundles, and the plant competitiveness measure

Super scale/bundle/ composite measure	Scale/individual measure	Factor loadings	Cronbach coefficient (α)
JIT practices (JITP)	Daily schedule adherence (ADHEREN)	0.79	0.86
	Equipment layout (ELAYOUT)	0.75	
	The kanban system (KANBAN)	0.73	
	Setup time reduction (SETUPT)	0.71	
	JIT delivery by suppliers (DEL_SUP)	0.77	
	JIT links with customers (LINKCUS)	0.82	
Quality management (QUALMNGT)	Customer focus (C_FOCUS)	0.80	0.85
	Feedback (FEEDBK)	0.77	
	Process control (PROCTRL)	0.89	
	Supplier involvement (SUP_INV)	0.84	
Manufacturing strategy (MNFGSTRA)	Manufacturing strategy strength (STRENGT)	0.87	0.86
	Communication of manufacturing strategy (COMMUNI)	0.72	
	Formal strategic planning (STRPLAN)	0.86	
	Manufacturing–business strategy link (MNFG_BUS)	0.89	
Work integration system (WORKINTG)	Interaction facilitation (FACILI)	0.84	0.68
	Coordination of decision making (COOD_DM)	0.84	
	Job rotation (JROTATE)	0.44	
	Management presence on the shop floor (MBWA)	0.85	
HRM policies (HRMPOLI)	Training (TRAIN)	0.87	0.86
	Compensation for breadth of skill (BSKILL)	0.72	
	Multifunctional employees (MULTFUN)	0.87	
	Recruiting and selection (REC_SEL)	0.88	
Plant competitiveness (PLNTCOMP)	Unit cost of manufacturing (UCOST)	0.63	0.62
	Quality of product conformance (CONFQUAL)	0.83	
	On-time delivery performance (DELONTIM)	0.75	
	Flexibility to change product mix (PRODMIX)	0.52	

measures JIT practices is reliable and unidimensional with all of its scales contributing significantly to forming the super scale.

3.3.2. Infrastructure practices

A similar procedure was used to construct the quality management super scale, the manufacturing strategy super scale and the two human resource bundles: work integration system and the HRM policies. The results of the reliability and unidimensionality analyses are also reported in Table 4.

3.3.3. Plant competitiveness

Plants implement JIT to achieve goals which encompass all of the typical operations competitive priorities such as cost, quality, delivery and flexibility (Groenevelt, 1993; Primrose, 1992; Crawford et al., 1988). A composite measure reflecting a plant's achievement along these four dimensions was constructed in order to capture the effectiveness of JIT practices. Operationally, plant managers were asked to compare their plants with the competition in their industry in terms of (i) unit cost of manufacturing; (ii) quality of product conformance; (iii) on-time delivery performance; and (iv) flexibility to change product mix. The ratings were placed on a five-point scale as follows: superior or better than average (5); better than average (4); average or equal to the competition (3); below average (2); and poor or low end of the industry (1). The four individual competitiveness measures were then added to develop a composite measure of plant competitiveness. Table 4 shows that the composite measure is reliable and unidimensional.

3.3.4. Control variables

Plant competitiveness is affected by many factors other than JIT practices and infrastructure practices. Complete identification and elimination of these factors may not be possible due to limitations of the data. Based on our review of the literature (White et al., 1999; Groenevelt, 1993; Primrose, 1992; Inman and Mehra, 1990; Im and Lee, 1989), we identified some of the factors that are expected to impact plant competitiveness but are outside the scope of this study. They are as follows.

3.3.4.1. Plant utilization. The average percentage of plant capacity utilized.

3.3.4.2. Product customization. The extent of customized products produced in the plant (highly customized to highly standardized).

3.3.4.3. Plant size. The size of the plant was measured in terms of the total number of hourly and salaried personnel which was then log transformed.

Plant utilization and product customization measures were standardized by industry and country to remove industry and country differences. We used the natural log transformation of the plant size variable for the following two reasons. First, from a conceptual viewpoint, the relationship between the size of the organization and its structure (centralization and formalization) is not linear because increasing size creates a critical mass which transforms an organization from less centralized and formalized to highly centralized and formalized. Second, from a statistical point of view, the log transformation will reduce the variance in the distribution of plant size values across observations, minimizing scaling problems among independent variables in the regression analysis.

The data for this study were collected from three industries in three countries. In order to compare the above measures on the same basis and alleviate any multicollinearity problems in regression analyses, we standardized all the scales first by industry and then by country. The super scales (quality management, manufacturing strategy) and the HR bundles (work integration system and HRM policies) were then formed by averaging the standardized scales. Table 5 shows the descriptive statistics and the correlation matrix of all the control variables, super scales, HR bundles and the composite competitiveness measure used in this study.

4. Methods

4.1. Universal and contingency perspectives

A universal perspective is the simplest form of relationship that can exist between two variables. Simply put, this perspective states that the value of one of the variables changes with changes in the value of the other. A multiple linear regression is used to test the hypotheses where one or more independent variables are entered as control variables. The statistical significance of the beta coefficient associated with the variable of interest will provide support for the universal perspective.

Following Venkatraman (1989), this perspective is tested using a moderator variable. In general, a moderator is a third variable that affects the direction and/or strength of the relationship between an independent and a dependent variable. Our initial attempt to examine the contingency perspective by estimating an equation that included all the interaction terms encountered serious multicollinearity problems. Typically, such problems are addressed by either centering or standardizing the variables. However, neither of these approaches proved to be adequate in addressing the multicollinearity problems. Following Parthasarthy and Sethi (1993), we estimated the following reduced model to test the contingency perspective:

$$\begin{aligned}\mathrm{PLNTCOMP}_i &= \beta_0 + \beta_1\,\mathrm{PUTILIZ}_i + \beta_2\,\mathrm{CUSTOM}_i + \beta_3\,\mathrm{LNSIZE}_i + \beta_4\,\mathrm{JITP}_i \\ &\quad + \beta_5\,\mathrm{INFRASTRUCTURE}_i + \beta_6\,\mathrm{JITP}_i \\ &\quad \times \mathrm{INFRASTRUCTURE}_i + \varepsilon_i \qquad (1)\end{aligned}$$

where $\mathrm{PLNTCOMP}_i$ is the competitiveness of plant i, $\mathrm{PUTILIZ}_i$ the level of utilization of plant i, CUSTOM_i the extent of product customization in plant i, LNSIZE_i the natural logarithm of size of plant i, JITP_i the extent of use of JIT practices in plant i, $\mathrm{INFRASTRUCTURE}_i$ is an element of the infrastructure of plant i.

The universal perspective will be supported if β_4 is significant. Additionally, we will find support for the contingency perspective if β_6 is significant.

4.2. Configurational perspective

Following Drazin and Van de Ven (1985), and Venkatraman and Prescott (1990), we test the hypothesis based on the configurational perspective (i.e. calculating fit and relating

Table 5
Descriptive statistics and correlations[a]

Variables	Mean	S.D.	1	2	3	4	5	6	7	8	9
1. Plant competitiveness (PLNTCOMP)	14.95	2.36									
2. Plant utilization (PUTILIZ)	79.63	13.89	0.10								
3. Product customization (CUSTOM)	2.91	1.17	−0.10	0.04							
4. ln[plant size] (LNSIZE)	6.22	1.27	0.22**	0.21**	−0.21**						
5. JIT practices (JITP)	3.31	0.37	0.50***	0.22**	−0.20*	0.47***					
6. Quality management (QUALMNGT)	3.50	0.43	0.39***	0.14	−0.16	0.33***	0.65***				
7. Manufacturing strategy (MNFGSTRA)	3.56	0.49	0.52***	0.24**	−0.28***	0.46***	0.62***	0.59***			
8. Product technology (PRODT)	3.68	0.35	0.42***	0.14	−0.08	0.20*	0.49***	0.52***	0.57***		
9. Work integration system (WORKINTG)	3.25	0.39	0.44***	0.14	−0.18*	0.39***	0.63***	0.58***	0.69***	0.55***	
10. HRM policies (HRMPOLI)	3.27	0.35	0.44***	0.24**	−0.16	0.28***	0.59***	0.57***	0.58***	0.58***	0.73***

[a] $N = 92$.
* $P \leq 0.1$.
** $P \leq 0.05$.
*** $P \leq 0.01$.

it to plant competitiveness) using the *profile deviation method*. This method requires the specification of an *ideal profile* and demonstrates that adherence to such a profile has systematic implications for plant competitiveness (Venkatraman, 1989). The three steps involved in the profile deviation method are as follows.

4.2.1. Step 1: identify the ideal profile

Specification of an ideal profile may be done in one of two ways. First choice is to hypothesize a profile that is supported by theory. Second choice is to develop a profile empirically using a calibration sample containing a fraction of the highest performing organizations (Venkatraman, 1989).

An ideal profile derived from theory is not constrained by the characteristics of the organizations in the sample. More specifically, the theoretical approach allows an accurate ideal profile to be specified even if none of the organizations in the sample correspond closely to the ideal type proposed by the theory.

In contrast, an empirical ideal profile specified from a portion of the sample representing high performing organizations is dependent on the characteristics of the organizations in the sample. It is possible that none of the organizations in the sample has reached the maximum level of effectiveness predicted by the theory. Consequently, an ideal profile generated empirically may not correspond to the theory. Therefore, using the theory based ideal profile should result in a more valid test of configurational theories (Doty and Glick, 1994). However, support for the theory would be strengthened if the same hypothesis is *also* supported using an empirical ideal profile. For this reason, we apply both approaches to test the hypothesis based on the configurational perspective.

4.2.1.1. Weighting scheme. The systems method frequently uses Euclidean distance to assess the fit (misfit) with respect to the ideal type. A differential weighting scheme should be used if the dimensions of the ideal type are theorized to have unequal importance. Consequently, a weighted Euclidean distance can be used as the measure of misfit. In such situations, the specification of the weights is crucial as it determines the relative importance of a dimension in relation to the others. According to Doty and Glick (1994), there are at least three approaches for operationalizing the selection of weights:

(i) weight JIT practices and each infrastructure practice equally;
(ii) weight JIT practices and all infrastructure practices equally—i.e. the combined weight of all infrastructure practices will be equal to that of JIT practices;
(iii) weight JIT practices and each infrastructure practice differentially to reflect their a priori theoretical importance.

In option (i), JIT practices' weight is equal to the weight of an infrastructure practice. In this case, the infrastructure as a whole becomes dominant because the weight of JIT practices is one while the total weight of infrastructure is five. We believe that JIT practices and infrastructure as a whole ought to be weighted more equally, so we do not adopt this option.

For this study, we found no theoretical basis justifying differential weighting of the dimensions (e.g. we do not know whether quality management is more important than work integration system in forming a cohesive infrastructure when JIT practices are being employed). Hence, we did not use option (iii).

We adopt option (ii) for this study. Each of the dimensions will be weighed equally (MacDuffie, 1995). We identified five infrastructure practices. Hence, a weight of 0.2 (1/number of infrastructure practices) will be assigned to each of the infrastructure practices so that the total weight of the infrastructure adds to 1.

4.2.1.2. Theoretical ideal profile. As argued above, a high rating on JIT practices along with a high rating on each infrastructure practice should lead to high plant competitiveness. Based on this reasoning, the proposed theoretical ideal profile for JIT is as follows:

JITP	JIT practices	High
QUALMNGT	Quality management	High
MNFGSTRA	Manufacturing strategy	High
PRODT	Product technology	High
WORKINTG	Work integration system	High
HRMPOLI	HRM policies	High

4.2.1.3. Empirical ideal profile. Following Drazin and Van de Ven (1985), and Venkatraman and Prescott (1990), an empirical profile will be generated from the data pool using the following steps. First, the plants will be classified into one of two samples: the "calibration sample" or the "study sample". The "calibration sample" will contain plants whose competitiveness scores are in the top 10%. The other 90% of the plants will be classified as the "study sample". The average values of the JIT practices and infrastructure practices variables for the calibration sample constitute the empirical ideal profile. The empirical ideal profile, thus obtained, is represented by six average values (one for JIT practices and five for the infrastructure). Each of the plants in the "study sample" are then compared to the empirical ideal profile to determine its deviation (misfit) from the ideal profile.

4.2.2. Step 2: calculate fit (or misfit)

From an organizational design point of view, fit can be defined as the consistency across multiple dimensions of organizational design and context (Doty et al., 1993). In this study, fit is the consistency across multiple dimensions of infrastructure practices and JIT practices. Operationally, fit (or, more appropriately, misfit) is the weighted Euclidean distance between a point in a multidimensional space as defined by the ideal profile and a point representing an experimental (or focal) unit (i.e. a unit that is not in the set of the units that defines the ideal profile).[1] The greater the distance (deviation), the greater the misfit. Each plant in the "study sample" will be compared with the ideal profile and the plant's degree of fit (or misfit) will be calculated using the following equation:

$$\mathrm{FIT}_i = \sum_{k=1}^{n} W_k (X_k - X_{ik})^2 \tag{2}$$

[1] However, in the case of a theoretical profile, no unit is used to generate the ideal profile; hence, all units are experimental or focal units.

where FIT_i is the distance between a particular plant i and an ideal plant type, X_{ik} the score of the kth variable of a particular plant i, X_k the score of the kth variable of the ideal plant, W_k the weight of the kth variable, and k the number of variables $1, \dots, n$.

4.2.3. Step 3: link the measure of fit with plant competitiveness

Finally, the relationship between the distances (degree of fit) calculated in step 2 and plant competitiveness will be examined. A significant negative relationship will support the hypothesis based on the configuration perspective. More specifically, we will examine if deviations (FIT_i) are negatively related to plant competitiveness. A significant negative value of β_6 in the following regression model will provide support for the configurational perspective.

$$\begin{aligned}\mathrm{PLNTCOMP}_i = {} & \beta_0 + \beta_1\,\mathrm{PUTILIZ}_i + \beta_2\,\mathrm{CUSTOM}_i + \beta_3\,\mathrm{LNSIZE}_i \\ & + \beta_4\,\mathrm{FIT}_i + \varepsilon_i \end{aligned} \tag{3}$$

where $\mathrm{PLNTCOMP}_i$ the competitiveness of plant i, $\mathrm{PUTILIZ}_i$ the utilization of plant i, CUSTOM_i the extent of product customization done in plant i, LNSIZE_i the natural log of size of plant i, FIT_i the degree of fit between a particular plant i and an ideal plant type.[2]

5. Results

5.1. Universal and contingency hypotheses testing

We used multiple regression models to test specific hypotheses. There are five regression models corresponding to the five infrastructure practices. Included in each model are the control variables, the JIT practices main effect, one of the infrastructure practices main effect, and the corresponding infrastructure interaction term. A significant relationship between the JIT practices main effect and plant competitiveness would support hypothesis H1. Evidence of a positive moderating effect between JIT practices and an infrastructure practice on plant competitiveness exists if the corresponding interaction effect is positive and significant.

We evaluated the assumptions underlying the regression models and examined possible data problems. The normality and homoskedasticity assumptions of the error terms were tested for each of the estimated models, and no violation was noted. Collinearity is a potential problem in multiple regression models containing interaction terms (Jaccard et al., 1990). Standardization of the variables reduced multicollinearity to an acceptable level as evidenced by the variance inflation factor (VIF) ≤ 10. We also computed the studentized residual and Cook's influence statistics to ascertain whether extreme and influential observations biased the results obtained (Neter et al., 1996). However, no such violations were observed.

Table 6 presents the results of the regression analyses. All of the regression models are statistically significant (at a significance level of 0.01). Columns 1–5 correspond to these models. In each of the five columns, the main effect of JIT practices is significantly and

[2] Calculated as the distance between a particular plant i and an ideal plant type along pertinent dimensions.

Table 6
Estimation of the regression models—dependent variable = plant competitiveness (PLNTCOMP)—based on the contingency perspective

	Column 1: test for effect of *quality management*	Column 2: test for effect of *manufacturing strategy*	Column 3: test for effect of *product technology*	Column 4: test for effect of *work integration systems*	Column 5: test for effect of *human resource policies*
Intercept	13.4118***	14.6061***	13.2804***	13.7550***	13.4741***
Plant utilization (PUTILIZ)	0.0424	−0.0988	−0.0427	0.0505	0.0352
Product customization (CUSTOM)	0.0471	0.1275	0.0109	0.0212	0.0804
ln[plant size] (LNSIZE)	0.2030	0.0625	0.2348	0.1561	0.1920
JIT practices (JITP)	0.5399*	0.4836*	0.4898*	0.6263**	0.5567**
Quality management (QUALMNGT)	0.6560*				
JITP × QUALMNGT	0.5568*				
Manufacturing strategy (MNFGSTRA)		1.0262***			
JITP × MNFGSTRA		0.0107			
Product technology (PRODT)			0.6975***		
JITP × PRODT			0.4623*		
Work integration system (WORKINTG)				0.7255*	
JITP × WORKINTG				0.5457*	
HRM policies (HRMPOLI)					0.7614**
JITP × HRMPOLI					0.6286**
F	3.967***	4.875***	4.598***	4.018***	4.759***
R^2	0.22	0.25	0.24	0.22	0.25
Adjusted R^2	0.16	0.20	0.19	0.17	0.20

* $P \leq 0.1$.
** $P \leq 0.05$.
*** $P \leq 0.01$.

positively related to plant competitiveness (at significance levels of 0.05 and 0.10). This provides preliminary support for hypothesis H1 suggesting that other factors being equal, implementing JIT practices alone is associated with superior plant competitiveness.

In addition to the JIT main effect, we also found support for the contingency hypotheses. Table 6 shows that the regression coefficient for the interaction term in all of the equations, except for manufacturing strategy (column 2), is significant and positive (with significance levels between 0.05 and 0.10). These results provide support for hypotheses H2a, 2c–2e, and suggest that there is a positive moderating effect of each of the following infrastructure practices: quality management, product technology, work integration system, and HRM policies.

For the regression results presented in Table 6, R^2 varies between 0.22 and 0.25 (adjusted R^2 varies from 0.16 to 0.20), and the significance levels (P-values) of the interaction terms' coefficients vary from 0.05 to 0.10. Our review of papers employing regression analyses to test contingency hypotheses in field research suggests that the R^2 and P-values that we have observed in our study provide adequate support for the proposed hypotheses (McClelland and Judd, 1993; Morris et al., 1986).

Table 6 shows that the interaction term in column 2 is not significant and, therefore, does not support hypothesis H2b. This implies that manufacturing strategy does not moderate the relationship between JIT practices and plant competitiveness. There are at least two possible explanations for this finding. First, the measures of manufacturing strategy used in this study capture the efforts made by management to implement manufacturing strategy but not the quality of implementation. Second, highly competitive plants may already have manufacturing strategy embedded in their routine decision making process. Hence, such plants may not have to devote as much effort to manufacturing strategy implementation. The less competitive plants, on the other hand, may be devoting significant efforts to manufacturing strategy implementation to improve their competitiveness.

As competitiveness improves, manufacturing strategy implementation efforts are likely to decrease, as such effort becomes routine. In this scenario, a contingent relationship between JIT practices and plant competitiveness at different levels of manufacturing strategy implementation effort can be non-significant or even negative (Bates, 1995). Nevertheless, it is difficult to determine if the lack of support for hypothesis H2b is an aberration due to this specific data set or a true state of nature. Testing the proposed hypothesis using a different set of data in the future would be necessary to shed further light on this relationship.

All in all, the results indicate that the relationship between JIT practices and plant competitiveness is moderated by the infrastructure practices. We conclude that the infrastructure practices should be aligned with JIT practices to maximize plant competitiveness.

5.2. Configurational hypotheses testing

We did not find support for the moderating effect of manufacturing strategy on the relationship between JIT practices and plant competitiveness. This raises a question as to whether manufacturing strategy should be included in the empirical analysis of the configurational perspective. One may choose to exclude manufacturing strategy from the empirical analysis if the contingency perspective is thought of as a stepping-stone for the configurational perspective. On the other hand, one may choose to include manufacturing strategy

Table 7
Estimation of the FIT regression models—dependent variable = plant competitiveness (PLNTCOMP)—based on the configurational perspective

Variable	Manufacturing strategy included		Manufacturing strategy excluded	
	Column 1[a]	Column 2[b]	Column 3[a]	Column 4[b]
Intercept	18.938***	14.395***	18.601***	14.092***
Plant utilization (PUTILIZ)	−0.0023	−0.0044	−0.0013	−0.0038
Product customization (CUSTOM)	0.0537	0.301	0.0336	0.2893
ln[plant size] (LNSIZE)	−0.0699	0.076	−0.0352	0.1067
FIT	−0.6325***	−1.2262***	−0.6074***	−1.1626***
F	9.309***	3.812***	8.558***	3.245***
R^2	0.30	0.17	0.28	0.15
Adjusted R^2	0.27	0.12	0.25	0.10

[a] Theoretical ideal profile.
[b] Empirical ideal profile.
*** $P \leq 0.01$.

in the configurational perspective because it is holistic, where synergy among different infrastructure practices and JIT practices is expected. Therefore, the results obtained in the analysis based on the reductionist perspective (contingency perspective) should not matter. In this study, we conducted an analysis of the configurational perspective both with and without manufacturing strategy (see Table 7) to examine the robustness of our findings.

Column 1 of Table 7 corresponds to the analysis based on the theoretical ideal profile, while column 2 corresponds to analysis based on the empirical ideal profile when manufacturing strategy is included. Both models are significant at a level of 0.01. Following Venkatraman and Prescott (1990), we used the plants with competitiveness scores in the top ten percent[3] (calibration sample) to generate the empirical ideal profile, and the remaining observations were used as the "study sample". A negative significant coefficient of the variable FIT in column 1 provides support for the hypothesis H3. The coefficient of the variable FIT was also found to be negative and significant when the analysis was conducted using the empirical ideal profile approach (column 2) which provided additional support for H3.

Columns 3 and 4 of Table 7 present the results of the configurational analysis when manufacturing strategy is excluded. The results are similar to those found when manufacturing strategy was included except that the R^2 are slightly lower. Thus, the findings based on the configurational perspective seem robust.

5.3. *Implications of the findings*

The results of our empirical analysis support both universal and contingency perspectives. In a situation where both perspectives apply, a main effect is no longer a general effect, but rather a conditional effect (Aiken and West, 1991; Jaccard et al., 1990). Thus, it would

[3] Ten percent of 92 is 9.2, the 10th and 11th plants had very close competitiveness scores so the 11 plants having the highest competitiveness scores were used. Therefore, the number of observations used in columns 2 and 4 is 81 as opposed to 92 in columns 1 and 3 of Table 7.

be inaccurate to infer that implementation of JIT practices alone (i.e. without adequate infrastructure) will achieve superior plant competitiveness. Instead, our findings emphasize the need for infrastructure practices to attain superior plant competitiveness, supporting the contingency perspective.

We also found support for the hypothesis based on the configurational perspective. Agreement of the results obtained from the theoretical and the empirical ideal profile approaches strengthen support for the theory we have proposed. Also, the similar results of the analyses with and without manufacturing strategy suggest that findings based on the configurational approach are robust. Results of the analysis suggest that the proposed configuration of the levels of JIT practices and infrastructure practices provide synergy, and therefore, can serve as a target ideal type for plants that want to enhance their competitiveness.[4]

6. Conclusions and future directions

Despite the widespread adoption and popularity of JIT manufacturing systems, some basic questions remain to be answered. The present study attempts to answer one such question: what is the relationship between JIT practices and infrastructure practices? The current literature is mostly prescriptive regarding infrastructure design and lacks systematic empirical investigation. This study identifies the infrastructure practices and systematically investigates the relationships between JIT practices, infrastructure practices, and plant competitiveness from three perspectives.

The present research introduces the concept of *fit* in the context of JIT practices and infrastructure practices in an attempt to explain why JIT is a success in one plant and a failure in another. We posit that a higher degree of fit between JIT practices and infrastructure practices will result in superior plant competitiveness. We examined the concept of fit empirically from three perspectives: universal, contingency, and configurational. The universal perspective examines whether JIT practices are effective by themselves to ensure superior plant competitiveness. The contingency perspective helps to identify the infrastructure practices that are critical for the successful implementation of JIT practices. The configurational perspective helps us realize that multiple infrastructure practices need to be instituted in order to invoke synergy among JIT practices and infrastructure practices, and thereby attain superior plant competitiveness.

Both from a theoretical and a practical standpoint, this study is valuable in that it introduces the notion of fit between a managerial practice and its infrastructure in general, and JIT practices and infrastructure practices in particular. This study improves our understanding of the interactions between the infrastructure practices and JIT practices. The proposed framework helps managers put these interactions into perspective from a systems viewpoint and recognize different strategic consequences. The framework provides managers with the ability to better design and/or prepare a manufacturing firm for effective and efficient implementation and operation of JIT manufacturing system at the plant level.

[4] We conducted sensitivity analysis of the results with respect to the length of time JIT practices were implemented in a plant. The results of the sensitivity analysis corroborated the robustness of our findings.

In this study, we identified the elements (or content) of infrastructure practices necessary for successful JIT implementation. A logical direction for future research would be to study the process(es) of implementation. Here, process(es) means different ways in which both the JIT practices and the infrastructure practices can be implemented to rapidly achieve superior plant competitiveness. For example, two plants may identify and pursue the same contents of successful JIT implementation; however, the process followed by individual plants can make one plant a high performer and the other a low performer. Longitudinal data will be required to conduct such studies.

While this study examined some interesting hypotheses related to JIT practices and plant competitiveness, there is still much research needed in this area. Our primary focus in this study was limited to understanding the interaction between JIT practices and infrastructure practices within a plant, and its impact on plant competitiveness. A logical extension of this study would be to examine the interactions between JIT practices and infrastructure practices across plants belonging to a supply chain and how such interactions impact supply chain competitiveness.

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