PERGAMON

Omega 28 (2000) 631–651

omega
The International Journal of Management Science

www.elsevier.com/locate/dsw

Just-in-time purchasing: an empirical study of operational practices, supplier development and performance

Alberto De Toni, Guido Nassimbeni*

Università degli Studi di Udine, Dipartimento di Ingegneria Elettrica, Gestionale e Meccanica, Via delle Scienze 208, 33100 Udine, Italy

Received 1 April 1999; accepted 1 January 2000

Abstract

This paper examines the role of supplier development in establishing and managing efficient buyer–supplier operational links. The paper develops and assesses a measurement instrument for "operational" and "supplier development" just-in-time purchasing practices, followed by an examination of the relationships between the two sets, and an investigation into whether the use of "operational" and "supplier development" practices has a bearing on higher plant performance. A plant-level survey was carried out on a sample of electronics and machinery plants. The study empirically:

- documents the close connection between the buyer–supplier operational link and the buyer's practices for supplier development;
- demonstrates that recourse to supplier development programs and their nature depend on the kind of vendor–vendee operational connection;
- test whether different plant performance outcomes result from the implementing of different "operational" and "supplier development" practices. It demonstrates that better-performing plants exhibit more advanced design and logistic links with sources, more formalised vendor-rating and ranking procedures, greater use of organisational devices for supplier-organisational integration and place greater importance on supplier assistance and training.

Keywords: Just-in-time; Buyers; Suppliers; Empirical research

1. Introduction

World-class manufacturing, that is, the "set of processes designed to achieve a suitable global competitive advantage" [41], places particular emphasis on buyer–supplier interaction practices and on the role of the suppliers in the same extended production system [54]. However, the role of procurements in the effective implementation of modern approaches to operations has been a relatively recent rediscovery. Since the early 1980s studies on just-in-time (JIT) have shown a need

* Corresponding author. Tel.: +39-432-558333; fax: +39-432-558251.

E-mail address: nassimbeni@uniud.it (G. Nassimbeni).

0305-0483/00/$ - see front matter
PII: S0305-0483(00)00016-5

to revise traditional supply management practices, in that the JIT system requires rigorous synchronisation of material flow [33,40].

Ever since the 1980s, the interest surrounding effective supplier relationship has grown. Literature on various JIT, total quality management, purchasing, and other operations management fields have dwelled on supplier relations topics such as supplier certification programs, supplier partnership and single sourcing. Within the operations management (OM) studies, a specific stream of research analyses issues concerning JIT buyer–supplier interaction, namely the "JIT purchasing" (JIT-P) stream of contributions. This literature often fails to adequately take into account existing organisation theory (OT) perspectives when exploring the determinants of effective JIT supply relationships. Furthermore, literature on JIT-P abounds in theoretical contributions. However, few studies examine the different JIT-P practices and the sets of practices on the basis of empirical surveys and statistical analyses [44].

In this paper, the authors focus on the supplier development actions set in motion by the buyer, perhaps the most crucial purchasing activity. In fact, the basic objective of the function is to secure supply sources that provide an uninterrupted flow of required materials at a reasonable cost. First, this involves selecting competent suppliers, and then working with them to upgrade their capabilities. A supplier development program can be defined as a systematic organisational effort to create and maintain a network of competent suppliers [19,30,47].

The importance of supplier development becomes even more critical when implementing JIT sourcing programs: JIT creates a demand for increased certainty in supply, in addition to other concessions from suppliers such as improved conformance quality, higher frequency of deliveries and a more customised supply service. In this context, characterised by the presence of specific investments and contractual incompleteness, the organisation theory and the transaction cost economy (TCE) perspective suggest that "relational contracting" [32,51,52] is the appropriate governance form of the buyer–supplier exchange. Supplier development practices represent an essential aspect of the "relational" exchange. The "relational (exchange) approach", unlike the "arm's length" approach, calls for continuous monitoring, assistance, incentives and integration of the pool of suppliers.

On the basis of an empirical research, the study:

- develops and assesses an instrument for measuring "operational" and "supplier development" JIT-purchasing practices;
- analyses the relationships between the two sets of practices, using both OM and OT perspectives;
- compares the use of "operational" and "supplier development" practices in high and low-performing plants, outlining which practices lead to successful JIT implementation.

In summary, this paper explores some key issues concerning the selection of a pool of suppliers integrated into a common design or production chain. Although several other authors have already faced this topic, few studies have carried out a detailed and empirical examination of the crucial relationships between buyer–supplier operational interactions and supplier development activities. The paper shows which aspects of supplier development are important for successful JIT implementation, findings which can also serve as a guide for practising managers.

2. Literature concerning just-in-time purchasing

The first contributions which specifically focused on the impact of JIT practices on procurements were the work of Schonberger and Gilbert [42] and Hahn, Pinto and Bragg [18]. They sparked a series of studies on buyer–supplier operational and relational practices promoted by new approaches to operations, namely JIT purchasing (JIT-P). Schonberger and Gilbert [42] examined a large number of JIT-P practices, including frequent and reliable deliveries, small shipment size, quality assurance methodologies used by suppliers, nearby suppliers or cluster of remote suppliers, standardised packaging, formal and sophisticated vendor rating/ranking instruments, and supplier assistance in meeting quality requirements. In addition, Schonberger and Gilbert discuss the importance of supplier-based reductions and long-term supply contracts towards developing a true JIT link with sources. A series of studies followed these pioneering contributions.

Hall [21,22], following a detailed analysis of the Japanese supply system, broadens the scope of the term JIT-P, describing the suppliers simply as the external extension of the manufacturing plant. The last operational activity within the supplier's plant should be effectively linked with the first operation inside the buyer's plant. The author investigates which supplier selection criteria, production planning procedures, packaging and shipment modes are more conformable to a JIT environment.

Ansari and Modarress [1–3] and Lee and Ansari [29] examined the differences between traditional and JIT-P practices, highlighting benefits and problems encountered in their implementation. The authors investigate issues concerning human (top management commitment, union support) and operational factors (incoming part inspection, mode of transportation, packaging, scheduling) involved in JIT-P programs.

Using a case-study approach, Gupta [17] and Harrison and Voss [23] analysed a few of the issues concerning setting up a JIT supply at the customer's and supplier's plant, focusing on scheduling, shipping and quality assurance practices. Newman [35] and Das and Goyal [9] examined some JIT-P implementation problems from the vendor's point of view and highlight the importance of contractual incentives to the seller towards creating a stable JIT link.

It should be noted that research interest on JIT-P practices has progressively involved different branches of operations management, from production planning to purchasing, from inventory control to materials handling. External and internal JIT dimensions thus become an inter-disciplinary subject.

At present, it is possible to find a heterogeneous series of JIT-P practices in the literature, ranging from deliveries synchronisation to buyer–supplier integrated production planning, from supplier involvement in product development to supplier assistance and training. Notwithstanding their heterogeneity, it is possible to recognise two main classes of JIT-P practices:

- "*Operational*" *practices*, intended as those practices which allow the creation of a link between the buyer's and supplier's operations, namely, product/process development, production planning and scheduling, and delivery;
- "*Supplier development*" *practices*, intended as those practices which are aimed at creating and maintaining a network of competent suppliers, such as supplier selection and monitoring, supplier assistance and training, the provision of incentives for continuous improvements, and supplier organisational integration [30,47].

The two sets of practices are presented in greater detail in the following sections.

2.1. The "operational" practices

The operational link between buyer and supplier develops mainly in three areas, within which different JIT-P practices (hereafter italicised) can be identified:

- **Product/process development.** *The supplier involvement in product/process development* has become an essential element among the set of JIT-P practices available. Lee and Ansari [29] demonstrated that the supplier's technical advice and assistance could generate improved parts design, achieve lower costs and higher quality and productivity. Several studies and empirical observations have demonstrated the benefits of collaborating with the supplier at the product/process design and development stage [6,7,28,45]. These benefits can be summarised as follows: reduction in development costs (early availability of prototypes, consistency between design and supplier capabilities, reduced engineering changes), improved product quality, reduction in overall development time (identifying the supplier's technical problems early on), possibility of incorporating innovations suggested by the supplier [5]. The involvement of the supplier in design activities is usually accompanied by an intense *exchange of information concerning product* (materials and components to be supplied, engineering/industrialisation choices, etc.) engineering and *process* (production cycles and tools, process technologies, etc.). This involves design simplification and product modularisation, component standardisation, the choice of materials, production cycles and processes.
- **Production planning and scheduling.** Several JIT-P practices are involved here: frequent and small-lot supplies (typical of the JIT environment) require synchronisation between contracting orders and scheduling activities, thereby allowing the buyer's and supplier's production planning to integrate with control systems. The latter is a three-stage process [21]. First, the aggregate demand forecasts inform the supplier which materials are needed. This generally leads to the drafting of *blanket purchase orders*. Next, the supplier is sent a copy of the master production plan. With *an integrated production planning system* (i.e. ordering system linked directly to the manufacturer's production system) the supplier has foreknowledge of his client's requirements, thereby improving adherence to schedules. Finally, the materials are shipped to the buyer plant under a pull logic-operated delivery plan. In the short-run both production authorisation and the shipment of materials from the supplier can be achieved through *kanbans*.
- **Delivery.** The JIT supply system ideally involves a reduction in the quantity per shipment and an increase in the frequency of supplies. JIT deliveries, that is *deliveries synchronised* to production requirements, are probably the most discussed JIT-P practice in the literature (see [17,21,40]). There are two other aspects which work together closely and they are:
  - The need for quality at source. The main objective of JIT is to eliminate any source of waste and increase the rate of material flow. The reduction in buffer stocks, specifically the reduction (or elimination) of incoming inspections (*free pass deliveries*), is possible only if the quality of the supplies is consistently high. It becomes essential to have *certified suppliers* to promote an *exchange of information on quality* (joint definition of quality specifications, transmission of quality tests and charts, and transfer of statistical process control data);

- The congruence of packaging. Frequent and small-lot deliveries underline the importance of the vendor–vendee *packaging congruence*: the use of standard, re-usable, automatically identifiable containers can help speed up incoming procedures to the advantage of flow rate [35].

2.2. The "supplier development" practices

"Supplier development" practices, as already mentioned, are the activities necessary in creating and maintaining (controlling, assisting, motivating and integrating) the pool of suppliers [30,47]. Thus, the areas of "supplier development", and their corresponding JIT-P practices, are:

- **Supplier selection and monitoring.** According to the contributions of Cole [8], Willis and Huston [53], Purdy et al. [38], and Weber et al. [48], the creation of a JIT link with the suppliers calls for broader knowledge and more systematic control over the sources. In fact, the JIT system renders the buyer much more vulnerable to interruptions in the flow of materials, requiring more stable links with sources. Thus, the need for *specific and formal procedures for vendor rating and ranking* arises.
- **Supplier assistance and training.** The importance of *supplier assistance and training* during the development of a JIT connection has often been debated in the literature. Bache et al. [4] and Das and Goyal [9], note, for example, that technical and economical resources should be provided to assist suppliers in developing an effective operational link. Inman [24], in the implementation of the total quality management (TQM) program, discusses the importance of training courses aimed at making the suppliers aware of problems involved in quality. The establishment of interactive relationships with suppliers replaces the traditional approach of substituting inefficient sources by giving the supplier support and assistance [31].
- **Supplier incentives.** *Contractual incentives* is one of the mechanisms which stimulate the supplier's development. The length of the contract is a frequently cited benefit: the long-term commitment encourages the supplier to be more innovative and to improve quality and service [1,3,29,31]. In addition to providing greater duration, Newman [35] points out, the supply contract has to take into account the costs sustained by the supplier to implement statistical process control procedures, modifications and/or modernisation of productive assets and facilities to guarantee smoother running operations and an effective JIT link. In other words, the supply contract should compensate the vendor for any additional costs incurred when changes are made in production and logistic/distribution areas [43].
- **Supplier organisational integration.** These are intended to be the *organisational devices* activated by the buyer (meetings with and between suppliers, organisational roles delegated to the link with the main suppliers) to speed up integration with external units. The broader buyer–supplier interdependence area involves not only sales forces on the one side and purchasing forces on the other side, but also other departments within both organisations (such as design, production and quality department). What becomes essential, is to have joint organisational buyer–supplier interfacing roles capable of guiding this wider interaction [47].

Notwithstanding the variety of articles published (see [44,46] for an extensive bibliographic review of JIT-P studies), most of the studies mainly consider "operational" JIT-P practices, devoting less attention to the "supplier development" actions set in motion by the buyer when implementing JIT sourcing programs. In particular, initial research on JIT-P has focused mainly on practices aimed at synchronising the supply flow with internal production activities (such as deliveries of orders on a daily basis and in small lot sizes, the kanban-procurement approach, interaction between the customer's and supplier's MPC Systems). Few subsequent studies, such as [4,8,24], demonstrated the importance of practices concerning the development and management of JIT suppliers (supplier selection, training and incentivation).

Supplier development actions and their importance in achieving effective JIT link-ups with sources has hardly been given the space it deserves in the literature or the attention by management. Krause and Ellram [27] note that supplier development is described as an integral part of many relationships between Japanese Manufacturers and their suppliers. However, the same cannot be said for many firms in the west.

2.3. Relationships between the sets of JIT-P practices: the operations management and the transaction cost economy perspectives

The theoretical justifications of the hypothetical link between the buyer–supplier operational connection and buyer actions aid supplier development (monitoring, assistance, incentives, organisational integration) discussed in OM literature can be summarised as follows:

- The JIT system makes the buyer more vulnerable to supply disruption. The formation of a JIT link with suppliers would thus lead to a broadening and more systematic control of sources, requiring sophisticated and formalised instruments for the suppliers' *per-*

formances monitoring [48,53];

- A design or logistic link would be feasible provided that the supplier possess advanced design, along with productive and logistic capabilities. Their development may require the support and *assistance* of the buyer [4,31]. Moreover, in acquiring these capabilities the supplier may need to invest substantial resources, which would be justifiable only in the presence of adequate *contractual incentives* [1,3,14].
- The operational link involves not only purchasing forces, but also other departments within both organisations. Therefore, *organisational devices* would be necessary in order to oversee this wider interaction and to implement organisational integration between buyer and suppliers [27,47].

As previously mentioned, OM literature fails to adequately take into account existing organisation theory when explaining the links between the different buyer–supplier interaction practices. The transaction cost economy is one of the most important theoretical frameworks in inter-organisation theory and will be adopted here to justify the hypothesised link.

According to TCE, the transaction costs of exchange are the most significant determinants of the governance form of buyer–supplier relationships [49–51]. Transaction costs are largely determined by the extent to which the assets required by the relationship are transaction-specific. The extent to which assets can be redeployed towards alternative uses and by alternative users without sacrificing production value is referred to as "asset specificity". There are three main kinds of asset specificity. The first is site specificity, an example being that of successive stations located in a cheek-by-jowl relation to each other so as to economise on inventory and transportation expenses. The second is physical asset specificity, an example might be that of specialised dies required in the production of components. Human-asset specificity is third creating bilateral dependency and posing added contracting hazards. In addition to this, uncertainty and frequency are two other characteristics of transactions between firms which have an impact on the exchange process [49,51].

According to TCE, the setting up of an advanced buyer–supplier operational link would lead to a breakdown in the traditional "market-based" exchange, based on multiple sourcing choices, priced-based mechanism on sources selection and short-time horizons. Buyer–supplier operational synchronisation and design synergy promoted by the JIT approach are associated with site, physical and human-asset specificity. For example, site assets specificity arises when the supplier locates his warehouses or assembly lines in proximity of the buyer's plant. Physical asset specificity arises when the transaction requires the acquisition of specific tools, and human specific assets can involve the training of personnel, the development of specific quality assurance practices or compatible procedures to meet the partner's idiosyncratic requirements. In addition, the contractual incompleteness associated with the buyer–supplier exchange is augmented due to added environmental and behavioural uncertainty; the exchange becomes more difficult to define ex-ante since it involves not only the supply of an "object" alone, but also complex bi-directional logistic, design and informative services. Moreover, it is also more difficult to measure ex-post, given the difficulty of circumscribing the respective responsibilities and ambiguities in performance evaluation.

In order to protect transaction-specific assets from opportunistic appropriation, and to cope with the effects of exchange uncertainties, buyers will choose to internalise the transaction or otherwise arrange to increase the extent of hierarchical control over the other party. This would give rise to an intermediary solution between the integrated manufacturer and the "market", in that, suppliers and buyers agree to co-operate with one another to form a long-term, co-operative relationship guided by expectations of repeated transactions. This form of relationship is characterised by "relational contracting". Therefore, according to TCE theory, the operational link should have a direct impact on "supplier development" practices since it would require:

- Adequate supplier selection and monitoring actions. In the absence of market-based control mechanisms, the supply exchange could be subject to opportunistic temptations. Williamson [52] observes: "more generally, long-term, incomplete contracts require special adaptive mechanisms to effect realignment and restore efficiency when beset by unanticipated disturbances". The main adaptive mechanism is precisely the constant and careful evaluation of sourcing behaviour: an accurate rating system can restore competitive pressure within the pool of suppliers by monitoring and comparing the supplier's improvement over time. In addition, an accurate multi-dimensional rating can reduce the "contractual hazards" associated with possible buyer-specific investment.
- Supplier assistance and training initiatives. They serve as testimony to the buyer's commitment in setting up a stable and long-term relationship with its sources. Williamson [51] argues that intermediate governance forms are maintained by means of economic weapons such as hostages and credible commitments to keep opportunistic behaviour at bay. Particularly when the design or logistic links require highly specific investments on the part of the supplier, supplier assistance and training initiatives set

in motion by the buyer represent a signal of commitment reciprocity: reciprocal assets tend to moderate opportunistic actions by serving as 'hostage' in the exchange process [51]. Otherwise, an asymmetrical relationship might arise enhancing the risks of exploitation.

- Adequate incentives to suppliers. Only the expectation of stable, more exclusive, long-term relationships provides the incentive for specific investment and mitigates the risks of short-term opportunistic behaviour. Without the perspective of a long-term relationship, that is, without adequate contractual incentives, the suppliers would be reluctant to make specialised investments in support of one another. These incentives are important in order to maintain an efficient exchange in situations where contracts are incomplete, leaving space for opportunistic behaviour.

Notwithstanding the strong conceptual bonds "operational" and "supplier development" JIT-P practices exhibit, they remain largely unexplored on an empirical basis as of yet. In addition, many of the empirical contributions use a case-study approach (and therefore are situation-specific) or present general descriptions of JIT-P implementation issues [27,44]. Thus, what emerges from the literature is a critical need for comprehensive empirical studies.

3. Hypotheses

This study's objectives are to develop and assess a measurement instrument for "operational" and "supplier development" JIT-P practices and to test two hypotheses related to the set of practices considered. The first hypothesis can be expressed in the following terms:

Hypothesis 1. There is a relationship between "operational" and "supplier development" JIT-P practices.

The theoretical justifications of the hypothetical link between the buyer–supplier operational connection and the buyer's action to aid supplier development (monitoring, assistance, incentives, organisational integration) are numerous, both for OM and TCE theory, as outlined in the previous paragraph. This study is intended to examine and test this relationship. However, a specific group of studies can be found in the literature that put the existence of a "true JIT-link" with sources and of real actions of supplier development into discussion. These contributions argue that "most of the costs are the supplier' s and most of the benefits are to the customer' s" in many JIT projects [46]. In other words, the buyer asks the suppliers for a JIT-based supply service without offering substantial compensations (for example in terms of contractual incentives), or investing in sources (for example in assistance and training), that is, without engaging in real actions of supplier development. These actions demand significant (specific) buyer investments, thereby determining higher switching costs. Furthermore, the sources engaged in a "relational" exchange escape from direct market competitive pressure: in the long run this can produce deterioration in their performances. For these reasons, the buyer may prefer to avoid any engagement in supplier development actions which would render him more vulnerable to opportunistic behaviour of sources.

In addition, this study is intended to examine the link between "operational" and "supplier development" practices and plant performance. Plant performance appears to be strictly dependent on the effectiveness of procurement activities (the quality of the supplied materials determines the quality of the final product, procurement lead time and delivery reliability influence time performances, lot size and frequency of deliveries have an impact on inventory levels and therefore on cost performances, etc.). Plant performance thus seems to be dependent on the operational buyer–supplier link and on buyer actions aimed at the development of a network of competent suppliers.

The second hypothesis can be expressed in the following terms:

Hypothesis 2. Better-performing plants exhibit a higher use of "operational" and "supplier development" JIT-P practices.

4. Methodology

To test these hypotheses, a sample group consisting of 52 plants was surveyed and data collected. The methodological steps have been summarised in the following paragraphs.

4.1. Research approach and survey strategy

The plant will serve as our unit of analysis since the JIT-P practices analysed are implemented at the plant level. The sample is composed of Italian plants employing more than 100 people. A dual stratified, random sampling strategy was adopted to select plants according to industry and type. The study concentrated on the electronics and machinery industries where JIT implementation and interaction with the suppliers are competitive variables of ever increasing importance [16]. Within each industry, the plants were

stratified under "traditional" or "advanced". By "advanced" plants we mean those which are reputed as high performing in their sector. This choice of stratification is justified by the need to analyse and compare JIT-P practices in different performing plants.

All plants were selected at random, "traditional"

Table 1
Characteristics of sample plants

	Mean (entire sample $n = 52$)	Distribution	
		Sub-samples	Percentage of plants
Sales (millions $)	88.2	Under 5	33.3
		5–38	33.4
		Over 38	33.3
Incidence of purchase on sales	48.3	Under 40%	31.7
		40–60%	50.1
		Over 50%	18.2
Number of employees	613	Under 250	40.4%
		250–800	34.6
		Over 800	25.0
Production process			
One of a kind[a]	20.2%	Under 2%	50.0
		2–30%	30.0
		Over 30%	20.0
Small batch	40.4%	Under 15%	30.4
		15–60%	34.7
		Over 60%	34.9
Large batch	20.8%	Under 2%	41.3
		2–40%	42.0
		Over 40%	16.7
Semi-repetitive	27.2%	Under 5%	44.2
		5–40%	30.2
		Over 40%	25.6
Repetitive	1.7%	Under 8%	91.5
		Over 8%	8.5
Kind of products			
Highly customised[a]	31.2%	Under 5%	39.1
		5–30%	34.8
		Over 30%	26.1
Somewhat customised	17.9%	Under 5%	48.8
		5–25%	23.3
		Over 25%	27.9
Standard with custom options	29.8%	Under 5%	31.8
		5–30%	36.4
		Over 30%	31.8
Somewhat standardised	25.6%	Under 15%	40.0
		15–60%	30.0
		Over 60%	30.0
Highly standardised	7.7%	Under 10%	82.6
		Over 10%	17.4

[a] The figure represents the average value of this characteristic within the sample. Therefore, the sum of these values, which is equal to 100% within each firm, can be other than 100% when referred to the entire sample.

plants were selected from the Kompass [26] list of Italian plants, "advanced" plants from a master list compiled by the authors turning to experts from the two industries as their source of information. These experts were consultants operating for several Italian agencies. We compared their information with that given by plant and production managers of firms operating in the sectors analysed.

Initially, the plant managers were contacted by letter. We explained to them the aims of the project in greater detail and then asked whether they were willing to co-operate. The plants that had agreed to take part were then visited, qualitative information was gathered and direct personal contact established. This contact strategy resulted in a high response rate (60%). The data and their elaboration refer to a sample of 52 units, 25 in the electronics sector of which 14 are "traditional" and the remaining are "advanced" plants, and 27 plants in the machinery sector of which 16 were listed as "traditional" and 11 as "advanced". The principal characteristics of the sample are reported in Table 1.

4.2. The measurement instrument

The questionnaires were developed in four stages. First, prior research was reviewed to identify the existing objectives and perceptual measures of the practices analysed. Existing measures were identified in the works of Sakakibara et al. [39] and Flynn et al. [12,13]. Other measures were developed and validated in previous research work by the authors ([10,34]). When available, existing measures were then adapted to facilitate their use in this study. Second, we developed new perceptual measures ("formalised vendor rating/ranking procedures", "organisational integration devices", "supplier assistance and training", "contractual incentives", "information exchange on product", "information exchange on production process", "integrated production planning", "packaging congruence", these scales are reported in Appendix A) using 5-point Likert-scales. Third, the initial version of each scale was reviewed by some plant managers. During this phase, the operationalisation process of each practice was tested and the wording simplified. Finally, scales and objective items were assembled into different questionnaires targeted at various plant-level respondents.

The items of each perceptual scale were spread throughout the questionnaires in order to prevent the respondents from recognising the construct analysed. Each item was addressed to at least three respondents in order to reduce subjectivity. The greater part of these questions was addressed to the purchasing, plant and production managers. Some of the questions were also directed to the quality manager, process engineer, information system manager, two supervisors and four workers to make a total of 12 respondents per plant.

An internal research co-ordinator was appointed to each plant. His job was to administer and collect the questionnaires. The participants were assured of strict confidentiality. Not all the co-ordinators returned the entire questionnaire set. We received 497 usable responses, an overall response rate of 79.6% for all groups of respondents. To test the inter-rater reliability for respondents in the same plant, a one-way analysis of variance was performed for each of the measures comparing within-plant differences with between-plant differences. All measures exhibited significantly greater between-plant variation than within-plant variation. According to Georgopoulos [15], under such conditions it is correct to aggregate data at the higher level of aggregation and the constructs were calculated using the mean of the respondent's scores.

4.3. Validation of the measurement instrument

All measures were subject to:

- Reliability assessment. It was operationalised as the internal consistency of the item in each scale. Initially, items making up the scale which did not correlate were deleted prior to undergoing analyses. Subsequently, Cronbach's alpha (see for example [55]) was calculated for each scale. All the constructs have an alpha value greater than the cut-off value (0.6) which is considered acceptable for newly developed scales [36]. The Cronbach-alpha values of all (newly developed and adapted) scales are reported in Table 2.
- Validity assessment. The main types of validity, i.e. content and construct validity, were verified respectively:
  - by reviewing the literature and the theoretical revisions used by the authors. This was then compared with the answers given by a few of the firm managers sampled;
  - by using factor analysis to test the uni-dimensionality of multi-items perceptual measures. In order to guarantee the convergence of all items of each scale to a common factor, items were dropped unless the scale had a minimum eigenvalue of 1.00 and each item factor loading was greater (in absolute value) than 0.40 [25]. The scales showed high validity and only in certain cases the existence of more than one underlying dimension led to the elimination of certain items.

Table 2 summarises the measurements used, their mean, standard deviation, reliability coefficient, and operational definition. Table 3 indicates the results of the factor analysis for construct validation, showing

Table 2
Summary of measures

Measures	No. of items of the construct[a]	Mean	Standard deviation	Cronbach alpha	Operationalisation
Supplier development					
Formalised vendor rating/ranking procedures	4	3.80	0.97	0.85	Evaluates, through perceptual questions, the level of normalisation of the vendor rating/ranking procedures, referring to the main performances parameters (reliability, quality, service, technological and productive competence)
Organisational integration devices	2	3.33	0.88	0.64	Determines, through perceptual questions, if the buyer uses organisational devices (= organisational interfacing roles and periodic meetings with the sources) in order to promote the supplier integration
Supplier assistance and training	5	3.06	0.69	0.73	Evaluates, through perceptual questions, nature and intensity of the assistance and training provided to main suppliers
Contractual incentives	3	1.69	0.60	0.82	Evaluates, through perceptual questions, if the supply contract rewards the main suppliers for increases in the quality and reliability of supplies and for a reduction in the component development and delivery time
Operational link					
Product/process development					
Supplier involvement in product development	4	3.26	0.86	0.84	Evaluates, through perceptual questions, the nature and intensity of the main supplier's involvement in product development activities
Information exchange concerning the product	3	3.59	0.77	0.82	Surveys, through perceptual questions, the intensity of the information exchanged during the product development activities regarding the products and components to be supplied and the choice of materials
Information exchange concerning the production process	3	3.01	0.83	0.90	Surveys, through perceptual questions, the intensity of information exchanged regarding production cycles, process and tools used
Production planning and scheduling					
Shared production forecasts (blanket purchase orders)	–	29.7%	35%	–	Evaluates the percentage of purchasing (value) via blanket purchase orders (objective data)
Integrated production planning	3	3.43	0.87	0.70	Evaluates, through perceptual questions, if the internal production planning system is integrated with that of the main suppliers
Pull (kanban) procurement approach	3	2.24	0.91	0.96	Evaluates, through perceptual questions, if there is a "kanban/pull system" in the plant and between the plant and the suppliers
Delivery					
Deliveries synchronisation	3	2.92	0.66	0.66	Evaluates, through perceptual questions, if the deliveries are frequent and in small lots
Free pass for deliveries	–	15.7%	28.3%	–	Determines the variation (in percentage) of the incoming materials (value) accepted for use in manufacturing, without inspections, evaluated over the last four years (objective data)
Suppliers quality certification	3	3.35	0.73	0.70	Detects, through perceptual questions, if the plant uses certified suppliers

(continued on next page)

Table 2 (*continued*)

Measures	No. of items of the construct[a]	Mean	Standard deviation	Cronbach alpha	Operationalisation
Information exchange concerning quality	4	3.66	0.71	0.85	Evaluates, through perceptual questions, the availability and use of information concerning the quality of the materials supplied, the results of quality tests and trials carried out by the supplier, statistical process control data from suppliers of critical parts
Packaging congruence	3	3.05	0.83	0.76	Detects, through perceptual questions, if the packaging used by the main suppliers meets specific requirements and is consistent with the loading and handling requirements of the plant

[a] Only for perceptual measures.

the eigenvalue and the portion of variance explained by the first factor and the factor loadings of the items in each scale.

There is a list of scales and items used for the measurement of the various constructs in Appendix A.

4.4. Data analysis

Data analysis was carried out in several consecutive steps.

4.4.1. Preliminary analysis

A factor analysis (principal component method with varimax rotation) was conducted on the "operational" measures. Many of the practices analysed are closely correlated. Factor analysis was therefore carried out to uncover the underlying dimensions between the measures, eliminating problems of multicollinearity between them and ultimately reducing the number of variables to a limited number of orthogonal factors [11]. Furthermore, factor analysis was utilised to verify the articulation of the "operational" practices proposed in Section 2.1. Factors with eigenvalues greater than 1 were included. The matrix of correlation coefficients among the "operational" measures is reported in Table 4 and the rotated matrix of factor loading is shown in Table 5.

The orthogonal factor rotation identifies three main factors:

1. The first factor (Table 5) shows how the practices of "deliveries synchronisation", "integrated production planning", "shared production forecasts" (blanket purchase orders), "packaging congruence", and "pull (kanban) procurement approach" all converge. This accounts for more than 37% of the total variance and is defined hereafter as the "logistic link".
2. The second factor shows the convergence of the following practices: "information exchange on product", "supplier involvement in product development", and "information exchange on process". This accounts for more than 17% of the total variance and is defined hereafter as the "design link".
3. The third factor is made up of the following converging practices: "information exchange on quality", "free pass deliveries", and "supplier quality certification". This accounts for more than 9% of the total variance and is defined hereafter as the "quality link".

It must be pointed out that the results of the factor analysis partially modify the "operational" practices classification proposed in Section 2.1. While the practices of "product/process development" clearly show a separate factor, two practices of the sub-area "delivery", that is "deliveries synchronisation" and "packa-

ging congruence'', have a greater affinity with the practices of the sub-area ''production planning and control''. Finally three of the practices placed in the sub-area ''delivery'' and concerning the buyer–supplier quality interaction identify a separate factor (''quality link'').

Even if the bi-variate correlation coefficients between the ''supplier development'' measures were not suspect, we performed a factor analysis on these measures too. The orthogonal factor rotations confirmed that each of the four practices analysed was independent.

4.4.2. Testing Hypothesis 1

Relationships between the two sets of practices were analysed using both a bi-variate (zero-order Pearson's correlation) and a multivariate (canonical correlation) approach, applied to the four ''supplier development'' variables and the three ''operational'' dimensions identified by the orthogonal factor analysis. The results, reported respectively in Tables 7 and 8, may be summarised as follows:

1. The first canonical correlation coefficient is quite large (0.757, Table 8) and the statistical significance ($P = 0.000$) of the first canonical variate is satisfactory. Hypothesis 1 is therefore supported: there is a significant relationship between ''operational'' and ''supplier development'' JIT-P practices.
2. The ''design link'' is the ''operational'' dimension which is most closely connected to the ''supplier development'' variables examined. In fact, it dominates the first canonical variate (factor loading = 0.597, Table 8), followed by the ''logistic link'' dimension (factor loading = 0.394). In addition,

Table 3
Factor analysis by scale

Measures	Eigenvalue associated with the first factor	Percentage of variance explained by the first factor	Factors loadings				
			Item #1	Item #2	Item #3	Item #4	Item #5
Supplier development							
Formalised vendor rating/ranking procedures	2.66	70	0.44	0.85	0.87	0.87	–
Organisational integration devices	1.47	74	0.86	0.86	–	–	–
Supplier assistance and training	2.45	49	0.63	0.69	0.86	0.74	0.55
Contractual incentives	2.23	74	0.86	0.87	0.86	–	–
Operational link							
Product/process development							
Supplier involvement in product development	2.75	69	0.87	0.89	0.73	0.81	–
Information exchange on product	2.22	74	0.85	0.90	0.83	–	–
Information exchange on production process	2.53	85	0.91	0.92	0.92	–	–
Production planning and scheduling							
Integrated production planning	1.89	63	0.68	0.84	0.85	–	–
Pull (kanban) procurement approach	2.79	93	0.96	0.97	0.97	–	–
Delivery							
Deliveries synchronisation	1.76	59	0.69	0.85	0.74	–	–
Supplier quality certification	1.92	64	0.51	0.89	0.93	–	–
Information exchange concerning quality	2.82	70	0.87	0.91	0.74	0.83	–
Packaging congruence	1.99	67	0.83	0.77	0.83	–	–

Table 4
The matrix of correlation coefficients[a]

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Deliveries synchronisation	1.00										
2. Shared product forecasts (blanket orders)	0.54**	1.00									
3. Integrated production planning	0.43**	0.44**	1.00								
4. Pull (kanban) procuring approach	0.51**	0.56**	0.33*	1.00							
5. Supplier quality certification	0.32*	0.15	0.13	0.34*	1.00						
6. Free pass for deliveries	0.18	0.14	0.16	0.31*	0.33*	1.00					
7. Packaging congruence	0.56**	0.38**	0.58**	0.52**	0.19	0.130	1.00				
8. Information exchange on product	0.22	0.41**	0.20	0.43**	0.15	0.22	0.42**	1.00			
9. Information exchange on process	0.19	0.25	0.41**	0.37**	0.45**	0.23	0.30*	0.29*	1.00		
10. Information exchange on quality	0.25	0.23	−0.10	0.28*	0.55**	0.58**	0.038	0.12	0.22	1.00	
11. Supplier involvement in product development	0.37**	0.41**	0.21	0.41**	0.25	0.36*	0.45**	0.80**	0.26	0.27	1.00

[a] (*Signif. LE 0.05; **Signif. LE 0.01 (2-tailed)).

what emerges following the analysis of the bi-variate correlations (Table 7) is that significant relationships exist between the "design link" and three of the "supplier development" practices, especially "supplier assistance and training" ($r = 0.458$, $P = 0.001$, Table 7) and "contractual incentives" ($r = 0.501$, $P = 0.000$). Vice versa, the "design link" seems to be weakly associated with "formalised vendor rating/ranking procedures". This practice was found to significantly correlate only with the "quality link" ($r = 0.354$, $P = 0.011$). Finally, the "logistic link" shows a significant connection with "supplier assistance and training" ($r = 0.414$, $P = 0.003$) and "organisational integration devices" (0.301, P = *0.032) practices.*

The "design link" is thus seen to be the factor most correlated to the supplier development actions set in motion by the buyer firm.

4.4.3. Testing Hypothesis 2

Prior to testing the second hypothesis, we compared "traditional" and "advanced" plants in term of their performance, in order to verify the statistical difference between the two sub-samples. Three main performance dimensions were selected: quality (management's perception of plant quality performances), time (management's perception of plant time performances), and cost (management's perception of plant cost performances).

The *t*-tests for equality of means in "traditional" and "advanced" plants, reported in Table 6, generally show a significant statistical difference (with an interval of confidence of 95%) between the two sub-samples.

Discriminant analysis was then utilised to compare the use of "operational" and "supplier development" JIT-P practices in low and high-performing plants. Discriminant analysis is the appropriate statistical technique when the dependent variables are categorical and the independent variables are metric [20]. In our case, the dependent categorical variable corresponds to the affiliation group of each plant ("traditional" and "advanced" plants), while the independent metric variables correspond to the "operational" and "supplier development" JIT-P practices. Results of the analysis are presented in Table 9. The discriminating factors are: "formalised vendor rating/ranking procedures" ($P = 0.008$), "organisational integration devices" ($P = 0.008$), "supplier assistance and training" ($P = 0.000$), "logistic link" (0.011), and "design link" (0.001). Table 9 shows the relative contribution of each independent factor to the discriminant function, as indicated by the standardised discriminant coefficient. The multivariate F test indicates that the discriminating factors were significant, with $P = 0.001$. In addition, the classification matrix in Table 9 reveals that 86.54%

Table 5
The factor loadings of the rotated factor matrix

	Factor 1 "logistic link"	Factor 2 "design link"	Factor 3 "quality link"
Deliveries synchronisation	*0.8267*	0.1910	0.1667
Integrated production planning	*0.7273*	0.1884	−0.2286
Shared production forecasts (blanket orders)	*0.7145*	0.2416	0.1467
Packaging congruence	*0.6928*	0.4236	−0.1543
Pull (kanban) procurement approach	*0.6628*	0.3181	0.2734
Information exchange on product	0.1931	*0.9055*	0.0958
Supplier involvement in product development	0.2490	*0.8098*	0.2575
Information exchange on product process	0.2474	*0.5088*	0.1408
Information exchange on quality	0.0027	0.0499	*0.9147*
Free pass for deliveries	0.2234	0.1158	*0.7069*
Supplier quality certification	0.1133	0.3305	*0.6521*
Eigenvalues	4.16	1.94	1.04
Percent of total variance explained by rotated components	37.9%	17.7%	9.5%

of the cases were correctly classified by the discriminant function.

These results generally support the hypothesis whereby "advanced" plants have a higher use of three "supplier development" practices and two "operational" dimensions.

5. Discussion

5.1. Hypothesis 1

As hypothesised, the set of "operational" JIT-P practices statistically correlates with the set of "supplier development" practices. However, the canonical correlation has indicated how the three "operational" dimensions play a somewhat different role in determining such a link. For this reason, the link between each "operational" dimension and the "supplier development" practices examined will be discussed separately.

5.1.1. "Quality link" — "supplier development" practices

The connection between the vendor–vendee quality practices and formalised vendor rating/ranking procedures ($r = 0.354$, $P = 0.011$, Table 7) is in agreement with the empirical evidence resulting from other research work [4,8,38,45]. The implementation of such practices can be considered a prerequisite for JIT. The elimination of slack resources and the tighter inte-

Table 6
Comparison between the two sub-samples

	Means		
	'Traditional' plants $n = 30$	'Advanced' plants $n = 22$	*t*-test probability
Management's perception of plant quality performances (5-point Likert scale)	3.48	4.10	0.001
Management's perception of plant time performances (5-point Likert scale)	2.7	3.4	0.010
Management's perception of plant cost performances (5-point Likert scale)	2.87	3.46	0.025

Table 7
The matrix of bi-variate correlation coefficients[a]

	1.	2.	3.	4.	5.	6.	7.
1. Formalised vendor rating/ranking procedure	1.000						
2. Organisational integration devices	0.117 (0.417)	1.000					
3. Supplier assistance and training	0.284* (0.044)	0.489** (0.000)	1.000				
4. Contractual incentives	−0.023 (0.873)	0.415** (0.002)	0.251 (0.075)	1.000			
5. Quality link	0.354* (0.011)	0.175 (0.218)	0.292* (0.038)	−0.092 (0.517)	1.000		
6. Logistic link	0.184 (0.197)	0.301* (0.032)	0.414** (0.003)	0.041 (0.771)	0.000 (1.000)	1.000	
7. Design link	0.209 (0.139)	0.365** (0.008)	0.458** (0.001)	0.501** (0.000)	0.000 (1.000)	0.000 (1.000)	1.000

[a] In parentheses the significance (2-tailed) level P: *$0.1 < P < 0.05$; **$P < 0.01$.

gration of the process in accordance with a JIT logic appear to be possible only if the flow offers adequate quality assurance.

This operational dimension also appears to be moderately connected with the practice "supplier assistance and training" ($r = 0.292$; $P = 0.038$, Table 7). The implementation of quality practices by the suppliers may require the support of the buying firms. The correlation coefficients between the "quality link" and the two remaining supplier development practices are not significant. Evidently, a buyer–supplier exchange limited to quality problematics does not justify the use of organisational integration devices and contractual incentives on the part of the buying firm.

5.1.2. "Logistic link" — "supplier development" practices

This "operational" dimension appears to be linked to two "supplier development" practices: "supplier assistance and training" ($r = 0.414$, $P = 0.003$, Table 7) and "organisational integration devices" ($r = 0.301$, $P = 0.032$, Table 7). In the literature the correlation between the buyer–supplier logistic link and supplier assistance is frequently pointed out. To justify this link it is generally argued that the JIT production and supply system requires both parties to make a series of changes in the form of product and process improvements, simplification of the material flow along the pipeline, increased resource flexibility, stabilisation of production programs, improved communication, and co-ordinated plans for the transport of materials. JIT supply, that is, frequent, reliable and well-timed deliveries, requires the supplier to reshape his own production and logistic system, whereby adopting appropriate quality control methods and implementing compatible management systems [37]. This research thus confirms that the buyer's firm often assists the supplier's plant in carrying out these necessary changes.

The connection between the logistic link and the contractual incentives to suppliers is often noted in the literature, since an increase in the frequency and reliability of supplies means additional costs for suppliers in the areas of scheduling, handling and packaging activities. The JIT interaction should therefore include appropriate contractual incentives to compensate the supplier for the greater quality and service content and increased costs sustained. The empirical evidence from this survey, however, disproves such a link ($r = 0.041$, $P = 0.771$, Table 7) and indicates, instead, that contractual incentives accompany the design link. This result will be discussed below.

5.1.3. "Design link" — "supplier development" practices

The dimension "design link" is closely linked to three "supplier development" actions, namely, "contractual incentives" ($r = 0.501$, $P = 0.000$, Table 7), "supplier assistance and training" ($r = 0.458$, $P = 0.001$), and "organisational integration devices" ($r = 0.365$, $P = 0.008$). In addition, the canonical correlation analysis (Table 8) points to the "design link" as the most important factor in triggering "supplier development" actions. Possible reasons for this high degree of correlation seem to be the following:

- The collaboration in product development is a highly complex and demanding operation for both parties involved. This, therefore, leads to more decisive and extensive actions of supplier organisational integration than the other "operational" dimensions.
- The supplier's participation in the design of the product, and thus the admittance of external designers to the development teams, characterises plants structurally and culturally receptive to the contributions of the sources. Involving suppliers in the product development phase implies a change in mentality. The aim is to create a more open and long-term relationship overcoming that old, traditional and antagonistic mind set. In this type of environment (cultural sooner than operational) initiatives of supplier qualification (assistance and training) find a more natural setting.
- The most distinctive capabilities from the buyer's point of view, such as the ones which make the supplier a resource to invest in, are those which the supplier can put back into the product, namely, material selection, joint development of prototypes, value analysis, reduction or standardisation of the components. In other words, the buyer supports suppliers who above all can prove their capability at increasing the value of the object supplied as well as the final product. This would explain why the buyer is more disposed at offering contractual incentives to those suppliers that collaborate in the design process.

5.2. Hypothesis 2

From the results of the discriminant analysis, better-performing plants exhibit a stronger design ($P = 0.001$, Table 9) and logistic links ($P = 0.011$) with sources. Thus, it has been confirmed that plant performance, being dependent also on procurement activities, is influenced by the presence of JIT-based link with the pool of suppliers.

At the same time, the analysis demonstrates that better-performing plants tend to develop more formalised vendor rating and ranking procedures ($P = 0.008$, Table 9), use organisational devices for supplier organisational integration ($P = 0.008$) and give greater importance to supplier assistance and training ($P = 0.000$).

Table 8
Canonical correlation: results

	First canonical variate
Canonical correlation	0.757
Redundancy R^2 (operational link → supplier development practices)	17%
Redundancy R^2 (supplier development practices → operational link)	12%
Statistical significance (Bartlett test)	$P = 0.000$
Supplier development practices	Canonical loadings
Organisational integration devices	*0.502*
Formalised vendor rating/ranking procedures	0.392
Supplier assistance and training	*0.802*
Contractual incentives	0.341
Explained variance	29%
Operational link	
Quality link	0.323
Logistic link	0.394
Design link	*0.597*
Explained variance	21%

Two factors fail to discriminate between plants: "quality link" and "contractual incentives". In relation to the first dimension, comparing the average value of these measures with the rest, we see that two of them have values that are among the highest ("supplier quality certification": 3.35, "information exchange on quality": 3.66, range: 1–5, Table 2). A possible explanation can be that the practices regarding management and quality control of entry flows have by now become widespread even among the "traditional" plants, given the ever more exacting market demand on quality.

"Contractual incentives" do not constitute a discriminating factor between plants as design link does, even though both factors were found to correlate closely. Analysing the data we find that none of the plants with an under average design link make significant use of contractual incentives. These are mostly plants classified as "traditional". However, only 65% of the plants with an over average design link and classified as "advanced" have significant "contractual incentives". On the other hand, the average value of these measures is low (mean = 1.69, range: 1–5, Table 2), a demonstration that the contractual incentive is, in general, used only by few firms for supplier development.

From a theoretical point of view, these results confirm the relationship between buyer–supplier operational links and the buyer's actions for supplier development. However, these results demonstrate that the intensity of the hypothesised relationship depend on the operational link with sources. Quality, logistic and design interactions are associated with different supplier development practices.

From a managerial perspective, the results of this study raise several issues that have implications for supply management practice. First, the study suggests that appropriate supplier development actions should be adopted when the buyers develop an advanced operational link with sources. Moreover, these actions should depend on the kind of links developed with sources. The buying organisation should select the supplier development practices that are more appropriate for quality, logistic, and design interactions. While supplier assistance and training actions support all three links examined (quality, logistic, design) formalised vendor rating/ranking procedures are more likely to be developed when a quality link is established. Furthermore, organisational integration devices and contractual incentives should accompany the design link in

Table 9
Discriminant analysis: factor discriminating performances[a] and classification matrix[b]

	Means		Univariate *F*-statistics	Standardised discriminant coefficient
	'Traditional' plants $n = 30$	'Advanced' plants $n = 22$		
Supplier development practices				
Formalised vendor rating/ranking procedures	3.483	4.204	0.008	0.387
Organisational integration devices	3.040	3.682	0.008	0.245
Supplier assistance and training	2.740	3.564	0.000	0.737
Contractual incentives	1.632	1.712	0.638	−0.548
Operational dimensions				
Quality link	−0.469	0.062	0.705	−0.423
Logistic link	−0.305	0.402	0.011	0.171
Design link	−0.402	0.529	0.001	0.529

Actual group	No of cases	Predicted group membership	
		'Traditional' plants	'Advanced' plants
'Traditional' plants	30	27 (90%)	3 (10%)
'Advanced' plants	22	4 (18.2%)	18 (81.8%)

[a] Multivariate *F* test: $P = 0.001$.
[b] Percent of grouped cases correctly classified: 86.54%.

particular. The study shows that managers should foster supplier development initiatives once a design link is established. Co-operation in product development activities implies more intensive personnel interaction and an a higher exchange of product and process technology information. Moreover, the design link is more customer-oriented and the supplier involved in co-design activities is in general more difficult to replace. Therefore, the design link presents higher supplier development requirements.

In addition, our study shows which operational links and supplier development actions have a stronger relationship with plant performances. In order to enhance the plant's competitive position, managers should emphasise logistic and design links with sources. The development of an efficient and reliable pool of suppliers integrated in design and logistic activities requires formalised vendor rating/ranking procedures, organisational integration devices and supplier assistance and training initiatives. The evidence indicates that these three supplier development actions, together with design and logistic links, discriminate between better-performing plants and "traditional" ones.

6. Conclusions

On the basis of an empirical research, this study has analysed the relationships between "operational", "supplier development" JIT-P practices and plant performances. The results obtained can be summarised as follows:

- An instrument capable of measuring the two sets of JIT-P practices has been developed and assessed;
- The study empirically documents that the various "operational" JIT-P practices considered show three underlying factors: "quality link", "logistic link" and "design link". Each of these factors can be interpreted as manifesting a distinct type of interaction.
- The study demonstrates the connection existing between the "operational" and the "supplier development" practices of the buyer. This connection depends on the type of operational interaction. The "quality link" is accompanied by the use of formalised tools for supplier monitoring. The "logistic link" is correlated to supplier assistance initiatives and to organisational devices for supplier integration. The "design link", being significantly connected with three of the four practices examined ("contractual incentives", "supplier assistance and training", "organisational integration devices"), seems to be the most important factor in triggering the supplier development actions set in motion by the buyer firm.
- It has been shown that better-performing plants make more use of the JIT-P practices examined. Plants classified according to performances can be explained in terms of their operational link with sources (the "quality link" dimension being the only exception) along with actions aimed at developing a pool of suppliers (the "contractual incentives" practice being the only exception). This result highlights the importance of "supplier development" and "operational" JIT-P practices for overall plant performance.

In conclusion, it is worth remembering that this study involved only two sectors in one country. The results of the study need to be verified in other sectors and countries, where the problematics and dynamics of the buyer–supplier relationships may be significantly different. It should also be remembered that each company exhibits its own specificity in terms of the operating system, nature of the processes, level of decomposability of productive tasks, and technological features, making the various forms of interaction with suppliers diversely critical. In any case, the study offers precise indications on which practices are more likely to lead to good performances.

Appendix A. Scale and non-scale listing

Supplier development

- **Formalised vendor rating/ranking procedures**

  Indicate the degree of formalisation you use to evaluate suppliers, referring to the parameters below:

  (parameter 1 = not formalised . . . 5 = aspects formalised and analysed in detail)

1. 1 2 3 4 5 Reliability and promptness of Delivery
2. 1 2 3 4 5 Quality
3. 1 2 3 4 5 Service
4. 1 2 3 4 5 Level of technological and productive competence of the supplier

* 1 2 3 4 5 Total cost of supplies

* 1 2 3 4 5 Financial strength

- **Organisational integration devices**

1. In our firm it is the specific task of some people to follow the problematics of the most important suppliers
2. Our firm periodically organises meetings with the suppliers

* Our firm encourages a strong interaction between our engineers and technicians and those of our main suppliers

- **Supplier assistance and training**

Which of the following forms of assistance/collaboration are provided for the main suppliers?
(1 = none . . . 3 = occasionally activated . . . 5 = regularly activated)

1.	1	2	3	4	5	Organised visits to the supplier
2.	1	2	3	4	5	Organised visits to your firm
3.	1	2	3	4	5	Technical assistance
4.	1	2	3	4	5	Managerial assistance
5.	1	2	3	4	5	Transfer of productive tools
*	1	2	3	4	5	Financial aid

- **Contractual incentives**

1. The contract drawn up with our main suppliers in general stipulates rewards for increases in the quality of the supplies
2. The contract drawn up with our main suppliers in general stipulates rewards for a reduction in the component development and delivery time
3. The contract drawn up with our main suppliers in general stipulates rewards for respecting agreed delivery times

* The contract drawn up with our main provides that target prices be periodically adjusted.

Operational link

Product/process development

- **Supplier involvement in product development** — (adapted from [39])

1. Some of our suppliers are involved in the design of our products/components
2. Some of our suppliers are involved in the industrialisation of the products/components
3. Some of our suppliers are involved in the activity of simplification/modularisation of our products
4. Some of our suppliers are actively involved in product development activities

- **Information exchange on product**

1. We exchange information/evaluations with our suppliers during the design and/or industrialisation stages of our products/components
2. There is an intense exchange of information and suggestions, with our main suppliers, regarding the choice of materials for the components to be supplied
3. We have an intense exchange of design information and suggestions with our main suppliers, regarding products and components supplied

- **Information exchange on production process**

1. We have an intense exchange of information and suggestions, with our main suppliers, regarding production cycles
2. We have an intense exchange of information and suggestions, with our main suppliers, regarding the productive tools used
3. We have an intense exchange of information and suggestions, with our main suppliers, regarding production processes

Production planning and scheduling

- **Shared production forecasts** — (adapted from [39])

_% Percentage of purchasing (value) via blanket purchase orders with call off scheduling by the plant.

- **Integrated production planning**

1. Our planning system is not limited to programming the use of the internal production capacity but also takes into account the capacity of some main suppliers
2. We inform our main suppliers about the forecasted use of the production capacity so that they can be prepared on time
3. Changes in the production plans are passed on to our suppliers at once

- **Pull (kanban) procurement approach** — (adapted from [39])

1. In regard to some components, our suppliers fill our kanban containers, rather than filling purchase orders
2. In regard to some components, our procurement system is based on a predefined number of kanban containers which are exchanged with the suppliers when necessary

3. In regard to some components, shipments from our suppliers are regulated by a kanban pull system

Delivery

- **Deliveries synchronisation** — (adapted from [39])

1. Our suppliers deliver to us on short notice
2. We receive daily shipments from the main suppliers
3. Shipments from our main suppliers are the right quantity to satisfy our immediate needs
* We rely on just-in-time deliveries from many of our suppliers

- **Free pass for deliveries** — (adapted from [39])

Taking 100 as the total value of purchased materials, what percent of the incoming material is accepted for use in manufacturing without inspection during the years given in the table?

Four years ago %	Two years ago %	Current year %

- **Supplier quality certification** — (adapted from [12,13])

1. We use mostly suppliers we have certified
2. We rely on a small number of high quality suppliers
3. Quality is our number one criterion in selecting suppliers

- **Information exchange on quality** — (Adapted from [12,13])

1. Data concerning the quality of parts and components under consideration for purchasing are at our disposal
2. We can easily use data from tests (of quality) conducted by a supplier or by an independent laboratory
3. We require evidence of statistical process control from suppliers of critical parts
4. Our suppliers have to send us information/documents certifying the results of specified tests and inspections on materials

- **Packaging congruence**

1. Containers and packaging procedures of incoming materials from our main suppliers correspond to our precise requirements
2. The incoming materials from our main suppliers can be automatically identified (bar-coding)
3. Our main suppliers use packaging instruments (pallet-containers) suited to our internal handling system
* When evaluating the total cost of supplies, we even consider the packaging procedures

Performances

Please indicate your opinion about how your plant compares to its competitors in your industry, on a global basis (adapted from [12]).

1.	1	2	3	4	5	Unit cost of manufacturing
2.	1	2	3	4	5	Product and process quality
3.	1	2	3	4	5	Product delivery time

The items noted by an asterisk (*) were dropped to improve the validity and reliability of the measurement instrument.

References

[1] Ansari A, Modarress B. Just-in-time purchasing: problems and solutions. Journal of Purchasing and Materials Management 1986;22(2):11–5.

[2] Ansari A, Modarress B. The potential benefits of just-in-time purchasing for US manufacturing. Production and Inventory Management 1987;28(2):30–6.

[3] Ansari A, Modarress B. Just-in-time purchasing. New York: The Free Press, 1990.

[4] Bache J, Carr R, Parnaby J, Tobias AM. Supplier development systems. International Journal of Technology Management 1987;2(2):219–28.

[5] Bonaccorsi A, Lipparini A. On the emergent role of suppliers in the innovative process. In: International Product Development Conference on New Approaches to Development and Engineering, Brussels, May, 1992.

[6] Clark K. Project scope and project performance: the effect of parts strategy and supplier involvement on product development. Management Science 1989;35(10):1247–63.

[7] Clark K, Fujimoto T. Product development performances. Boston: Harvard Business School, 1991.

[8] Cole GS. The changing relationship between original equipment manufacturers and their supplier. International Journal of Technology Management 1988;3(3):299–324.

[9] Das C, Goyal SK. A vendor's view of the JIT manufacturing system. International Journal of Operations and Production Management 1989;9(8):56–67.

[10] De Toni A, Nassimbeni G. Operational and organisational JIT purchasing attributes: underlying dimensions and relationships. In: Draaijer D, Boer H, Krabbendam K, editors. Management and new production systems. Twente: University of Twente, 1995.
[11] Dillon W, Goldstein M. Multivariate analysis — method and applications. New York: John Wiley & Sons, 1984.
[12] Flynn BB, Schroeder RG, Sakakibara S. The impact of quality management practices on performance and competitive advantage. Decision Sciences 1995;26(5):659–91.
[13] Flynn BB, Schroeder RG, Sakakibara S. A framework for quality management research and an associated measurement instrument. Journal of Operations Management 1994;11(4):339–66.
[14] Galt JDA, Dale BG. Supplier development: a British case study. International Journal of Purchasing and Materials Management 1991;27(1):16–22.
[15] Georgopoulos BS. Organizational structure, problem solving and effectiveness. San Francisco: Jossey-Bass Inc, 1986.
[16] Gilbert JP. The state of just-in-time implementation and development in the USA. International Journal of Production Research 1990;28(6):1099–109.
[17] Gupta YP. A feasibility study of JIT purchasing implementation in a manufacturing facility. International Journal of Operations and Production Management 1990;10(1):31–41.
[18] Hahn CK, Pinto PA, Bragg DJ. Just-in-time production and purchasing. Journal of Purchasing and Materials Management 1983;19(4):2–10.
[19] Hahn CK, Watts CA, Kim KY. The supplier development program: a conceptual model. Journal of Purchasing and Materials Management 1990;Spring:2–7.
[20] Hair JF, Anderson RE, Tatham RL, Black WC. Multivariate data analysis. Englewood Cliffs: Prentice Hall, 1995.
[21] Hall RW. Zero inventories. Homewood, IL: Dow Jones-Irwin, 1983.
[22] Hall RW. Attaining manufacturing excellence. Just-in-time, total quality, total people involvement. Homewood, Il: Dow Jones-Irwin, 1987.
[23] Harrison A, Voss C. Issues in setting up JIT supply. International Journal of Operations and Production Management 1990;10(2):84–93.
[24] Inman RA. Quality certification of suppliers by JIT manufacturing firms. Production and Inventory Management Journal Second Quarter 1990;58–61.
[25] Kim JQ, Mueller CW. Factor analysis: Statistical methods and practical issues. London: Sage Publications, 1978.
[26] Kompass. Kompass Italia: General yearbook of Italian economy. Torino: Kompass Italia, 1992.
[27] Krause DR, Ellram LM. Critical elements of supplier development. European Journal of Purchasing & Supply Management 1997;3(1):21–31.
[28] Lamming R. Strategic options for automotive suppliers in the global market. International Journal of Technology Management 1990;5(6):649–84.
[29] Lee S, Ansari A. Comparative analysis of Japanese just-in-time purchasing and traditional US purchasing system. International Journal of Operations and Production Management 1985;5(4):5–14.
[30] Leenders M. Supplier development. Journal of Purchasing and Materials Management 1989;Spring:47–55.
[31] Lyons F, Krachenberg AR, Henke Jr WJ. Mixed motive marriages: what's next for buyer–supplier relations? Sloan Management Review 1990;Spring:29–36.
[32] Macneil IR. Relational contract: what we do and do not know. Wisconsin Law Review 1985;4:483–525.
[33] Monden Y. Toyota production system. Norcross: Industrial Engineering and Management Press, 1983.
[34] Nassimbeni G. Factors underlying operational JIT purchasing practices. International Journal of Production Economics 1996;42(3):275–88.
[35] Newman GR. The buyer–supplier relationship under just-in-time. Production and Inventory Management Journal Third Quarter 1988;45–50.
[36] Nunnally JC. Psychometric theory. New York: McGraw-Hill, 1978.
[37] Prida Romero B. The other side of JIT in supply management. Production and Inventory Management Journal Fourth Quarter 1991;1–2.
[38] Purdy L, Astad U, Safayeni F. Perceived effectiveness of the automotive supplier evaluation process. International Journal of Operations and Production Management 1994;14(6):91–103.
[39] Sakakibara S, Flynn BB, Schroeder RG. A framework and measurement instrument for just-in-time manufacturing. Production and Operations Management 1993;2(3):177–94.
[40] Schonberger RJ. Japanese manufacturing techniques. New York: The Free Press, 1982.
[41] Schonberger RJ. World-class manufacturing. The lessons of simplicity applied. New York: The Free Press, 1986.
[42] Schonberger RJ, Gilbert J. Just-in-time purchasing: a challenge for US industry. California Management Review 1983;26(1):54–68.
[43] Seshadri S. Supplier incentives and resources constraints under uncertainty. Managerial and Decision Economics 1994;16:89–98.
[44] Stamm CL, Golhar DY. JIT purchasing: attribute classification and literature review. Production Planning and Control 1993;4(3):273–82.
[45] Turnbull P, Oliver N, Wilkinson B. Buyer–supplier relations in the UK automotive industry: strategic implications of the Japanese manufacturing model. Strategic Management Journal 1992;13:159–68.
[46] Waters-Fuller N. Just-in-time purchasing and supply: a review of the literature. International Journal of Operations and Production Management 1995;15(9):200–36.
[47] Watts CA, Hahn CK. Supplier development programs: an empirical analysis. International Journal of Purchasing and Materials Management 1993;Spring:11–7.
[48] Weber C, Current J, Benton W. Vendor selection criteria and methods. European Journal of Operation Research 1991;50(1):2–18.
[49] Williamson OE. Markets and hierachies: analysis and antitrust implications. New York: The Free Press, 1975.

[50] Williamson OE. Transaction costs economics: the governance of contractual relations. Journal of Law and Economics 1979;22:3–61.
[51] Williamson OE. The economic institutions of capitalism. New York: The Free Press, 1985.
[52] Williamson OE. Comparative economic organization: the analysis of discrete structural alternatives. Administrative Science Quarterly 1991;36 (6):269–96.
[53] Willis T, Huston CR. Vendor requirements and evaluation in a JIT environment. International Journal of Operations and Production Management 1990;10(4):41–50.
[54] Womack JP, Jones DT, Ross D. The machine that changed the world. New York: McMillan, 1990.
[55] Zeller RA, Carmines EG. Measurement in the social sciences. Cambridge: Cambridge University Press, 1980.