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**The Encapsulation of Decentralized
Information in Networks of Firms**

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by

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Abstract

This paper gives an interpretation of the recent diffusion of the processes of productive outsourcing founded on two explanatory points. The first is that such processes replace a hierarchical paradigm of information diffusion with a decentralized paradigm in which independent subcontracting firms autonomously collect and process part or all of the prominent information. The second is constituted by the change of the modality of production innovation, becoming the result of autonomously developed inputs that are successively made complementary by the work of the network through an encapsulation process of the information. This is made possible by the fact that after an initial phase in which a new input is jointly projected by the contractor and the subcontractor and in which the information comes shared, a phase follows in which the prominent information for the specification of the characteristics of the product and for the solution of the local and unforeseen problems is collected and processed in a sequential manner and then encapsulated in the input by autonomous production units. In comparison with the vertical integration (make) or the market (buy), this form of governance (subcontract) allows for the organization in more efficient manner of the processing of the information, for the reduction of the informative costs and for the minimization of the risk of spillover.

1. Introduction

An evident fact in the recent evolution of the manufacturing industry is the general increase of the occupational weight of small firms. (Carre and Thurik 1998, Spilling 1996, Acs and Audretsch 1993, Lovemand and Sengenberger 1991). Just as obvious is the fact that small firms wouldn't have been able to grow to such extent if there hadn't have been a parallel development of the networks of firms by means of outsourcing processes based on vertical relations of subcontracting. The recognition of this fact has involved a profound renewal of the principles founding the structure and the evolution of industrial organization.

In particular, it has called for a critical analysis of the causes that explain the border of the firm. The theory of transaction costs has offered, for example, a wide analysis of the vertical integration processes by adopting interpretations also very different from each other. In the original version (Williamson 1985), this approach assumes that vertical integration can obtain the same result of complete contracts. A criticism of this simplification is that the integrated firm has to solve information problems that are very similar to those managed by a network of firms, because both of them are composed by agents with autonomous objective function and specific capabilities. This analogy requires a close examination of the process through which coordination without integration is obtained and especially the mechanism through which the information is collected, diffused and processed in the network.[1]

The scheme proposed in this paper intends to offer an interpretation of the advantages of the process of productive externalization over the vertically integrated firm. The specific object of analysis is provided by the diffusion mechanisms of the information in the networks of firms.

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[1] "There is no doubt that hold-up problems are of central concern to business people. In negotiating joint venture agreements, venture capital contracts, or any of a number of other business deals, much time is spent on building in protections against hold-ups. At the same time, such contracts are *prima facie* evidence that hold-up problems do not get resolved solely by integration of buyer and seller into a single party - the firm. Indeed, there seems to be something of a trend today toward disintegration, outsourcing, contracting out, and dealing through the market rather than bringing everything under the umbrella of the organization.

Section 2 offers a stylized representation of the process of collection and diffusion of information within and between firms, founded on the distinction between a hierarchical paradigm, that is characteristic of the vertically integrated firm, and a decentralized paradigm, that is differentiated in three distinct typologies, the organized vertical market, the corporate network and the cluster. Section 3 discusses how the network of firms improves the specialization in the processing of information. Section 4 describes finally the encapsulation process of information, that characterizes the subcontracting relationships between firms that are in vertical relation with each other.

2. A stylized representation of informative models of the relations between firms

The structure of an organization is the set of decision rules that connects informative inputs to decision outputs for the members of the organization (Marschak and Radner 1972). A stylized description can assume that members of an organization take decisions (D) on the basis of decisions received hierarchically (D'), of information (I) and of their own evaluation function (E_i). The decision process of a generic member m of the organization can be represented by a function h so defined:

(1) $\qquad h_m = M: (D';I) \text{ x } E_m \rightarrow D$

Applying such function to the description of a production process, it is possible to specify the decisions to be taken according to three typologies:

(a) the market strategy (D_m);
(b) the organization of human and non human capital (D_c);
(c) the definition of the productive process (D_p).

The information typologies used to take such decisions can be defined in analogous mode:

(a) the information on the market of destination of the product (I_m);
(b) the information on the characteristics of human and human capital (I_c);
(c) the information on the productive process (I_p).

This trend has seen the emergence of alternative, often ingenious solutions to hold-up problems."

An important characteristic of an organization is that the information is not however freely available, that is that every agent does not listen to all the messages diffused in the organization. Their utilization requires a specialization process, which depends on the adopted organizational structure. In particular, the collection of the information has a selective nature since it consists in perceiving within the mass of available information the one that is prominent for the decision process. From the point of view of the single subject, to make information exploitable, it must be first collected, eventually transmitted to others and finally processed in order to take decisions representing new information put in the productive system. Moreover one must assume that every subject has his own evaluation function E_i, that is private information. In order to make information and decisions circulate in the organization without distortions, it is necessary that the evaluation functions allow for the alignment of incentives.

In the first organizational paradigm, that we can define as hierarchical, the circulation of information can be described through a model in which a subject, placed on the highest hierarchical level, receives all the information, across a hierarchical structure in which the subject, who is placed at the lowest level of the organization, collects information according to the criteria fixed by the deciding subject and he communicates it to the latter to be processed.

According to the definitions given above, the subjects can be designated as the deciding subject (L), the middle management (Q) and the dependent subjects (W). The information (I_m, I_c, I_p) collected by the dependent subjects is transmitted, through the intermediate level Q, that has the task of coordination and of decoding the information, to the highest level of the hierarchy (L), that takes the decisions (D_m, D_c, D_p) using its own evaluation function (E_l). Such decisions are again to be communicated to the intermediate level, that processes them according its own evaluation function (E_q) and transmit them so corrected (D'_m, D'_c D'_p) to the lowest level, that processes them according his own evaluation function (E_w) to take its decisions (D''_m, D''_c, D''_p).
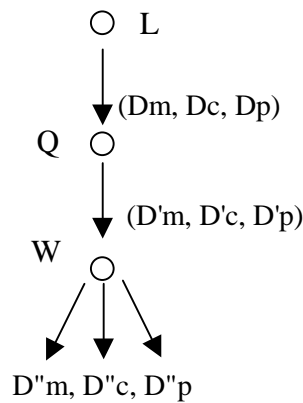
The hierarchical paradigm can be represented as follows:

(Holmström and Roberts 1998).

Figure 1

HIERARCHICAL PARADIGM

Information flows
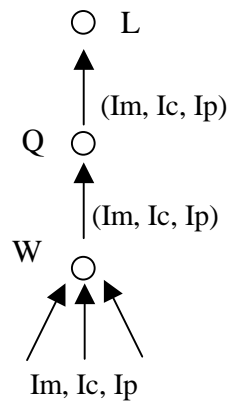
Decision flows

Functionally, the decision process can be described as follows:

$$(2) \qquad L : (Im, Ic, Ip) \text{ x } (El) \rightarrow (Dm, Dc, Dp) \rightarrow$$

$$\rightarrow Q : (Dm, Dc, Dp) \text{ x } (Eq) \rightarrow (D'_m, D'_c, D'_p) \rightarrow$$

$$\rightarrow W : (D'_m, D'_c, D'_p) \text{ x } (Ew) \rightarrow D''_m, D''_c, D''_p.$$

It is possible to interpret this paradigm as a whole integrated firm, but it can also represent the relations typical of the traditional Japanese *keiretsu*, in which a big contracting firm coordinates a number of small dependent subcontracting firms. In the case of vertical integration the subjects correspond respectively to the property, to the management and to the workers, in the case of the relation between contractor and subcontractors to the leading firm, to the market maker[2] and to the small dependent subcontracting firms.

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[2] The market-maker acts exclusively as an intermediary of the information flows between the producing firms. An example is given by the buyers in the industrial districts. (Casson 1997)

The running of this informative paradigm depends on, among other things, two variables:

(a) The efficacy of both the upward and the downward channels of communication;

(b) The characteristics of the evaluation functions (E_l, E_q, E_w), on which the alignment of the incentives in the transmission process of the decisions from the top to the bottom depends.

The literature on the treatment of information in organizations (Marschak and Reichelstein 1998, Bolton and Dewatripont 1994, Radner 1993, Riordan and Sappington 1987, Sah and Stiglitz 1986, Arrow 1975), that defines efficiency principally in terms of temporal lags and numerousness of the subjects processing the information, discusses the conditions relative to the variable (a). The possible distortions caused by the incentive problem have been discussed first by the managerial literature and then by the asymmetrical information models (Holmström and Roberts 1998, Pagano 1998, Aghion and Tirole 1997, Milgrom and Roberts 1988).

The previous representation points out however at least three other features of the hierarchical paradigm:

(a) the existence of filters that can be defined as bureaucratic (the Q level), that besides collecting information also have the function of resolving the problems of coordination and of communication between the highest and the lowest levels;

(b) the centralization of information processing involves a temporal and material scission between this processing and the collection of the information, carried out in a decentralized way by the subject placed at the lowest level;

(c) the necessity to separate in modules the decisions taken by the higher levels in order to communicate them to the lower levels.

In relation to such problems many causes of inefficiency in the hierarchical paradigm correspond:

(a) The incentive alignment problem becomes prominent through the assignment of the functions of intermediate coordination and communication to a specific class of subjects, the intermediate level Q becoming excessively costly;

(b) the dimension of the information to be collected and processed grows more than proportionally to the intensity of relations in the organization;

(c) the more the decisions are not separable in modules distinct from each other, the more the decision process must be assigned to subjects placed at lower levels.

The recent empirical observation of networks of firms shows in fact that:

(a) from the point of view of the firm's internal organization, bureaucratic filters tend to disappear, always making more frequent the practice of skipping levels in big firms or the vanishing of the market maker in networks of firms;

(b) from the point of view of the organizational structure, the increase of the dimension of the network causes a hierarchical decomposition of the firms with a progressive extension of the practices of downsizing and of outsourcing;

(c) from the point of view of the relations among firms, the predominant technological paradigm has become more and more a heterodirect process, given by the combination of decisions taken autonomously by the firms and then made complementary by the interaction in the network.

On this account, it is possible to describe the recent evolution of industrial organization as a progressive substitution of the hierarchical paradigm with organizational paradigms of a decentralized type, characterized by a diffusion process of information in which a key role is played by the relations of subcontracting.

The decentralized paradigms can be classified according to three typologies:

(a) the organized vertical market, characterized by the presence of the leading firm, that controls the decisions relative to both market strategy and human and non human capital, and of the vertical chain of subcontracting firms, to which the decisions on the productive process are delegated;

(b) the corporate network, in which, being the leading firm specialized in the control of market strategy, the decisions relative to production management (capital and process) are decentralized to subcontracting firms;

(c) the cluster, where all the decisions on both market strategies and production management are taken in a decentralized manner by the firms belonging to the network.

Graphically, the organized vertical market, that has as an example the more recent Japanese production model of quasi-integration (Asanuma 1994, Aoki 1988) or the reorganization of the car industry (Helper and Levine 1992, Helper 1991, Monteverde and Teece 1982), can be represented as the relation between the leading firm (L), that processes the information relative to the market and to the human and non human capital (I_m, I_c) and it takes the relative decisions (D_m, D_c), decentralizing to the subcontracting firms (F_1 e F_2) the collection of information on the productive process (Ip_i) and the relative decisions (Dp_i). The decision process is concluded by a phase (the decision Dp), that can be defined as information encapsulation, having the function of making

complementary the decisions relative to the productive process, taken autonomously and in a decentralized manner by the subcontractors specialized in productive phases different among them.
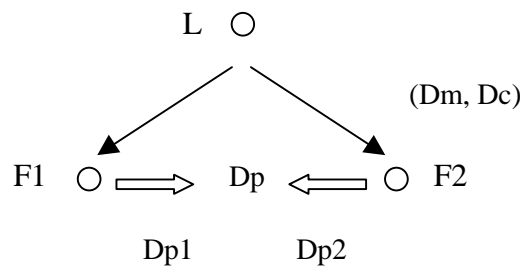
Figure 2

<div align="center">

DECENTRALIZED PARADIGM 1
ORGANIZED VERTICAL MARKET

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Information flows
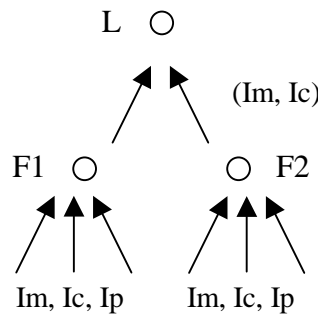
Decision flows

Functionally, the decision process can be represented in the following way:

(3) $L : (I_m, I_c) \times (E_l) \rightarrow (D_m, D_c) \rightarrow$

    $\rightarrow F_i : (D_m, D_c, Ip_i) \times (E_{fi}) \rightarrow (D_{pi}) \Rightarrow D_p.$

The *corporate* network, exemplified by the entrepreneurial networks (Belussi and Arcangeli 1998, Lazonick 1992, Johnston and Lawrence 1988) or by the externalization strategies abroad of medium firms (Brown and Butler 1993, Simon 1992, Birley, Cromie and Myers 1991), is instead characterized by the fact that information relative to capital is also decentralized. The leading firm (L) collects by means of the subcontracting firms (F_1, F_2) only that part of the organizational and technological information (I_m) prominent for the decisions on market strategy (D_m), delegating to the subcontractors the collection and the processing of information relative to the capital and to the

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process (I_c, I_p), as well as the relative decisions (D_{ci}, D_{pi}), afterwards encapsulated in the decisions (D_c, D_p).

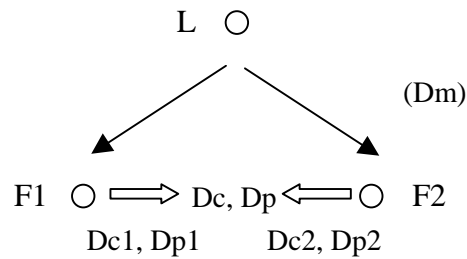**Figure 3**

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DECENTRALIZED PARADIGM 2
CORPORATE NETWORK

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Information flows
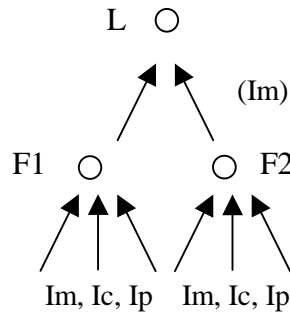
Decision flows

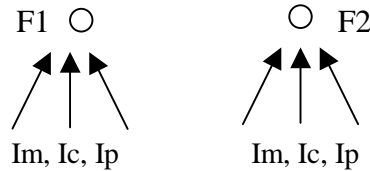The decision process can be then described in the following way:

(4) $L : (I_m) \times (E_l) \rightarrow (D_m) \rightarrow$

 $\rightarrow F_i : (D_m, I_{ci}, I_{pi}) \times (E_{fi}) \rightarrow (D_{ci}, D_{pi}) \Rightarrow D_c, D_p.$

The *cluster*, exemplified by the Italian industrial districts (Becattini 1990, Brusco 1982) or by the Silicon Valley model (Saxenian 1994, Frieberger and Swaine 1984), is finally characterized by the complete decentralization of the treatment of information that implies that the upward communication of information disappears. The subcontracting firms (F_1 e F_2), that entertain between them vertical relations, autonomously collect and process the prominent information and take separately all the decisions (D_{mi}, D_{ci}, D_{pi}), that are subsequently encapsulated in the decisions (D_m, D_c, D_p).
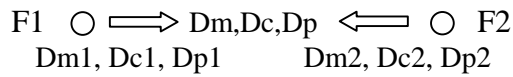
<div align="center">

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</div>

Figure 4

<div align="center">

DECENTRALIZED PARADIGM 3
CLUSTER

</div>

Information flows

$$\text{F1} \bigcirc \qquad \bigcirc \text{ F2}$$

Im, Ic, Ip   Im, Ic, Ip

Decision flows

F1 $\bigcirc \Longrightarrow$ Dm,Dc,Dp $\Longleftarrow \bigcirc$ F2

Dm1, Dc1, Dp1   Dm2, Dc2, Dp2

This representation corresponds to a simplified decision process:

(5) $F_i : (I_{mi}, I_{ci}, I_{pi}) \; \text{x} \; (E_{fi}) \rightarrow (D_{mi}, D_{ci}, D_{pi}) \Rightarrow D_m, D_c, D_p.$

The different typologies of the decentralized paradigm have in common two specific elements that, using the terminology of Dow (1990), concerns the first the behavioral relation that goes from the informative inputs to the decisions and the second the technological relation that goes from the decisions of the single firm to their implications in terms of informative input received by the other firms of the network.

The first element, that is analyzed in section 3, is related to the fact that the decentralized paradigm economizes on the transmission of information, assigning to those firms that collect the information the task of processing it, with an increasing saving from the case of the organized vertical market to that of the cluster. This is permitted by the fact that information doesn't flow to a deciding subject different to the receptor of the information: the latest information is collected and processed locally by the subcontractors.

The second point, discussed in section 4, is constituted by the presence in the decentralized paradigm of the encapsulation process of information, that makes complementary the decisions taken by the subcontractors and that allows for economizing on the informative costs and for attenuating the risk of information spillover.

3. The specialization in the processing of information

A useful concept to measure the informative efficiency of an organization is that of specialization. In particular, this aspect has been developed by Bolton and Dewatripont (1994), in which the efficiency of the network is a function of the tradeoff between the lowering of the processing costs of the information permitted by specialization and the increasing of the communication costs necessary to connect the subjects of the network.

In comparison with the scheme described in the previous section, the first element that differentiates the decentralized paradigm from the hierarchical one is the disappearance of an intermediate level (the Q level) of coordination-communication, that is absorbed by the network. The skipping of a passage that the information and the decisions have to make represents a simplification of the organizational process. Whether this coordination function is performed by the management or by the market maker, it involves the presence of a further evaluation function that distorts the diffusion process of the information. Besides it involves intermediation costs that can be absorbed by the firms of the network. Over a certain dimension of the organization, such costs grow beyond measure and create the effect underlined by Aoki (1994) to explain the informative efficiency of the Japanese *kanban*. In this particular case, the subcontracting firms, although they co-project the product together with the contractors, do the task of resolving the local shocks autonomously, as for example the defective quality of the components or the bad functioning of the machinery. In the integrated firm these operations request instead a specific subject that takes charge of the function of planning and control, and that becomes much more costly the more the dimension of the *kanban* raises.

The other advantage of the decentralized paradigm is that the coincidence between the subject that collects and processes the information allows for the exploitation the learning economies. In the hierarchical model, the scission between the receptors of information and the deciding subjects becomes more inefficient more it is important to distinguish in the informative flows that are prominent. This learning process can be carried out more effectively if the subject who collects the information is the same as who elaborates it.

The model of Bolton and Dewatripont assumes that the necessary information to take a decision is represented by a cohort $I = (I_1,…,I_i)$ and that to make information usable it is necessary to process all the i objects of a cohort, with the hypothesis that the cohorts are independent among them. If a subject of the network is specialized however in the processing of a single element of the

cohort, the processing time of the whole cohort can drop because it is a function of the processing frequency x of a generic element of the cohort I. The advantage of the specialization is however balanced by the increase of the communication cost with the subjects that process the other elements of the cohort.

The representation given in the previous section adopts a simplification of the model of Bolton and Dewatripont: it is possible to ignore the communication costs for that part of information that must not be communicated hierarchically, since in the decentralized paradigm this information is collected and processed autonomously from the single subcontracting firm, whose decisions are made complementary to the decisions of the other firms processing other elements of the cohort through the encapsulation of information.

To express the associated advantages by such a simplification, it is useful to distinguish between the case in which the information is processed by the firm that has collected it (decentralized paradigm) and that in which instead it is communicated to the deciding firm, different from the first (hierarchical paradigm).

In this way, it is possible to assume that the information cohort $I = (I_m, I_c, I_p)$ is communicated and processed by another firm who did not collect the information with cost in time unit given by:

(6) $C = t(x)\,(a+bn),$

where t is the time necessary to process a generic element I_i of the cohort I, that is function of the frequency x with which such element is processed, a represents the fixed cost of communication, b a unitary cost of processing (con $a,b > 0$ e $a+b < 1$) and n the numerousness of the cohort.

In the hierarchical paradigm the cost can be specified as follows:

(7) $C^G = t(x)\,(2a + bn),$

since the information must effect a double passage from the level L to the intermediate level Q and from the latter to the lowest level W.

If information is instead processed in decentralized mode, the cost is given by:

(8) $C^D = t(x)\,(bn)$

The cost function can be put in relation with a benefit function of the information which depends on the modality with which the capacity of the subject of processing the information raises. To make the subject receptive to the information it is necessary not so much to specialize in the sense of getting used to perceiving the same information as rather to highlighting the prominent information (Antonelli 1996). This capacity grows much more when the subject who collects the information is the same as the one who processes it and takes the relative decisions. By means of this process of trial and error not only the capacity of discriminating the prominent information is increased but also that of inferring from the selection process the elaboration modality more appropriate to which the decision has to be taken.

Formally, if B is the benefit that comes from the information:

(9) $B = B(x)$ con $B'(x) > 0$.

In two typologies of the decentralized paradigm (the organized vertical market and the corporate network), the subject is specialized in the processing of a restricted set of information. It is then:

(10) $B^D(x) > B^G(x)$,

since in the decentralized paradigm, with the only exception of the cluster, the dimension of the processed cohort I is inferior to the case of the hierarchical paradigm.

The advantage associated with the decentralized paradigm is then measured by:

(11) $B^D(x) - B^G(x) > t(x)\,(bn) - t(x)\,(2a+bn)$.

The inequality shows how the gain from the decentralized paradigm is given by two components: the learning economy ($B^D - B^G$), caused by the specialization of the subject in the processing of a part of the cohort I, and the disappearance of the intermediate level ($C^D - C^G$), that decreases the communication cost.

The other source of relative advantage of the decentralized paradigm - and that is instead greater in the case of the cluster in comparison with the paradigms of the organized vertical market and of the *corporate* network - is given by the disappearance of the degeneration of the decisions

from *D* to *D'* and to *D''*, that causes a problem of incentives alignment. In the hierarchical paradigm, the presence of the distortions introduced by different evaluation functions provokes instead obstacles above all from the point of view of the diffusion of the information. An example is offered by Helper (1991), that shows as General Motors has met great difficulty in convincing its internal divisions to share between them the respective productive costs. Generally, the acknowledgement of the centrality of the informative process in the production organization involves admitting that the theory of property rights is established on a wrong dichotomy: the idea that it is assigned only to the market the solution of the incentive problem and to the vertical integration that of the hold-up problem and of the spillover threat.[3] A vision empirically more significant assumes instead that the solution of such problems is rather assigned to the decrease of the firm's size and to the increase of specialization. In the first place, in small firms the incentive problem is attenuated by the existence of a simplified hierarchical structure. The decentralized paradigm allows in fact, through the process of vertical disintegration, of making the firms of the network more homogenous, creating a situation more similar to that of teams and of cooperatives (Aoki 1994). In the second place, the existence of specialized firms in the network has the principal end of favoring not opportunistic relationships supported by the non replaceability of the partners with which subcontracting relationships are entertained.[4]

The other variable that allows the unfolding of the advantages of the decentralized paradigm is the capacity of the channels of communication between the firms. In the decentralized paradigm the hierarchical communication is replaced by the vertical relations with the subcontracting firms.

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[3]   "As noted earlier, a virtue of the property rights approach is that it simultaneously addresses the benefits *and* the costs of ownership. Markets are identified with the right to bargain and, when necessary, to exit with the assets owned. This greatly clarifies the market's institutional role as well as its value in providing entrepreneurial incentives. On the other hand, firms are poorly defined in property rights models and it is not clear how one actually should interpret the identities of *B* and *S*. In an entrepreneurial interpretation, *B*, and *S*, are just single individuals, but this seems of little empirical relevance. If, on the other hand, firms consist of more than one individual, then one has to ask how one should interpret the unobserved investments (in human capital) that cannot be transferred. An even more fundamental questions is why firms, as opposed to individuals, should own any assets. At present, the property rights models are so stylized that they cannot answer these questions." (Holmström and Roberts 1998, p. 79).

[4]   In an empirical work concerning the evidence of trust in the subcontracting relationships in the car industry in Japan and United States, Sako and Helper conclude: "Lastly, trust and opportunism are valid concepts only in situations where actors can choose from alternative courses of action. This study gives support to this notion. We find in particular that customers' provision of technical assistance to suppliers is significant in enhancing trust and attenuating customer opportunism only in cases where customers are free, but not when they are constrained by market structure or technology. In other words, customers can be made to behave in a predictably trustworthy or non-opportunistic manner if they cannot replace their existing suppliers easily, regardless of other factors. It is when easily accessible alternative suppliers exist that suppliers give careful consideration to safeguards in deciding how much opportunistic or trustworthy behaviour to expect from their customers." (Sako and Helper 1998, p. 407)

The communication channels among firms that occupy different tiers of subcontracting are improved and extended by the encapsulation process of information.

4. The encapsulation process of information

The more recurrent method with which a hierarchical paradigm is replaced by a decentralized one is through processes of productive externalization, creating relationships of subcontracting. Such processes are subdivided in three phases that differ among them for the state of the prominent information:

Phase 1. The information is scattered.
a) The contractor decides to externalize the production of a new input.
b) The contractor addresses a population of potential subcontractors with a general idea of the new input.
c) Some subcontractors study the feasibility of the new input specifying the range of possible investment.

Phase 2. The information is shared.
d) The contractor accepts some proposals on the basis of an outline of the general characteristics of the input.
e) The subcontractor projects the prototype of the input.
f) Investment.

Phase 3. The information is encapsulated.
g) The subcontractor produces the input and it decides autonomously any changes to the process that can derive from local shocks and unforeseen contingencies (errors, imperfections, adaptations to its own productive process).
h) The contractor inserts the input in its product, introducing autonomously only the adaptations that comes from unforeseen contingencies relative to its production process.
i) If market signals problems or technology evolution imposes changes in the production process, they are solved or adopted in the decentralized mode with the aid of the relevant information.

This process is characterized by the fact that the necessary information is collected and processed autonomously by the subcontractors. This decentralized mode allows for the encapsulation of the relevant information, that is the process through which the two firms - subcontractor and contractor - observe independently the environment and give differentiated representation of it in which possible mistakes are not correlated. This implies that the information employed by the two firms is hidden from each other, that the process of innovation is based on inputs developed sequentially from the single firms and subsequently combined in the output, and finally that the selection of the productive paradigm is the result of a decentralized process in which the local improvements are not distinguishable from the viewpoint of the whole productive process.

To explain how such a process offers a rational response to the need of economizing on (a) information costs and (b) control costs, and represents then a reason of efficiency of the decentralized paradigm, t is necessary to explain why the hierarchical paradigm, both in the case of vertical and of quasi-vertical integration, does not allow the reduction of information costs and control costs toward the subcontractors.

With regard to information costs in literature different arguments have been offered (Choi 1998, Casson 1997, Riordan 1990, Riordan and Sappington 1987, Crocker 1983, Arrow 1975). In particular, Casson (1997) argues that vertical integration can be interpreted as a reaction to doubts in the quality of the information: extending the property to the adjacent productive phases, a firm is insured against the risk that information is wrong. The argument of Casson follows Riordan (1990), according to which the crucial consequence of the vertical integration is the change in the information on the upward costs. In his model what differentiates vertical integration from subcontracting relationship is the fact that in this last the contractor does not know the costs of the subcontracting firm and that involves the fixation of inefficient quantities and prices. However in a vertically integrated firm the producer knows the price and the quantity of the productive factors and that allows the determination of an efficient equilibrium.

If the alternative between the types of governance considered in these interpretations is that between "make" or "buy", the alternative to be regarded in the case of the network is that among "make", "buy" or "subcontract": to the vertical integration and to the recourse to the market is added a hybrid model that consists in the outsourcing of the production to the subcontracting firms. In particular, if this process involves small firms - as typically happens in the case of the cluster - the process of continuous bargaining, characterized by the direct contact in the phase 2, is an effective

instrument for knowing upward costs. An argument such as that of Riordan, namely that a subcontractor obtains higher profit by overvaluing its costs, has little significance in a competitive system such as that of a network where any attempts at hiding in an opportunistic manner the true costs are not possible to last too long without being uncovered. This is true because it is necessary that the potential subcontractors are in continuous interaction in a stable population with limited entry and exit flows. Such flows are much lower the higher the maturity level of the productive process, in other words its not being easily repeatable. The subcontracting relationship is then more advantageous than the recourse to the market, that requests market analysis and ad hoc evaluations, costly and rather reliable, and above all that conceals the circulation of information behind an impersonal relation of buying and selling. But it is also more advantageous in terms of informative costs in comparison with the vertical integration, in which the presence of different evaluation functions causes a distortion in the transmission of the decisions. Such a problem, as already discussed in the previous section, is much greater the wider is the diversity of the evaluation functions of the subjects that exchange information. This is then maximum in the hierarchical paradigm and minimum in the case of the cluster.

But the encapsulation process of the information allows for the reduction of the informative costs also owing to a consideration pointed out by Casson:

> A dense network of communication, though costly to maintain, provides an economy with considerable flexibility in responding to shocks. It is because the economy is continually disrupted by shocks that communication is required on a continuous basis. When everyone is connected to everyone else by a reasonably short path, then everyone can share in the process of adjustment to every shock. When the cost of adjustment borne by a single individual accelerates as the size of the shock increases, it is advantageous to spread the burden of adjustment. By widening the field of adjustment, then individual burdens are very significantly reduced. (Casson 1997, p. 46)

In the phase of information encapsulation, the problems relative to exogenous and unforeseen shocks become solved locally. That allows for the shortening of the reaction time to the shocks, meanwhile redistributing the burden of the necessary adjustments along the chain of the subcontractors. In contrast with the hierarchical paradigm, where the scission between the phase of the collection and that of the processing of the information requests planning in advance the choice of the prominent information, in the decentralized paradigm the single firm initiates sequential procedures of collection of the information that are carried out and mended locally. (Vercelli 1988)

To clarify further this point one has to consider that there is a qualitative difference between the three typologies of information (I_m, I_c, I_p): from left to right the information becomes less

systematic and more idiosyncratic. In the hierarchical paradigm, the deciding subject (*L*) can so make its own choices in order of minor idiosyncrasy, determining first the market strategy and then the organizational arrangement of the capital and the typology of the productive process. The lower level (*Q*) is then called to resolve the complementary problems between its decision and that of the higher degree and it is because the different levels of idiosyncrasy allow the separation of the decisions in modules distinct among them. The establishment of the decentralized paradigm is instead a consequence of the fact that all the three information types becomes relatively more idiosyncratic and they are consequently less separable in distinct modules. The encapsulation process must happen in an integrated manner, taking account of the different typologies of information at the same time. The encapsulated information is not however reversible, because the solution of the local problems is assigned separately and sequentially to the same holders of the information.[5]

The second point to be analyzed is how the encapsulation process reduces the control costs, that are in the case of the network related substantially to the problem of information spillover. If the information is encapsulated, a subcontractor is not easily replaceable and this fact makes the establishment of mechanisms of trust or at least of not opportunism advantageous. The existence of a network of firms makes in fact the problems of contractual incompleteness less prominent than those underlined by the theory of transaction costs (Holmström and Roberts 1998), since it assures visibility to opportunistic behavior that is punished by the exclusion of the responsible firm. The capacities utilized in the production process are indeed specialized enough to resolve the problem of information spillover.[6] In this way the network implements the task of "capacity market" (Loasby 1998), that integrates through subcontracting relationships the information held autonomously by the single firms.

The availability of information allows also for the specification of the factors that determine what kind of decentralized paradigm will tend to replace the hierarchical paradigm. In order to obtain insights, it is necessary to consider the alternative between non availability of the information

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[5]   This does not apply for the emergence of a new technological regime, because large shocks are usually faced better by the hierarchical paradigm. If indeed "the system is composed of highly specialized and inter-related units, the exploitation of the existing complementarities is an obstacle to the independent adaptation of the single units" (Caminati 1999).

[6]   "The organisation of capabilities is the organisation of systems for generating and testing new and improved skills. These systems are the institutions of economic evolution, which requires specialisation, but not uniformity within each specialism. There may at any time be 'one best way' of achieving a particular kind of result, but to train everyone within a specialism in that 'best way' would be a recipe for disaster. (Fortunately, there are always a few who escape or resist such training.) Diversity is necessarily a system

and productive specialization. A leading firm is able to maintain the control on a determinate informative typology and to then structure the collection and the processing according to the hierarchical paradigm, only if such typology is not easily transferable. Such condition allows for the organization of both the collection of the information and the transmission of decisions organized in modules that are not possible to be recompounded and utilized autonomously by the subcontractor. If instead the information is easily transferable, such attempts at keeping hierarchical the elaboration process of the information are bound to fail. The decision process will tend then to decentralize in the network and the subcontracting firm will autonomously take the decisions relative to the information freely available in the network, accentuating at the same time its specialization that safeguard it from the threat of spillover.

According to this interpretation, the organized vertical market will tend to establish when the information both on the market and on the capital cannot be handled in a decentralized mode or because of the high capital intensity or because of the high content of R&S. The corporate network will tend instead to become established when a high degree of control is possible only on the distributive channels and on the access to the market. Finally in the cluster all the information is diffuse in the network and only the specialization process allows protection from the problem of information spillover.

5. Conclusions

This paper offers an interpretation of the recent diffusion of the processes of productive outsourcing that characterize in an increasing manner all the industrialized countries. This fact has two central characteristics. The first is that it replaces a hierarchical paradigm of information diffusion, in which all the prominent information must flow to a central processing unit, with a decentralized paradigm in which independent firms collect and process autonomously part or all the information. The second is given from the change of the modality of innovation, that becomes the result of autonomously developed inputs, that are successively made complementary by the work of the network through an encapsulation process of the information. Such a process is made possible by the fact that after an initial phase, in which a new input is jointly outlined by the contractor and the subcontractor and in which the information is shared, there follows a phase in which the prominent information for the specification of the characteristics of the product and for the solution

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property, and it requires the absence of control; for control frustrates the development of capabilities to

of the local and the unforeseen problems is collected and processed in sequential manner and then encapsulated in the input by autonomous productive units. In comparison with the vertical integration (make) or the market (buy), this form of governance (subcontract) allows for a more efficient organization of the processing of information, for the reduction of the informative costs and for the minimization of the risk of spillover. The processing of the information becomes more efficient because of the simplification of the internal organization of the firms, through the practice of skipping level, and of the network structure, through the disappearance of the market maker. This evolution make resources available for the productive units and attenuate the distortions in the transmission of the decisions. Besides it is helped by the fact that the information is elaborated in the decentralized paradigm by the same subject that collects it and this allows for the exploitation of the learning economies. The information cost reduction is instead the consequence of the existence in the network of a competitive process, that makes the cost much more visible the more the chain of the subcontractors is in continuous interaction in a stable population with limited entry and exit flows. The dimension of such flows depends on the transferability of the productive process, which is much lower the more elevated is the technological level of the production is, and the more accentuated the degree of specialization. Finally the problem of information spillover is attenuated by the decentralized paradigm more efficiently than by the hierarchical paradigm because the encapsulation of the information does not allow the centralization of the informative flows to the end of their control and of the appropriation of the profits.

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which one might later wish to have access." (Loasby 1998, pp. 157-158)

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