Strategic and operational choices for small subcontracting firms

Empirical results and an interpretative model

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Introduction

Subcontracting is at present undergoing a period of renewed importance: the increase in the incidence of purchases on sales, with an average of over 50 per cent and in some industries reaching even 70 per cent, is confirmed by several investigations carried out at a national and international level[1]. The choice of externalization in the present competitive context is no longer contingent as in the past and is more than just the outside transferral of production tasks. This choice is becoming the result of a precise strategic plan: the supplier, in this view, is no longer considered as a complement or an appendix to the buyer's production structure, but a part of a common inter-company manufacturing system[2-4].

Empirical investigations have shown that the positive trend in subcontracting and the affirmation of new approaches to buyer-supplier relationships generally do not generate:

- An increase in subcontracting volumes directed towards small businesses.
- A more qualified and balanced relationship between large-sized buyers and small subcontractors[5,6]. This is especially evident if the analysis is restricted to large-sized purchasers. It is now becoming more frequent for the relationship between large firms and small subcontracting units to pass through companies (usually of medium size) that carry out the role of direct reference points for the large enterprises. Thus, the end units of the supply chain are often companies characterized by small size and modest added value incorporated into the object supplied[7].

The prospects for a co-operative relationship (partnership) with the buyer seem to relate only middle- to large-sized firms, capable of providing an high level of technological and qualitative content and incorporating significant added value into the subcontracted object[3,8].

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In more general terms, we are witnessing an increasing process of concentration in direct supply to large purchasing enterprises which leaves little room for small supplier firms. In the present transitional phase, in which a generalized process of rationalization of the pool of suppliers is taking place in large industrial enterprises, it appears to be of particular interest to:

- identify the variables that determine the continuation and development of direct subcontracting relationships between large buyers and small subcontracting units;
- analyse the technical-productive potential of small businesses: it is in this sphere, in fact, that the reasons for the structural weaknesses of their offer should be detected.

The interest in this subject is more evident if one considers that in the region being investigated (north-east Italy) the archipelago of small and very small industries forms a fundamental connective tissue, not only for the industrial but also for the social system. On the basis of an empirical research the authors analyse the role and prospects of the small firms inserted into the supply chain, pointing out characteristics, structural limits and potentials for re-qualification of their production profile and their offer.

The articulation of the work is the following. First of all the methodology used in the empirical investigation is summarized. On the basis of the empirical evidence the characteristics of the subcontracting relationship between the small suppliers and the large-sized purchasers analysed are highlighted. Finally, an interpretative model is proposed that indicates the areas of strategic and operational positioning of the smaller firms and possible development pathways towards more qualified small subcontractor-large purchaser relationships.

Methodology

The empirical investigation was carried out by means of structured questionnaires for a sample of firms, covering both purchasers and subcontractors. In regard to the purchasers, five large firms working on the multidomestic and global markets were chosen. These represent a significant part of the industrial life of the region and have a tradition of local subcontracting. The research concerning the purchasing firms was deliberately limited: in preference to a survey based on a large sample of heterogeneous units, it was decided to concentrate on an in-depth multiple case study of five large firms and their subcontracting system.

In comparison with these five large firms, 31 small suppliers, as shown in Tables I and II, were analysed. Since the meaning of the term “small firms” is often unclear it was found necessary to define the object of the investigation. Usually the criteria used to define company size are turnover and number of employees. However, these criteria vary considerably from industry to industry. In this work small subcontractors are understood as:

- economically independent enterprises;
- firms which do little planning, where operational procedures and rules of decision making are only slightly formalized and in which the exchange of information occurs in a relatively direct way;
- with less than 22 employees (Italian regulations).

Industry	Market	Number of suppliers examined
Electromechanical	Global	7
Mechanical	Global	7
Electronics	Global	5
Furniture	Multidomestic	6
Furnishings	Multidomestic	6

Table I.
Large purchasing firms: the sample

Number of firms	Industry	Average sales (million $)	Average number of employees
4	Technical services	0.21	4
2	Electronics	0.77	22
2	Furniture	1.60	14
11	Furnishings	0.74	11
11	Mechanical	1.56	15
1	Plastic	0.96	11
	Average sample	1.03	12.4

Table II.
Small subcontractors: the sample

Small business in the supply chain: main empirical evidence

Characteristics of the subcontracting relationship

Some of the main characteristics of the subcontracting offer and of the large purchaser-small supplier relationship emerging from the empirical survey are the following:

- Subcontracting is the life source of the small units, amounting to an average 96 per cent on the turnover.
- Almost all the firms have a long-term relationship with the large purchasers. However, an habitual long-term relationship does not correspond to contracts, and thus to formalized agreements, over a long period. In fact in about only 40 per cent of the cases is there a stable and formalized co-operation. The stipulation of a contract, in most cases, is preceded by a supplier-selection process which is generally based on criteria of pure economical convenience.

- The industrial market regarding the large enterprises is the most important commercial outlet. It absorbs about 86 per cent of the value of production of the subcontractors analysed. The market to which the surveyed subcontractors turn is prevalently provincial: the commercial orientation of the small units has a strictly local character.
- The firms examined are strongly dependent on a few purchasers. As can be seen from Table III, the foremost customer purchases, on average, 42 per cent of the production, while the three main customers acquire the overall majority (78 per cent) of the production of the small units.
- Quality and delivery reliability are the main requirements imposed by the contractors on almost all the sampled firms. Price is subordinate to conformity to required standards and to the ability to ensure a regular and prompt supply flow. In the opinion of the purchasers, the quality and delivery reliability provided by the small subcontractors is inadequate.

Technical-productive profile of small units

On the basis of empirical evidence, in this section a brief structural and technical-productive profile of the small units surveyed is presented.

Types of machinery. The types of machinery used are shown in Table IV. As can be seen, the majority of the firms examined (83.4 per cent) use manual control machinery, while a small number (2.4 per cent) have machining centres.

At first glance the percentage of Flexible Automation (CNC + MC) seems low (16 per cent). A closer examination, however, shows a substantial adoption of

Table III.
Dependency of the small units on the purchasers (production volumes acquired by the first clients)

Industry	First client (percentage)	First three clients (percentage)
Technical services	53	83
Electronics	35	85
Furniture	40	75
Furnishings	43	80
Mechanical	62	94
Plastic	20	45
Average	42	78

Table IV.
Types of machinery used

Machinery	Percentage
Manual control	83.4
Computer numerical control (CNC)	13.6
Machining centres (MC)	2.4
Other	0.6

FA: the ratio between the number of production workers and the total number of machines is about equal to 0.66 (two workers for each three machines), while the proportion for CNC is roughly three (three workers for each flexible unit). Thus about 33 per cent of the production (evaluated in man-time) takes place in flexible units. However, a unit of flexible automation for every three workers requires a high proportion of skilled workforce: the difficulty of recruiting properly trained personnel was stressed by the contractors during the interviews (as will be shown below).

Presence and use of data processing equipment. More than 40 per cent of the companies have not even got a personal computer (PC). When present the PC is used in the administrative area (82 per cent of the cases) and in wordprocessing (70 per cent). Almost 60 per cent of the companies use PCs in activities connected with production (purchasing, warehouses, deliveries). However, only 10 per cent of the units utilize PCs in the area of production planning and control: this is a typical staff area, tending to be overlooked in comparison to the activities which directly affect the operation value chain[9]. Computer-aided design and manufacturing systems (CAD-CAM) were found in only 16 per cent of the cases.

The absence of PCs in over 40 per cent of the firms sampled is worrying if one thinks that the reason is not so much the cost (more or less insignificant in respect to the average turnover or investments) as the unclear identification of the areas in which PCs could be of most use.

Obstacles to the introduction of innovation

Table V outlines the problems encountered by subcontracting firms in the introduction of innovation assessed by the entrepreneurs on a scale of 1 to 5. The main problem is the recruitment of trained personnel, a fact that was given a rather high score (3.9). The information gained from the questionnaire indicated that the manpower, as well as technically qualified personnel, favour employment in medium- to large-sized industries. These latter usually give

Obstacles	Average value (minimum = 1, maximum = 5)
Skilled workforce recruitment	3.9
Market uncertainty	3.0
High financial risk	2.7
Cost of innovation	2.5
Resource unavailability	2.4
Lack of technical capabilities	2.2
Lack of public support	2.1
Organizational difficulties	1.8

Table V.
Obstacles to the introduction of innovation

better work conditions and more stable work hours. Thus the employment prospects are more attractive.

The second problem in order of importance is market uncertainty, which considerably raises the financial risk linked to investments in innovation (third factor). The small units are particularly vulnerable to negative demand situations on the final market. Negative fluctuations force the intermediate producers to reintemalize so as to attain a greater utilization of their internal production capacity. This is followed by a lessening in the subcontracted volume directed to the small units, which often (as will be seen below) produce subsupplies with a low technical content (and so are easily internalized by the buyers).

The lack of technical know-how is considered a problem of medium to low importance (2.2), as also is the cost of innovation (2.4). It was noted that it is not so much the cost of innovation as the high financial risk that worries the subcontractors interviewed. In fact the empirical investigation showed that public institutions and professional associations readily provide financial support to the small firms (so the "lack of public support" occupies the penultimate position in the scale of obstacles to innovation).

Conclusions drawn from the empirical evidence

In brief, the following emerges from the empirical investigation:

- There is a high level of dependence of the small units on the purchasers. These require much, especially in terms of quality and delivery reliability, and offer little, for example in terms of training and technical support. The data gathered in fact shows that there is an unbalanced bargaining power between the two parties.
- The sample is well equipped with machinery. The expenditure on data processing equipment, however, seems minimum in comparison to the amounts invested in production assets: more than 40 per cent of the firms do not have a personal computer, and this absence was discovered even in units that have CN and CNC machines.
- The problems relating to the introduction of innovation mainly concern the lack of a skilled workforce (however, the investments in training are negligible), and to market uncertainty. This is due to the fact that the clients do not wish to establish stable and formalized subcontracting agreements with the small units.

In general, the subcontractors interviewed seem greatly to favour investments in fixed assets (machinery and production facilities). Even more generally the training/updating programmes are modest and restricted to a few channels. The insufficient circulation of information and the distance from the training/education channels have a negative effect not only on the technical aspects of the process. The similar investigation carried out on the purchasers

describes the small subsupplying units as lacking a cultural background to such an extent that they cannot fully comprehend the buyers offers proposals.

Strategic and operational choices: an interpretative model

The dynamics of the subcontracting relationship between large purchasers and small subcontractors are here interpreted using a model which considers two aspects:

(1) The *strategic positioning*, summarized in terms of kind and object of subcontracting. Other strategic choices (concerning for example price, promotion, distribution, see[10]) were not considered significant in this context.

(2) The *operational positioning*, regarding the introduction of innovation into the "operations".

The different positioning options are[11]:

- *Competitive success*. This corresponds to the competitive advantages obtained by the firm on the market. These are measured in terms of: market share (absolute or relative), qualitative level of the customers, etc.
- *Earning success*. This is proportional to the economic results obtained and derives from the ability of the firm to satisfy the market, using its structures to the best advantage. It is measured in terms of added value per worker, return on investments, etc.

It must be pointed out that competitive and earning success do not always go hand in hand: a firm may have competitive success even when it does not make the best use of its structure, as indeed can a company have high profits even in the absence of a dominant competitive position in the market to which it belongs.

The strategic positioning

It is possible to single out four areas of strategic positioning for the small subcontractors sampled. These areas are displayed in the matrix of Figure 1 obtained by crossing the two variables:

(1) *The object of subcontracting*. This can assume the values "product" or "process" subcontracting. The former is usually characterized by a greater added value since the subcontracted object incorporates more sophisticated and extended capabilities. The latter regards production phases (metal forming, straining, melting, mechanical working, heat and chemical treatments, etc.) or technical services (design, maintenance, testing, etc.).

(2) *The kind of subcontracting*. This can assume the values "capacity" or "speciality" subcontracting. The former is not characterized by particular technological contents: the subcontractor quantitatively extends the production capacity of the customer. The latter instead has

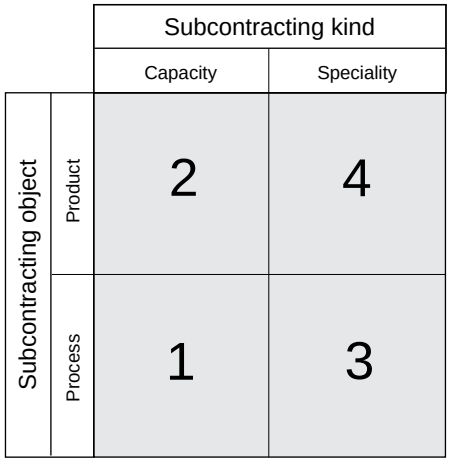

Figure 1.
The strategic positioning

technological contents that require specialized professional know-how and capabilities. In general the former is easily internalized by the buyer and thus brings less bargaining power to the subcontractor, with evident repercussions on his prospective earnings. The latter has instead particular significance for the buyer.

The empirical investigation has shown how the "product/speciality" subcontracting is preferred by the purchasers, compared with an offer that instead concentrates on the "process/capacity" subcontracting. Thus the greatest competitive and earning success corresponds to quadrant 4 in Figure 1. It is not by chance that the turnover of the microfirms sampled that have "capacity" subcontracting tends to be stable while it is increasing for the firms that have "speciality" subcontracting (in particularly: product/speciality subcontracting).

The greater part (66 per cent) of the firms sampled in the empirical survey have "capacity" subcontracting. Their competitive and earning profile is generally modest. The developmental trends in the subcontracting market are clearly favourable for the subcontracting firms that work in the sphere of specialized products. The commercial prospects of the subcontracting firms specialized in specific workings are not so favourable but are still positive.

The operational positioning

The behaviour of the firms on the operational level can be analysed by means of the matrix of Figure 2, which intersects a performance variable and a synthetic indicator of the amount of innovation introduced. The matrix considers two factors:

(1) *Added value per worker* (wages and salaries + charges + net income/ number of workers in the year considered). This indicator, even if

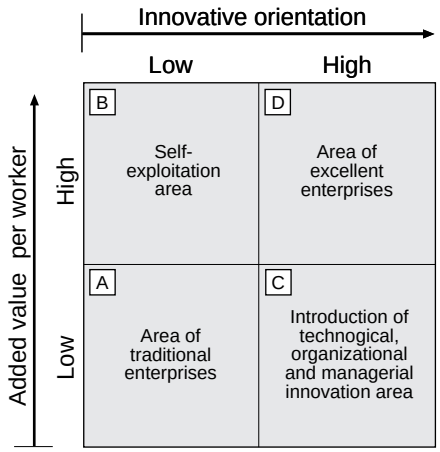

Figure 2.
The operational positioning

presenting different limits, is generally considered the most representative for the work-productivity in the small units[12]. The indicator considered is, in fact, linked to the most important operative "lever": the workforce, in particular its level of qualification and the way it is used.

(2) *Innovative orientation*, understood as the degree of technological (percentage of flexible automation, adoption of CAD-CAM systems, data processing equipment, etc.), managerial and organizational (quality and inventory management practices, level of formalization of the organizational structures, presence of production, planning and control instruments, etc.) innovation of the firm.

The four areas have different potentials in terms of competitive and earning success:

(1) *Area A (traditional firms)*. Here are found companies that combine a low innovative orientation with a low added value per worker. These companies are defined as "traditional": the machinery is usually obsolete, the management criteria unsystematic and the turnover of the employees high. Competitive and earning success are both modest.

(2) *Area B (area of self-exploitation)*. The competitive success is low while the moderate earning success often found in these companies is due to the burden of work borne by the employees: the overall hours of production are above normal, with night and even holiday workshifts, etc. In other words these small firms can make profits thanks to the "exploitation" of the workforce, labouring under conditions not found in medium- to large-sized companies. The firms in this quadrant fully exploit one of the strengths of small businesses: the low overheads, due

mainly to their lower administrative and wage-labour costs (e.g. inferior health and security benefits given to the employees):

(3) *Area C (area of the introduction of technological and organizational-managerial innovation).* It is characterized by low earning success because the companies are involved in innovation processes. They have invested money to introduce flexible automation and implement plans to improve some just-in-time and total quality management practices. The earning success is not yet significant (regular functioning is still far off and the transition period involves large learning costs) while the competitive success is usually moderate (due, for example, to relationships with more qualified and demanding purchasers). Among the causes that justify the counter-tendency between competitive and earning success, the principal one is probably found in the positive differential of product quality to which no adequate price differential corresponds. The purchasers, in fact, detect the innovative effort made by the subcontractor, and they reward it by commissioning larger productive volumes and greater involvement, but are not yet disposed to fully recompense the results obtained.

(4) *Area D (excellent enterprises).* The firms in this area have concluded the process of introducing the relevant innovation and are developing a continuous-improvement approach. The earning success tends to be high as are also the product and technology development performances. The latter make the subcontractor a likely candidate for operative integration with the buyer.

About 80 per cent of the sampled firms are found in the area of low innovative orientation (square 1: 45 per cent; square 2: 35 per cent), while only about 20 per cent of the companies have a well-developed orientation towards innovation. Only one of the sampled firms seem to guarantee first-rate performances.

Analysing the trend of the turnovers, it was found to be stable in the traditional firms and in those situated in the self-exploitation areas (with the exception of particular cases), while it was growing in those involved in innovative processes.

Paths of strategic and operational repositioning

The empirical investigation, as already pointed out, has shown how the large-sized purchasers examined are carrying out a process of sources rationalization and selection. In some cases this process has led to integrated relationships or more rarely partnerships, but only in regard to suppliers/subcontractors of significant size and of important or strategic materials. The small local subcontractors seem to remain confined in the category of so-called traditional suppliers when not completely excluded from the business relationships of the buyer.

On the basis of the strategic and operational positioning model proposed above, the behaviour of the small subcontracting firms which wish to assume an active role towards the purchasers can be schematized in two lines of action:

(1) A strategic repositioning in the sphere of the "product", in other words modify the offer in terms of "process/product" and of "capacity/speciality" subcontracting. The repositioning of the smaller companies can, in our opinion, develop in two phases:

- A first phase aimed at the acquisition of specialized know-how necessary for the manufacture of more sophisticated products (that is, from "capacity" to "speciality" subcontracting).
- A second phase in which the vertical integration increases to such a degree that a product (component or assembly), instead of just a single stage in the work, can be offered (in other words from "process" to "product" subcontracting). It is in this sphere that the purchasers seem to intend to continue business relationships with small subcontractors.

(2) An operational repositioning, that is interventions in the area of company operations. Also in this case two phases are hypothesized:

- Introduction of innovation; in particular: a more extensive use of flexible automation in the production process, implementation of some JIT and TQM practices (set-up time reduction, quality certification of procured materials, application of statistical process control and computer-controlled testing techniques...), and computer-based design systems, production synchronization, preventive maintenance, organizational changes to support the technological innovation. The relevance of these techniques and practices even for small firms is documented in various empirical investigations[13-17]).
- Consolidation of the introduced innovations by means of a continuous improvement logic.

It is the author's opinion that an efficient and joint strategic and operational repositioning can open up opportunities for operative integration of small firms (and in limited cases even partnership) with purchasers, opportunities that are now limited to medium- to large-sized suppliers.

Let us consider the ABC classification in Table VI. This summarizes the vendor rating systems used by the purchasing firms examined. Figure 3 shows a matrix representative of the junction between the two ABC classifications (class of material/class of supplier) and highlights, by means of circles proportional to the earning successes obtainable, the three quadrants corresponding to the most common combinations of kind of supplies/kind of supplier.

As pointed out, the greater part of the sampled subcontractors are situated in the "normal materials" and "traditional supplier" quadrant. Not only does this

	Class of materials	Class of suppliers
C	*Normal.* Generally materials of low value subjected to entrance controls. The inventories are usually managed with reorder methods	*Traditional.* The supply relationship in this case is based on price and develops according to short-term quantity-based contracts
B	*Important.* The quality and delivery reliability of these items are just as important as the supply price. The inventories are minimal or eliminated by direct supply to the manufacturing departments (JIT deliveries). They require quality certification, logistic congruence between the activities at the top and the bottom of the chain and an intense exchange of information on the production planning	*Integrated.* These suppliers offer sufficient guarantees of quality, reliability, product and volume flexibility. They are given medium- to long-term agreements
A	*Strategic.* Materials into which high know-how and technological capabilities are incorporated. These are often developed together with the supplier	*Partner.* Between the buyer and the supplier there is co-operation both in the sphere of the product (design and materials) and in the process development, an intense exchange of information, and combined investments in R&D

Table VI.
Class of materials and class of suppliers

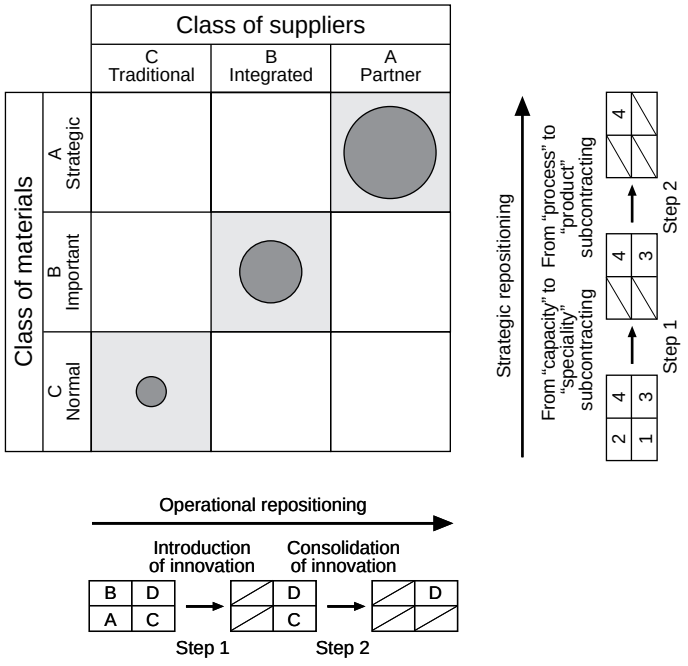

Figure 3.
Class of materials, class of suppliers and operational/strategic repositioning

quadrant offer extremely low earning prospects but also it renders the future possibility of direct business relationships with the buyer uncertain. In fact, the process of supplier base rationalization activated by the purchasers will determine the formation of direct relationships only with suppliers from classes B and A.

The small subcontractors who wish to build better qualified relations with the buyer – and so become suppliers of classes B or A – must modify the object and kind of their offer and at the same time introduce technological, organizational and managerial innovations. That is, they must carry out either a strategic repositioning (offering a subcontracted object with a high technological and qualitative content – subcontracting of speciality), or an operational repositioning, that is, innovate their operational, organizational and managerial system. The evolution towards more qualified relationships thus requires a repositioning along the two directions listed above.

Conclusions

The most important points arising from the empirical research can be summarized as follows:

(1) Large firms are gradually moving towards co-makership systems. International competitiveness itself is pushing these firms towards a more participative link with suppliers: cost, quality, time to the market are variables which are more and more correlated to the performance of the supply system.

(2) This process especially involves medium- to large-sized suppliers, characterized by a high level of technical capability and able to guarantee levels of quality. The small industries remain outside this process: the performance levels and the type of product or service supplied are not such as to make them candidates for a greater amount of participation.

(3) The survival and development of the small units in the supply market depend on their strategic and operational positioning. In particular the large purchasers prefer "product/speciality" subcontracting characterized by an adequate technological and qualitative content. The small units are also required to intervene in the operation area in order to introduce technological, organizational and managerial innovation (operative repositioning). In our opinion such interventions require these prior actions:

- *Training and qualification of the workforce*. In such rapidly changing technological contexts continuous training is not an optional. More in general, a large section of subcontractors must rediscover the forms of investment that are not concentrated on machinery and production facilities, that is the resources that are tangible and directly productive.

- *Work-organization restructuring*. In the sampled companies the entrepreneur of the small firms usually, in person, carries out all the roles of the organization, from that of direct interlocutor of the buyer to that of co-ordinator (when nor executor) of the productive activity. The typical attractiveness of the small business (specialized work-force, high capacity for reaction and adaptation to demand, flexibility) should be nowadays inserted into a more formalized organizational/managerial pattern that makes management more rational and efficient.

If there are few doubts that the choices of operational and strategic repositioning on the part of the small businesses should be accompanied by a growth in entrepreneurial culture, the question whether this change involves also a growth in size remains open. On one hand, the greater investments required by the small units from the large enterprises seem to be justified only if there is an overall growth (of production and sales volume, of market extension, etc.). On the other, however, it is precisely in these small dimensions, and thus the low inertia, that constitute the particular competitiveness of these enterprises. In any case, as also Semlinger observes[5], small firms which wish to be involved in the direct supply to large-sized producers might still be called "small" as far as the number of their employees or turnover is concerned; in terms of their qualitative attributes or technological capabilities, however, they must show less similarity to the traditional understanding of a small firm.

References

1. European Community Commission, *Development of Subcontracting in the EEC*, Brussels, 1989.
2. Cole, G.S., "The changing relationship between original equipment manufacturers and their supplier'', *International Journal of Technology Management*, Vol. 3 No. 3, 1988, pp. 299-324.
3. Bertodo, R., "The role of supplier in implementing a strategic vision", *Long Range Planning*, Vol. 2, 1991, pp. 40-48.
4. Morris, J. and Imrie, R., *Transforming Buyer-Supplier Relations*, Macmillan, Basingstoke, 1992.
5. Semlinger, K., "Small firms in big subcontracting", in Altmann N., Koehler C. and Meil, P. (Eds), *Technology and Work in German Industry*, Routledge, London, 1992, pp. 342-58.
6. Mendius, H.G. and Weimer, S., "Small supplier firms at the crossroads – meeting new challenges through cooperative retraining schemes", in Altmann N., Koehler C. and Meil, P. (Eds), *Technology and Work in German Industry*, Routledge, London, 1992, pp. 323-41.
7. De Toni, A., Nassimbeni, G. and Tonchia, S., "Small local firms inside the supply chain: challenges and perspectives", *Small Business Economics*, Vol. 7 No. 3, 1995, pp. 241-9.
8. Lamming, R.C., "Strategic options for automotive suppliers in the global market", *International Journal of Technology Management*, Vol. 5 No. 6, 1990, pp. 649-84.
9. De Toni, A., Filippini, R. and Forza, C., "Manufacturing strategy in global markets: an operation management model", *International Journal of Operations & Production Management*, Vol. 12 No. 4, 1992, pp. 7-18.
10. Porter, M.E., *Competitive Strategy*, The Free Press, New York, NY, 1980.

11. Coda, V., "La formula imprenditoriale", in Airoldi G., Brunetti G. and Coda V. (Eds), *Lezioni Di Economia Aziendale*, Il Mulino, Bologna, 1989.
12. Salter, W.E.G., *Productivity and Technical Change*, Cambridge University Press, London, 1960.
13. Finch, B.J., "Japanese management techniques in small manufacturing companies: a strategy for implementation", *Production and Inventory Management*, 3rd quarter, 1986, pp. 45-50.
14. Finch, B.J. and Cox, J.F., "An examination of just-in-time management for the small manufacturer", *International Journal of Production Research*, Vol. 24 No. 2, 1986, pp. 482-97.
15. Meredith, J., "The strategic advantages of new manufacturing technologies for small firms", *Strategic Management Journal*, Vol. 8, 1987, pp. 249-59.
16. Lefebvre, L.A., Harvey, J. and Lefebvre, E., "Technological experience and the technology adoption in small manufacturing firms", *R&D Management*, Vol. 23 No. 3, 1991, pp. 241-49.
17. Vrakking, W.J. and Mulders, P., "The implementation of 'world class manufacturing' principles in smaller industrial companies: a case study from consulting practice", *Technovation*, Vol. 12 No. 5, 1992, pp. 297-308.