

The Buyer-Supplier Exchange in the Presence of Design, Logistic and Quality Interactions: Results of an Empirical Research

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Abstract

On the basis of empirical research on a sample of Italian plants, this study:

- analyses the relationships between advanced buyer-supplier operational interaction practices (design link, logistic link, quality link) and the basic options of the buyer's purchasing strategy, such as: sources selection criteria, supply base reduction policies, long-term perspectives granted to suppliers (stability of procurement);
- compares these operational practices and purchasing policies in different performing plants. In other words, this study verifies if advanced buyer-supplier interaction practices and "cooperative" supply management policies exhibit a predictive validity of the plant performances.

The survey involved 497 respondents in 52 plants of two industries (electronic and mechanical). The study demonstrates that the establishment of an advanced operational link with sources significantly influence the basic option of the buying firm's purchasing strategy. In addition, it demonstrates that better performing plants exhibit a higher level of design and logistic interactions and a better use of long-term supply agreements with sources.

1. Introduction

"Traditional" supply management is characterised by four elements (Jackson 1985). First, the buyer interacts with many suppliers (order fragmented into several sources), in order to maintain multiple market alternatives and promote bidding competition among them. Second, the supply relationship is short-term, since the buyer wants to retain the possibility of switching the actual supply relationships quickly and opening new ones depending on favourable market opportunities. Third, price is the main vendor selection criteria, determined by competitive pressure in the supply market. Fourth, the customised effort of sources is kept low, since the buyer wants to have ready source replacement possibilities.

These four elements characterise "traditional" ("adversarial" or "arm's length") supply management. Though not recent, the debate concerning the conditions of its practicability, efficacy and efficiency, and its advantages and disadvantages in comparison with "non-market exchanges", is now of great topical interest (Johnston and Lawrence 1988, Helper 1991, Imrie and Morris 1992). For example, in recent years great attention has been given to the automotive Japanese supply system, which is reputed to be one the major success factors of the Japanese automotive industry (Womack et al. 1990, Fruin 1992, Richardson 1993).

The new current interest in the different forms of buyer-supplier exchange is to a large extent promoted by the diffusion of new approaches to operations. Management and production systems such as "Just in Time", "Total Quality Management" and "Concurrent Engineering" promote the adoption of quality control tools spread along the supply chain, integrated coordination of production flows, cooperation between all those units (inside or outside the firm's boundaries) involved in the product development. The new innovative "lean production practices" need to be implemented along the full production and logistic

chain for full exploitation, in order to synchronise the flows at the upper and lower end of the supply pipeline (Lamming 1996). In this context, Transaction Cost Economy (TCE) theorists would predict a failure of the traditional market-based exchange, that is, a failure of procurement logic based on "multiple sourcing", on a priced-based mechanism in the sources selection, on short term horizons (Williamson 1979, 1985). In fact:

- the buyer-supplier operational synchronisation and design synergy promoted by new approaches are associated to higher level assets specificity. For example, JIT and TQM Systems can require the development of specific quality assurance practices, the acquisition of specific tools, training of personnel, development of compatible procedures to meet the partner's idiosyncratic requirements. These investments present a tangible and intangible component. If the upper seem to be dominant in the initial stages of the advanced buyer-supplier link establishment, the latter ("human specific assets") develops mainly in the successive stages and is responsible for the gradual and continuous improvement of products and processes. Even the co-design approach requires specific investments, either in dedicated assets (i.e.: the acquisition of compatible CAD-CAM Systems) or in human skills. The joint product development is a process presenting a relevant "tacit" component and requiring narrow interaction between the designer and product engineers in order to provide prompt and continuous bi-directional feedback. This kind of innovative synergy needs relational resources distributed over time and matured through the progressive deeper knowledge of the partner's requirements;
- the contractual incompleteness associated to the buyer-supplier exchange becomes higher, due to the higher amount of environmental and behavioural uncertainty. In other words, the exchange becomes more difficult to define ex-ante, since it involves the supply not only of an "object" alone, but also of complex bi-direction logistics, design, informative services. Moreover, it is also more difficult to measure ex-post, given the difficulty to circumscribe the respective responsibility and the performance evaluation (and valorisation) ambiguity.

The first of these two variables (specific investment) exhibits an effect whose ambivalence is directly proportional to the second variable (contractual incompleteness):

- on one hand, specific investments constitute a necessary requirement to achieve high levels of "qualitative matching" between demand and offer;
- on the other hand, the inevitable contractual incompleteness leaves open space to opportunistic temptations (=unilateral appropriation of rents) solicited by the presence of specific investment itself.

Thus, according to TCE theory, the establishment of an advanced buyer-supplier operational link (that is, a link characterised by extensive product and processes complementary tasks) should depend on adequate incentives, in particular incentives to transaction specific investments, and in general incentives to foster those intense information exchanges, know-how sharing, process improvements promoted by the new approaches to operations. The most evident incentives are more exclusive relationships (possibly single sourcing agreements) and long-term contracts, which should:

- justify the transaction-specific investment;
- allow the "continuous improvement" perspective;
- mitigate opportunistic temptations. In other words, the perspective of a win-win relationship in the long run, should prevail on opportunistic tension in the short run.

In TCE terminology, the exchange should move from a "market-based" to a "relational" logic (Williamson 1985, 1991). Anyway, "relational-exchange" constitutes a risky alternative to the market, because the buyer becomes more vulnerable to opportunistic behaviour of sources. Furthermore, the sources engaged in a relational (=long term, exclusive) exchange escape from direct market competitive pressure: in the long run this can produce a worsening of their performances.

Both empirical research and theoretical debate exhibit contrasting positions about the advantages of long-term, stable supply relationships and about the diffusion of a true "relational" buyer-supplier exchange in western context (Sako et al. 1995, Helper 1991, Lamming 1990). Waters-Fuller (1995), following extensive review of JIT Purchasing literature, synthesises this diversity of positions by comparing two lines of thoughts: the "sceptical school" and the "advocate school". The first school asserts that exclusivity and longevity are associated to higher switching costs (i.e. lower source replacement possibilities), higher risks of supply disruptions and technological obsolescence. Therefore, the "cooperative" supply relationship produces in the long run an inefficient form of sourcing.

The second school considers the advantages of JIT sourcing (development of a congruent logistic network with consequent lower inventories, higher delivery reliability, improvements in product quality and delivery lead-times, lower supply management administrative cost, ...) prevailing over risks. In spite of the abundant literature on this topic, few contributions document on an empirical basis the actual evolution in buyer-supplier relationships, especially through comparative analysis, whether by cross national comparison of industrial change or sectoral transformation (Imrie and Morris 1992). In addition, most of the studies show only anecdotal evidence and qualitative analysis (Kalwani and Narayandas 1995). Much still remains unexplored, for example: have traditional supply management practices been substituted by more cooperative approaches, in particular in those industries in which strong operational buyer-supplier inter-dependencies can significantly improve the system performances? What is the real extent of this change? What kind of relationships are more likely to lead to good performances? (Helper 1991).

2. The hypothesis

This study considers the three main operational buyer-supplier links (De Toni and Nassimbeni, 1995, Nassimbeni 1996):

- *design link*. This consists in the involvement of suppliers in buyer's product development activities. The competitive necessity to shorten the product-life, to enhance the frequency of new-product launches, and the need to incorporate into new products higher content of technology have promoted a quick diffusion of this practice in many industries (Lamming 1990). Several empirical observations have demonstrated the benefits of collaborating with suppliers at the product/process design and development stages: reduction in development costs (early availability of prototypes, consistency between design and supplier's capabilities, reduced engineering changes), improvement in product quality, reduction in overall development time (due to early identification of the supplier's technical problems), possibility of incorporating innovations suggested by the supplier (Clark 1989, Clark and Fujimoto 1991, Turnbull et al. 1992);

- *logistic link*. This is accomplished when the supplier's deliveries are frequent and therefore small-lot sized, perfectly respondent to the buyer's quantity and quality requirements, rigorously synchronised with the buyer's production schedules. The logistic link supports the implementation of Just-in-Time, whose basic elements are: production flow pulled by the market, reduction of any kind of waste, reduction or elimination of inventories so that the production flow can progress without interruptions. The complete implementation of the JIT approach requires the strong support of sources: without de-coupling elements between the (internal and external) production units, a tight integration and synchronisation between the order contracting, scheduling, delivering activities is needed between all the units of the production chain;
- *quality link*. This is accomplished when the buyer and the supplier exchange information concerning quality aspects (joint definition of quality specifications, transmission of quality tests and charts, transfer of statistical process control data). This kind of link usually constitutes a pre-requisite for the implementation of the logistic one, since the direct supply of the production line (free pass deliveries) and the elimination of material buffers are possible only if the quality of the supplies is consistently high. However, the need to certify the suppliers and exchange information with them on quality can occur even for materials that are not supplied on a JIT basis.

On the basis of empirical research on a sample of Italian plants, this study:

- analyses the relationships between advanced buyer-supplier operational interaction practices (design link, logistic link, quality link) and the basic option of the buyer's sourcing policies, such as: sources selection criteria, supply base reduction policies, long-term perspectives (stability of procurement) granted to suppliers;
- compare those operational interaction practices and sourcing policies in different performing plants. In other words, this study verifies if the buyer-supplier interaction practices and "cooperative" sourcing policies examined exhibit a predictive validity of the plant performances.

The underlying hypothesis, which summarises all the detailed hypotheses which will be presented in the next section, is that the development of an operational link between buyer and supplier modifies the buyer's sourcing policies, in particular basic choices:

- a) Which supplier to select? (selection criteria);
- b) How many suppliers to utilise? (number of sources);
- c) What kind of relationship (short or long term) to develop with sources? (procurement stability).

2.1. Selection criteria

The traditional supply relationship is "price-dominated": price is the dominant sources selection criteria in the "arm's length" approach. The limitations of this approach are essentially two.

First, price is only a component of the actual total procurement cost: delays, qualitative or quantitative unreliability, packaging modes, post-sales assistance are examples of cost elements which are usually not included in the purchasing price (Willis and Huston 1990, Macbeth et al. 1988). Second, traditional "price-dominated" relationship reduces the source selection to the choice of a single economic parameter and encourages a limited uni-dimensional improvement.

It is largely argued that the development of an advanced operational link with sources generates the need for multi-dimensional sources evaluation and enhances the importance of "non-price" selection criteria (Willis and Huston 1990, Weber et al., 1991). In fact, the buyer needs sources able to sustain more qualified and involving interaction, that is, suppliers endowed of those design, production/logistic and quality relational skills required by new approaches. In addition, an accurate multi-dimensional rating can reduce the "contractual hazard" associated with the possible buyer specific investment (Christy and Grout 1994). Finally, according to transaction cost theory, supplier evaluation and monitoring constitute a rational control instrument over the supplier's behaviour: in absence of market-based control mechanisms, an accurate rating system can restore a competitive pressure inside the pool of suppliers by monitoring and comparing the suppliers improvement over time.

The sources selection criteria are often discussed in the literature. Helper (1991), Inman (1990), Weber et al. (1991), to mention just a few contributions, point out the importance of the factors which influence the material flow progress (such as: quality, delivery reliability, packaging) for vendor selection when the firm decides to implement JIT programmes. Cole (1988) and Willis and Huston (1990) underline the significance of parameters such as R&D capabilities, design (CAD, CAM) and management systems adopted, as well as some intangible attributes (for example managerial philosophy or the quality of management).

The first hypothesis can be expressed in these terms:

Hp. 1a. The weight given to price in the source selection is negatively correlated to the intensity of the buyer-supplier operational link

Hp. 1b. The weight given to "non-price" factors in the source selection is positively correlated to the intensity of the buyer-supplier operational link.

2.2 The number of sources.

Among sourcing decisions, the advantages and disadvantages of single/multiple sourcing choices are probably the most discussed in the literature.

Multiple sourcing (for each purchased part) avoids the buyer's dependence from a single supplier, reducing material stock out risks and permitting wider supply market monitoring (Kekre et al. 1995). In addition, the presence of multiple supplying alternatives enhances the buyer's bargaining power: through the comparisons of different supplying offers the buyer can reduce possible information asymmetries and stimulate a competitive pressure among the pool of sources. In this way, the buying firm reduces non-selection or source's opportunistic behaviour risks (Seshadri et al. 1991). On the other hand, multiple sourcing increases the administrative costs of procurements and, more in general, the total cost of transactions (distinct operators sustain the same costs, i.e.: production planning and machinery set-up costs). Furthermore, order splitting can impede the achievement of scale-economies, in particular when the supply is complex and can be rewarded only by adequate volumes (Newman 1988). Also, multiple sourcing can impede the qualitative uniformity of supply flows (Richardson 1993).

Thus, multiple sourcing implies advantages and disadvantages. Several authors argue that modern buyer-supplier design and logistic interaction renders its recourse difficult to achieve (Bache et al. 1987, Lyons et al. 1990, Ansari and Modarress 1990, Turnbull et al. 1992). JIT deliveries coming from different multiple sources seem to involve logistic integration, production planning, quality homogeneity, time synchronisation problems. Similarly, co-design seems to permit the participation of only few suppliers and the earlier

(=nearer to product concept) is their involvement in the product development activities, the more difficult it is for the buyer to maintain different procurement alternatives.

Notwithstanding the number of contributions, most of the evidence regarding the relationships between modern buyer-supplier interaction practices and supply base reduction policies is based on case-studies (Kekre et al. 1995).

Our second hypothesis is therefore the following:

Hp. 2a. The adoption of supply base reduction policies is positively correlated to intensity of the buyer-supplier operational link.

Assuming that the establishment of a buyer-supplier operational link is associated to the reduction of the number of sources, a major point of discussion then regards the entity of that supply base reduction, that is: the adoption of single-sourcing practices.

Some authors hold that single-sourcing is important for the realisation of a JIT link with the suppliers (see: Hall 1983, Treleven 1987). Others maintain that the competition among suppliers, even if restricted to a selected group of sources, is of critical importance if the costs are to be kept low and the quality of the supplies raised (Imrie and Morris 1992, Turnbull et al. 1992). A further hypothesis is then the following:

Hp. 2b. The adoption of single-sourcing policies is positively correlated to intensity of the buyer-supplier operational link.

2.3 The long-term perspective

We refer here to the expected length of the exchange relationship, rather than to the formal length of the contract. In the supply system of the Japanese automotive industry, for instance, contracts are usually annual even if the relationship is generally highly stable and contracts are tacitly renewed (Cusumano 1991, McMillan 1990, Fruin 1992, Nishiguchi 1994).

The importance of long-term supply relationships has been debated according to several theoretical approaches.

According to the TCE theory, the time horizon of the relationship depends on the kind of exchange. When the exchange is characterised by specific investments (and assuming the opportunistic behaviour and the bounded rationality of agents), market failures arise (Williamson 1985, 1991). In this case, only the expectation of stable (long-term) relationships provides the incentive for specific investment and mitigates the risks of short-term opportunistic behaviour. As discussed in the previous section, the operational interactions considered in this study (on design, logistic and quality) are associated to several kinds of capital and human specific investments.

Game theorists also argue that the perspective of repeated games promote collaborative behaviour, since future interaction permit one player to sanction or reward the other depending on his past conduct (Axelrod 1984).

Operation management theorists, in particular those belonging to JIT-purchasing field, argue that long-term relationship is a necessary requisite of the JIT system. Only the long-term perspective permits the continuous improvement logic to fully develop by benefiting of learning and relationship-specific scale effects. Anyway, most of the studies focused on the relationship between the time horizon of the exchange and the JIT practices exhibit qualitative analysis (Kalwani and Narayandas 1995).

The third hypothesis can be expressed in this terms:

Hp. 3. The adoption of long-term sourcing policies is positively correlated to intensity of the buyer-supplier operational link.

2.4 The impact on performances

Advantages and disadvantages of both the traditional and of the cooperative buyer-supplier exchange are several: the reasons of both the "sceptical school" and the "advocate school" are numerous. Thus, only empirical evidence can decree the performance superiority of one model over the other. Unfortunately, as Zaher and Venkatraman (1995) observe, investigating the performance implications of the different exchange governance structures is another important gap in current research.

This study has therefore analysed the relationships between: buyer-supplier operational (design, logistic, quality) interaction practices, buyer's sourcing policies and plant performances.

The corresponding hypothesis is the following:

H_p4: Better performing plants exhibit higher use of advanced buyer-supplier operational practices and cooperative sourcing policies.

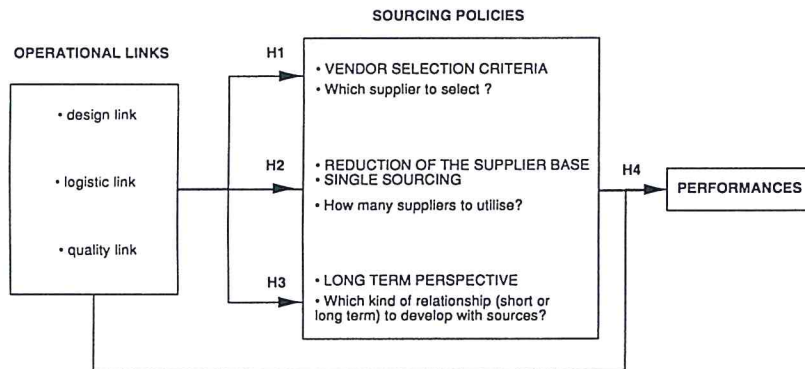


Figure 1 The model. Summarises the four hypotheses of the study.

3. Methodology

To test these hypotheses, a survey was carried out using structured questionnaires sent to a sample of 52 Italian plants. The methodological steps are summarised in the following paragraphs.

3.1 Research approach

We chose the plant as unit of analysis since the JIT-P practices analysed are implemented at the plant level. The sample was selected at random from plants employing more than 100 people and was stratified into "traditional" and "world class reputation" plants. By "world class reputation" we mean those which are reputed to have higher than average performances in the sector. "Traditional" plants were selected from the Kompass (1992) list of firms belonging to the two sectors; "World Class Manufacturing" (WCM) plants from a master list compiled using experts in industry as source (consultants and managers). The sectors analysed are those of electronics and machinery in which JIT implementation and

the interaction with the suppliers are competitive variables of increasing importance (Gilbert 1990).

The data and their elaboration refer to a sample of 52 units, 25 in the electronic and 27 in the machinery sectors. The principal characteristics of the sample are reported in table 1.

Table 1. Characteristics of sample plants

	Mean
• Sales (millions \$)	88.2
• Incidence of purchase on sales	48.3 %
• Number of employees	613
Production process:	
• one of a kind	20.2 %
• small batch	40.4 %
• large batch	20.8 %
• semi repetitive	27.2 %
• repetitive	1.7 %
Kind of products:	
• highly customised	31.2 %
• somewhat customised	17.9 %
• standard with custom options	29.8 %
• somewhat standardised	25.6 %
• highly standardised	7.7 %

3.2. Measurement

Prior research was reviewed to identify existing objective and perceptual measures of the practices analysed. When available, existing measures were then adapted to facilitate their use in this study. For non existing measures, new perceptual ones were then developed using 5-point Likert-scales; the score was determined as the non-weighted mean of the values of each single item. The initial version of each scale was reviewed together with three plant managers. In this phase, the operationalisation process of each practice was tested and the wording of questions was simplified. 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. In all, 497 respondents were involved.

The operationalisation choices are reported in the following.

Design, logistic, quality link. Existing measures were identified in the works of Flynn et al. (1994) and Sakakibara et al. (1993). Other measures were developed and validated in previous research work of the authors (De Toni and Nassimbeni 1995, Nassimbeni 1996). The design link was measured using three scales: "Information exchange concerning the product", "Information exchange concerning the production process", "Supplier involvement in product development". The logistic link was calculated as mean of five measures: "Deliveries synchronisation", "Integrated production planning", "Shared production forecasts", "Packaging congruence", "Pull (kanban) procurement approach". The

quality link was measured as mean of three other measures: "Information exchange on quality", "Free pass for deliveries", "Supplier quality certification".

The three main buyer-supplier links (design, logistics and quality link) were identified using principal component factor analysis: each of these three links correspond to a dimension underlying the set of the above mentioned scales. The measures of these three links are by construction orthogonal (we used the factor scores) and therefore multicollinearity problems were avoided in the successive regression analysis.

The supplier selection criteria. We have evaluated the weight given by the purchasers to the main supplier selection criteria: price, quality, delivery reliability, technological-productive expertise, economic-financial solidity. On a 5-point Likert scale, the purchasing manager specified the importance (weight) given to each of these selection parameters. The variable "importance of non-price selection criteria" was calculated as mean of the scores given to the four non-price criteria. A similar approach to the measurement of these constructs was used by Helper (1991) and Cusumano and Takeishi (1991).

The number of sources. In the sample examined, the extension of JIT programs to procurement activities began in recent times (5 years in average). We have therefore evaluated the variation of the number of sources in the last four years, weighting it on the variation of the purchases expenses. Alongside this objective measure, we used a perceptual scale to evaluate the presence of supplier base reduction policies. As far as concerns single-sourcing policies, we evaluated the variation in percentage of the number of single sources and the variation in percentage of the value of purchases coming from single-sources over a period of four years.

Long term perspective. To operationalise this construct, we used an approach similar to that adopted by Provan and Gassenheimer (1994) and Gundlach et al. (1995), who measured the "long term perspective" through the supplier support and assistance initiatives set in motion by the buyer. In fact, due to the intrinsic incompleteness of the supply contract, its formal length does not represent significant indicator of the "long term perspective". Instead, supplier support and assistance initiatives generally determine investment not recoverable in case of switching, therefore testifying in a clearer way the buyer's true cooperative willingness (the formal length of contract was in any case measured: its absolute value and the one weighted on the product life-cycle exhibited an high variance and were un-correlated to all the other measures). On a 5-point Likert scale, respondents specified the intensity of the technological and managerial assistance provided to main suppliers.

Since the buying policies depend, among other factors, on the kind of purchased parts, most of the questions refer to parts characterised by high value use (=volume of purchased parts * unit value). In this way, we have excluded from the analysis suppliers of non-critical parts (cfr Kraljic matrix [Kraljic 1983]), and therefore not involved by the perspective of cooperative exchanges with buyers.

3.3 Validation of the measurement instrument

All measures were subjected to:

- Reliability assessment, operationalised as internal consistency of the item on each scale. Cronbach's alpha (Zeller and Carmines 1980) was calculated for each scale. All the

constructs have an alpha value greater than the cut-off value (0.6) that is suggested as acceptable (Nunnally 1978).

- Validity assessment. Content validity was verified through a review of the literature, the theoretical revision used by the authors, a comparison with some managers of the firms sampled. Construct validity was verified by using factor analysis to test the unidimensionality of multi-items perceptual measures.

4. Results

Hypotheses H1-H3 were verified using regression analysis, assuming the three operational (design, production-logistic and quality) links as independent and the three sourcing policies (supplier selection criteria, supplier base reduction and long-term perspective) as dependent variables. Table 2 reports the results of the regression analysis.

Before testing the hypothesis H4, a preliminary analysis was conducted in order to verify the statistical difference between the two sub-samples ("traditional" and "WCM" plants) in terms of performance. The performance indicators selected concern the three main performance dimensions: quality (annual average percent of products returned because of customer dissatisfaction, management's perception on plant quality performances); time (average on-time delivery rate, management perception of plant time performances); cost (inventory turnover, management's perception on plant cost performances). The t-tests for equality of means in "traditional" and "WCM plants" 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 the operational practices and sourcing policies analysed in low and high performing plants.

Results are reported in table 3.

Table 2. Results of the regression analysis

	Importance of price in supplier selection	Importance of non-price selection criteria	Supplier base reduction	Single sourcing	Long term perspective
Hypotheses	1a	1 b	2a	2 b	3
adjusted R ²	0.009	0.119	0.120	0.033	0.396
F	0.862	3.199*	3.345**	1.521	11.930***
Significance of F	0.468	0.032	0.027	0.222	0.000
INDEPENDENT VARIABLES					
• design link	b=0.131	b=0.386**	b=0.389**	b=0.019	b=0.298**
• logistic link	b=0.195	b=0.049	b=0.201	b=0.268	b=0.513***
• quality link	b=-0.038	b=0.147	b=0.072	b=0.146	b=0.285*

b: standardised regression coefficients

p: significance: * p<0.05; ** p<0.01; *** p<0.001

Hypotheses 1. H1a is rejected: any significant relationship emerges between the importance of price in supplier selection and the three operational dimensions. In fact, the adjusted squared multiple correlation coefficient ($R^2=0.009$, table 2) and the F-test ($p=0.468$ in

the multivariate test) are un-significant. Instead, the analysis shows a significant relationship between the importance of non-price factors in supplier selection and the three operational dimensions ($R^2=0.119$, $p=0.032$). Therefore H1b is accepted. In this case, however, only the design link shows a significant relationship ($p=0.006$) with the dependent variable.

Table 3. Results of the discriminant analysis

	MEANS		Univariate F-statistics	Standardised discriminant coefficient
	"traditional" plants	"WCM" plants		
OPERATIONAL LINKS				
• design links	-0.412	0.543	p=0.004	0.878
• logistic link	-0.302	0.399	p=0.016	0.687
• quality link	-0.042	0.056	p=0.730	0.103
MULTIVARIATE F TEST: p=0.000				
Percent of grouped cases correctly classified: 71.15%				
SOURCING POLICIES				
• Importance of price in supplier selection	0.000	-0.088	p=0.784	-0.392
• Importance on non-price selection criteria	-0.124	0.254	p=0.234	0.354
• Supplier base reduction	-0.182	0.214	p=0.217	0.054
• Single sourcing	-0.180	0.088	p=0.353	0.379
• Long term perspective	-0.423	0.577	p=0.000	0.912
MULTIVARIATE F TEST: p=0.009				
Percent of grouped cases correctly classified: 76.74%				

Hypotheses 2. H2a is accepted: a significant relationship exists between supplier base reduction policies and the set of the three independent variables ($R^2=0.120$, $p=0.027$). Also in this case, however, only the design link is significantly related to the dependent variable ($p=0.006$). Hypothesis H2b is instead rejected ($R^2=0.033$, $p=0.222$): the development of any of the three operational links examined is accompanied by the recourse to single sourcing policies.

Hypothesis 3. Hypothesis H3 is accepted: a long-term perspective is significantly related to the establishment of an advanced operational link with sources ($R^2=0.396$, $p=0.000$). Each of the three independent variables is significantly associated to the dependent, but at different intensities. The logistic link shows the strongest relationship ($p=0.000$), followed by the design link ($p=0.009$) and the quality link (0.013).

Hypothesis 4. Discriminant analysis was used considering the two sets of independent variables (operational practices and sourcing policies) separately, in order to avoid multicollinearity problems. The results generally support the hypothesis: the operational

links show a clear discriminating effect (multivariate F-test: $p=0.000$, 71.15% of the cases were correctly classified by the discriminant function, table 3), as do the set of the sourcing policies (multivariate F-test: $p=0.009$, 76.74% of the cases were correctly classified by the discriminant function). Analysing the significance of each single independent variable, we discover that only three factors discriminate the plants: the design link ($p=0.004$) and the logistic link ($p=0.016$), among the operational factors, and the long-term perspective ($p=0.000$), among the sourcing policies.

5. Discussion

Hypothesis 1-3. The results of the statistical analysis point out two main elements of discussion. The first element concerns the relationship between the sourcing policies and the overall set of operational links examined. The second element consider the relationship between the sourcing policies and each single operational (design, logistic, quality) link.

As far as the first element is concerned, the following results emerge:

- among the sourcing policies analysed, three variables ("importance of non-price selection criteria", "supplier base reduction" and "long-term perspective") are significantly correlated to the presence of an operational link with suppliers. The variable "long-term perspective" shows the highest ($p=0.000$, table 2) relationship;
- two other variables ("importance of price in supplier selection" and "single sourcing") are not significantly related to the operational links examined. Evidently, when developing an advanced operational link with sources, the buyer reduces the supplier base avoiding however a total exclusive rapport. Similarly, if non-price factors assume higher importance when an operational link arises, the weight given to price doesn't shows any significant changes. Thus, price still continues to play an important role (average value = 4.58 in correspondent 5-point Likert scale).

Summarising, the establishment of design, logistics or quality interactions with sources modifies the buyer's sourcing options, imposing an exchange government structure different from the "market-based" one. However, such a change does not foresee single sourcing practices and the denial of price-related factors in supplier selection, that is, the elements (besides the long-term perspective) which *ideally* characterise the cooperative buyer-supplier relationship. Going back to the cited bibliographic review of Water-Fuller (1995), these results partially contradict those authors who argue that "firms tend to implement the easier aspects of JIT sourcing". Among the JIT practices more difficult to implement, Water-Fuller lists: the "long term contracts, the "data exchange", the "sole sourcing". This survey instead shows that the buyer's willingness to establish a stable, long term relationship with the integrated supplier is witnessed, even if not by formal long-term agreements, by assistance and training initiatives. As far as single sourcing is concerned, our data confirm that it doesn't accompany the establishment of an operational link with sources. We don't believe (as Water-Fuller do) that this result demonstrates the difficulties of buyers in implementing the most radical elements of JIT sourcing. Rather: we believe that it demonstrates the search for a compromise between two needs. On one hand, the buyer needs to give up the traditional "market-base" supply management. On the other hand, the buyer needs to avoid the risks of excessive dependence on sources.

The second element of discussion concerns the relationship between the sourcing policies and each single operational (on design, logistic, quality) dimensions. The following results emerge:

- the quality link reveals a less committed buyer-supplier interaction. It is associated to a long-term perspective ($p=0.012$, table 2), but is not accompanied by supplier base reduction policies or by clear valorisation of non-price supplier selection criteria. Evidently, the importance of quality in present competition has determined a wide diffusion of TQM practices almost at each step of the supply chain. Therefore, the ability to adequately interact with the buyer about quality-related topics is now an indispensable component of the supply offer, rather than a differentiation element;
- comparing the design and the logistic link, we discover that only the design link is associated to supplier base reduction policies and to a supplier selection which emphasises non-price criteria. Both links play instead a significant role in committing the buyer to a long-term relationship. In general, the empirical evidence shows that the design link is generally more exclusive and binding than the logistic link. Possible justifications are:
 - The collaboration in product development implies more intensive personnel interactions and a higher exchange of proprietary product and process technology information. Therefore, it is a link which presents higher exclusivity requirement (=supplier base reduction);
 - The design link is more customer-oriented (it requires a more customised contribution). In fact, specificities concerning product and process, involving technologies and materials, seem to be wider than those concerning the production-logistic process, that is, concerning only the timing and frequency of procurement rather than the *object* of supply. Because of the higher specificity of his contribution, the supplier involved in co-design activities is in general more difficult to replace (=lower supplier turn-over). For the same reason, the design interaction is more difficult to define ex-ante and to measure ex-post. Thus, the buyer is more vulnerable to supplier opportunistic behaviour. A more intensive supplier selection effort (=higher attention to non-price factors) is therefore required.

Hypothesis 4. From the results of the discriminant analysis, better performing plants have more advanced design ($p=0.004$, table 3) and logistic links ($p=0.016$) with sources. The quality doesn't show any discriminating effect ($p=0.730$).

As extensively argued in the literature, buyer-supplier design and logistics interactions can reduce the product development, production and delivery time, can improve quality and lower costs. As expected, these results confirm the strong relationship between plant performances and co-design or JIT purchasing practices.

Is not surprising that quality interaction doesn't discriminate on plants. Two of the items used to measure the quality link have values that are among the highest. Thus, the practices regarding the management and control of quality on entry flows are by now widespread: the ever more exacting market demand for quality call these practices to the attention of even the less well performing plants.

As far as the sourcing policies are concerned, only the "long-term perspective" exhibits a discriminating effect ($p=0.000$, table 3). It is thus confirmed that the perspective of lasting relationship is a necessary element of partnership: it justifies the transaction-specific investment, allows the "continuous improvement" logic, mitigates opportunistic temptations. Instead, the importance of price in the supplier selection and the use of single

sourcing doesn't differ in traditional and WCM plants. Therefore, the best performing supply systems (evaluated through their impact on plant performances) are not characterised by total exclusivity of relationship and a supplier selection not governed by price (cost) consideration.

Even if WCM plants show a greater attention to non-price supplier selection criteria, the differences between them and the traditional plant are statistically not significant ($p=0.234$). Clearly, the diffusion of the multidimensional vendor rating systems still remains limited, with the exception of plants which have developed a design link with suppliers. For these plants, the accurate rating of the supplier technological capabilities is presumably crucial.

Finally, the adoption of supplier base reduction policies doesn't discriminate on plant either. However, it should be noted that the average number of sources of the sampled plants has been globally lowered over the last four years by 9%. Therefore, the attention towards leaner supply structures is in any case widespread.

6. Conclusions

The most evident results of the survey can be summarised thus:

- The creation of an advanced link with sources modifies the basic options of the supply strategy of the buyer. In particular, operational inter-dependencies at the design, production-logistic or quality level orientate the buyer towards the long term convincing him to invest in integrated sources (for example thorough assistance and training). Even where there is a strong operative collaboration, however, single sourcing remains an unused policy and it is confirmed that price is one of the principle criteria for monitoring sources. The buying strategy that is created follows a sort of compromise between the need to abandon traditional buying procedures and the need to avoid the dangers of excessive dependence on sources;
- Design interaction seems to be the most exclusive and binding form of collaboration. This is presumably justified by the higher specificity of the contribution and the greater difficulty in substituting the sources involved in this form of interaction;
- Better performing plants exhibit a higher level of design and logistic interactions and a better use of long-term supply agreements with sources. Thus, co-design and JIT purchasing practices, together, with the stability of procurement, influence to a significant extent the plant performances.

There are various openings for further investigation at this point. The main one concern a series of aspects which, together with the three sourcing policies considered, complete the description and comprehension of the exchange structured referred to. Among these aspects are the existence of buyer tools for incentivating and sanctioning suppliers (for example, policies concerning the increase or decrease of the volume of or number of orders given to the suppliers), the possibility of vertical integration of the parties, the existence of hostages (such as partial property of production instruments). Again it would be interesting to consider the influence of the buyer's operative system on the relationship investigated: it is possible to hypothesise that the nature of the processes, the level of decomposability and measurability (predictability) of productive tasks, technological features (informative content, codifiability) vary from plant to plant and from industry to industry, making the various form of interaction with suppliers diversely critical. These aspects have not been

investigated to a sufficient degree in the literature on buyer-supplier interactions. A dense research agenda is opening on them.

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