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Inter-firm relations and innovative activity: A cluster analysis based on subcontracting firms in the French Sillon Alpin

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Abstract

The aim of this paper is to give a full description of the innovative nature of firms operating in the subcontracting industry. Mobilizing the two conceptions of the firm (contractual and competence perspectives), we specify three different types of firms according to the nature of their inter-firm relationships. Following the neo-schumpeterian approach of innovation, we complete this description by introducing other determinants that can encourage the innovative activity. The empirical test is based on a cluster analysis. It confirms that the nature of inter-firm relationships is a main source of inter-firm differences in their ability to innovate. It provides also evidence that small firms are innovative in the subcontracting industry.

Key words

Subcontracting industry, theories of the firm, innovative activity.

1 Introduction

In the French Alps, especially in the "Sillon Alpin[2]", the competitiveness of firms operating in the "manufacturing subcontracting industry" remains unsatisfactory. At the regional level, it is a huge problem since manufacturing is mainly composed of the subcontracting firms. Following the neo-schumpeterian approach of innovation, the solution to improve the competitiveness can be found in the ability of firms to keep up innovative products and processes and the underlying technologies (Pavitt, 1990). In this paper, we aim to indicate how different types of subcontracting firms and their innovative activity can be linked. It is a real challenge considering the very special nature of the industry[3] within which they operate. This industry is not delineated according to a sectoral basis (nature of the final output) but a destination basis (volume of the collected activity). This suggests that this industry consists of firms belonging to different

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[2] The Sillon Alpin is a geographic area in the French Alps which gathers the four departments of Savoie (73), Haute-Savoie (74), Isère (38) and Drome (26).

[3] Industrial subcontracting involves production activities only, excluding service industries such as security, catering and cleaning. Sectors described as pure subcontracting ones meaning that their turnover is carried out minimum 80% in this field (Sessi, 2006).

manufacturing sectors but all of them manufacture products on behalf of other firms[4]. The studied population is then specific *by nature* insofar firms are dependent (more or less) from partners or contractors. Notwithstanding the small number of empirical studies on the subcontracting firms (with very few exceptions at the industry level), they give us interesting lessons about the features of firms' heterogeneity within the industry. For the Sessi (2006), the subcontracting firms mainly differ in their size (subsidiaries of international groups together with small French independent companies) and in the types of relationships with their contractors (more or less favourable).

Following the theoretical literature, the nature of cross-firm relationships is identified as an important source of inter-firm differences in innovative activity (Cohen, 1995). In the case of the subcontracting firms, this source becomes a key determinant as far as their nature ensues from their inter-firm relations (Baudry, 2004). In that way, the identification of different types of inter-relations should explain the potential variety of innovative activities (and performances). The originality of the framework is based on the combination of two kinds of literature. On the one hand, we specify different natures of the subcontracting firms according to the two "visions" of the firm (Fransman, 1994), namely the transaction cost theory and the competence-based approach of the firm. The specification is based on the type of relations with their main contractor/partner. On the other hand, we call for the neo-schumpeterian theory of innovation to complete the specification with two classes of variables: the knowledge sources they used and their profile. These new dimensions are introduced to observe the degree of autonomy of (small) subcontracting firms in their innovative activity. As suggested by Cohen and Levinthal (1990), beyond their subcontracting relations, firms can develop internal resources and/or an ability to learn from interacting with other firms or institutions. "The capacity for absorbing knowledge, so-called "absorptive capacity" is a must for large or small innovative firms" (Fagerberg, 2005). All things considered, this framework will allow us to differentiate three theoretical types of the subcontracting firms and to indicate how they can be linked with the innovation intensity (improvement and/or development) and the type of innovation (process and/or product).

The empirical test is based on firms data collected in 2007 trough a special designed questionnaire in the French Sillon Alpin. Firms are the establishments operating in all the manufacturing subcontracting sectors of this geographic area (such as metal cutting and forming, moulds and models, foundry, technical pieces made of plastic and electronics). To identify the existence of differentiated types of subcontracting firms, we develop a classification system using a cluster analysis procedure. With this methodology, we aim to explain why some clusters of firms have a greater ability to innovate than others.

The paper is organized as follows. Section 2 presents the theoretical foundations and the two propositions that will be tested. Section 3 sets out the empirical procedure and describes the dataset. In section 4, the empirical results are discussed. Finally, we draw some conclusions.

2. Inter-firm differences in the innovative activity of the subcontracting firms: theoretical arguments about the main sources

Firstly, we introduce industrial subcontracting to specify the main challenges related to our research question (1.1). Secondly, we present the theoretical

[4] With some exceptions: there are firms that may have a weak activity in the field of subcontracting.

foundations of the model and the two propositions that will be tested empirically (1.2). This research aims to provide a better understanding of the innovative activity of the subcontracting firms through two main aspects. The first consists in the description of different theoretical types of inter-firm relationships in the field of subcontracting and their potential role on their innovative activity. The second attempts to identify the degree of autonomy of firms and to what extent they can develop new ideas from other sources of knowledge.

2.1 Introducing industrial subcontracting

The industrial subcontracting industry is very important for the geographical region under study. This region which stretches from Valence to Geneva (Sillon Alpin) has the biggest density of subcontracting firms over France. Nowadays, this industry is called into question. The main question which is addressed is about the competitiveness of the firms. Lately, many of them have experienced an alarming fall in their performance. In this context, policy makers are looking for the drivers to modify this trend. This work is part of the research program about this industry and is still at an exploratory stage.

Following the neo-schumpeterian approach, this fall in competitiveness is imputable to a lack of innovation in products and processes at the firm level (Pavitt, 1990). It is thus important to understand why some firms do better than others in terms of innovation. A first way of dealing with this question could be to provide a taxonomy of subcontracting firms in the way of Pavitt's (1984). This idea of a taxononomy [5] seems attractive, but shows serious limitations in this case. The first limit is about the classification criterion used. In Pavitt's taxonomy, the decisive criterion for classification is the sources of technological know-how used by firms. This criterion eliminates straightaway non innovative firms. We think it is a main limit since the lack of competitiveness may come from the fact that non innovative firms are over-represented in the subcontracting sectors. This hypothesis is deserves to be tested. The second limit is about the way the sectoral dimension is considered in the framework. In each category of his taxonomy, Pavitt has grouped data at the industry level and not at the firm level. He recognized himself that the weakness of his taxonomy is the high degree of variance still found within each category. To overcome this limit, many researchers have developed a taxonomy at the firm level and then compared it to sectoral clusters in order to take into account the variety of firms within the same industry (Niosi, 2000). But the level of aggregation usually retained to illustrate the variety of patterns of innovation across sectors is still high (De Jong, Marsili, 2006). If we use the same level of aggregation, most of the subcontracting firms will belong to the same industrial sector. Thus, the inter-sectoral comparison will lose much of its significance.

Rather than a taxonomy we propose a classification to capture the heterogeneity of firms within the same industry. Our contribution must be seen as a practical classification tool to describe the nature of subcontracting firms according to their innovative activity. We aim to build a tool adapted to the two main characteristics of this industry (Sessi, 2006). On the one hand, we have to take into account that this industry is made up of a large number of small independent companies. We cannot neglect these firms that carry weight in the industry. Moreover, many researchers claim that small size is no longer an obstacle to innovation. (Audretsh, 2004). However, specific determinants of innovation have to be introduced as well as convenient measures of innovative activity (Archigugi et al., 1991, De Jong, Marsili, 2006). More informal aspects of the innovation process are typical of small firms that can not be measured by traditional input or output indicators. On the other hand, subcontracting firms are by nature special firms: they are in a situation of dependence (more or less favourable) with regard to other firms. In this way, the characteristics of inter-

[5] A taxonomy aims at reducing the complexity of the population studied into easily recallable macro-classes (Archibugi, 2001)

firms relations can be seen as an important determinant of innovative activity (Cohen, 2005, Teece, 1996, Angel (2002). They fix both the nature of the firm and its ability to innovate. It is then essential to understand the features of inter-firm relations. The theories of the firm provide useful insights to explore these relations. However they are not sufficient to capture the determinants of innovation that may exist beyond these relations. That is why we mobilise the neo-schumpeterian approach of innovation to illustrate the potential role of a series of variables (related to the knowledge sources used by the firm and the characteristics of the firm). The objective is to understand to what extent firms are constrained by their inter-firm relationships or, on the opposite, are able to develop their own ability to innovate.

2.2. The nature of subcontracting firms from their inter-firm relationships: can they innovate?

The nature of subcontacting firms can be assessed through the two perspectives of the firm: the contractual based-approach (transaction costs theory in particular) and the competence-based approach (evolutionary theory in particular) (Foss, 1993, Fransman, 1994, Langlois, Foss, 1996, Cohendet, Llerena, 2005, Lazonick, 2005). From these two theoretical approaches, we identify different natures of subcontracting firms and observe to what extent they may differ in terms of intensity and types of innovation.

2.1.1 The contractual perspective: between suppliers and pure subcontractors

The transaction cost theory (Williamson, 1975, 1985, 1999) puts forth a theory of adaptative and non innovative organization because the role of business enterprise in the innovation process is ignored (Lazonick, 1991). The problem is reduced to the combination of given inputs and outputs in a way that minimizes transaction cost, given technology. As suggested by Foss (2001), “innovation, the creation of markets, learning within and between firms and so on… are either side-stepped or implicitly taken to be unimportant to economic organization”. Following this argument as suggested by Williamson himself (1999), there is limited room for firms’ innovative activity in the transaction cost theory. In the case of subcontracting firms, the room becomes even smaller. Subcontractors are only seen as a governance structure far from the vision of an organizational entity (Baudry, Gindis, 2005). Their “raison d’être” is mainly based on economizing and static perspectives. Subcontracting firms are not considered through their organizational competencies and their ability to develop new processes and new products.

It is possible to distinguish two types of inter-firm relations in the Williamson’s model. From these two types, we can differentiate two natures of firms in the subcontracting industry.

The first inter-firm arrangement takes place in a situation where a firm expresses a mere supplying need on the market. In this case, the degree of specificity related to the transaction is so weak (market of standard inputs) that the firm does not have to make specific arrangements with any partner. It will go to the supplier who is able to satisfy its need at lower cost. Here, the subcontractor is in fact a supplier. Its relationships with other firms are based on price mechanisms. In competitive market, such independent suppliers can be encouraged to innovate because they want to benefit from cost advantages (even if they are temporary) (Milgrom, Roberts, 1992). However, this forces us to consider whether appropriability conditions and market power are strong enough to encourage innovation (Archibugi, Pianta, 1996). In this case, all benefits can remain inside the innovative firm. The buyer will also benefit from a part of the value gained on a higher quality product or a cheaper product. Conversely, if

appropriability is low and diffusion and competition are too strong, benefits can quickly spread and firms will be discouraged to invest. This is true even if products are specialized. Competitive bids provide similar advantages. Looking for an independent supplier, the firm benefits from the best resources available and, if competition is adequate, it only pays for the real cost.

To sum up, there is a cluster of suppliers operating on the competitive market of standard inputs. They have no (or very few) privileged relations with partners/contractors. Their ability to innovate and the type of innovation depend mainly on the appropriability regime and the nature of the competitive environment (Teece, 1996). The intensity of innovation will be low and only visible on product or process improvement under a weak regime of appropriability and intense competitive pressure. In contrast, this ability to innovate will be more intense and oriented toward product or process development if the appropriability and competitive conditions are favourable.

In the second type of inter-firm relation, the firm does not operate on the competitive market of standard inputs. It is involved in the production of peripheral products that do imply assets with an average degree of specificity[6] in the case of repeated transactions. In this context, for the contractor, it can be less costly to leave the production to subcontractors if he succeeds in maintaining market incentives and in the meantime avoids bureaucratic distortions. (Williamson, 1990). The challenge for the contractor is to limit the potential power of the subcontractor, in order to avoid any situation of dependence (lock-in effect). This situation is well described by Teece (1996) in the case of "virtual corporations" which « subcontract anything and everything ». Several mechanisms can be of a good guarantee against this kind of risk. For example, the contractor can keep the propriety rights on specific assets or maintain a strong competitive pressure by a double sourcing purchase strategy (Baudry, 2004). Subcontractors are seen as governance structures based on arm's length contracts, likely to be in the balance at every moment, according to their performance. The degree of interdependence is generally low because activities concerned are peripheral ones. At the same time, the weight of the contractor can be heavy in order to benefit from scope and scale economies. In terms of supplier management practices, this zone requires minimal assistance to subcontractors, accompanied by single functional interfaces and the practices of price benchmarking (Cohendet, Llerena, 2005).

In this way, the ability of subcontractors to innovate can only exist through passive learning-by-doing processes as a by product of the division of labour. Though limited, the transaction cost theory is useful to describe the non innovative or less innovative firms. As suggested by Cohendet and Llerena, op.cit.), "in terms of technology transfer what is at stake in this zone (of quasi-market relations) is the exchange of artefacts, rather than innovative ideas or new tacit knowledge". Subcontractors are placed in a situation where they must most often comply with the instructions or technical specifications fixed by the contractor. They are not in charge of a part of the product design, which is too specific and too risky to be externalised. Sometimes, they can give some advice to the contractor. Considering the nature of this inter-firm relation, subcontractors find no incentives to innovate, nor in process, nor in product. Anyway, we have to admit they have no internal competence to innovate in the transaction cost theory. Nevertheless, it may be possible to consider that subcontractors are able to improve their processes because of passive learning effects (derived from the division of labour). As a matter of fact, subcontractors under dependence and competitive pressure will be stimulated to improve their processes in order to preserve their main outlet.

[6] Williamson (1990) considers that hierarchy is a more efficient institutional arrangement than market or hybrid-forms when assets are very specific.

All things considered, there is a category of subcontractors dependent on a main contractor. They do not have a free hand in the production conception because it is too risky for the principal. Classical contractual schemes are dominant to ensure the information processing. Their innovative activity is based on process improvements only, as a by-product of the division of labour.

2.1.2 The competence perspective: the innovative partners

The competence (evolutionary) perspective gives us a theoretical framework of the innovative firm. Subcontracting relations derive from the needs of contractors to access the complementary forms of knowledge required to make their own knowledge valuable. This perspective emphasizes the dynamic efficiency of capability building rather than the static efficiency of individual transactions. In this view, contracting relations no longer involve the external boundary functions of the contractor. Subcontractors are considered as "processors of knowledge" (Fransman, 1994) who produce high value components or systems that are strategic for contractors. They contribute to build the knowledge base of their contractors and benefit from their accumulated absorptive capabilities (Cohendet, Llerena, 2005). It is also important for contractors to enhance the absorbing capacities of their partners. Since the ressources of the subcontractor are essential, the innovation also derives from subcontractors' internal organization (Nelson, Winter, 1982, Teece, 1996). Here, the social nature of competences is emphasized. Routines that contain these competences "may extend outside the firm to embrace partners" (Teece, Pisano, Shuen, 1997). The key point is that the learning process is intrinsically social and collective and occurs not only through imitation but also because of joint contributions to the understanding of complex problems. .Some evolutionnary theorists have shown that multilateral collaborations and partnerships can be a vector for new organizational learning (Doz and Shuen, 1990, Mody, 1993). "Compared to arm's length market contracts such arrangements have more structure, involve constant interaction among the parts, more open information channels, greater trust, rely on voice rather exist, and put less emphasis on price" (Teece, 1996). They are based on relational long term-contracts and coordinative routines for an efficient circulation of creative ideas and knowledge. Cohendet and Llerena (2005), Teece (1996) have shown these kind of external linkages are major determinants of innovation, providing autonomy in the making of product and systems and strong incentives for firms even when asset specificity is involved. The incentives for opportunistic recontracting can be attenuated by equity stake, reputation effects, mutual commitments and the maintenance of reciprocity through the exchange of hostages.

In this view, there is a category of subcontractors called «partners ». They have competences which can complement the contractors' ones. The relational nature of long-term agreements and the complementary nature of resources/capabilities provide a high degree of autonomy and strong incentives to improve and develop new processes and products.

2.2 Apart from inter-firm relationships, can firms benefit from other sources of innovation?

The neo-schumpeterian and evolutionary approaches provide useful insights to identify the sources of inter-firm differences in innovative activity apart from the cross-firm relationships (Nelson, Winter, 1982, Dosi, 1988, Cohen, Levinthal, 1990). These approaches propose a dynamic conception of learning, in which firms may have limited knowledge at a moment, but are able to upgrade it.

The "absorptive capacity" of firms, defined by their capacity for absorbing extramural knowledge (Cohen, Levinthal, 1990), well reflects the cumulative

nature of knowledge. As noted by Fagerberg (2005), "this is of particular importance for smaller firms, which have to compensate for small internal resources by being good at interacting with the outside world". Arora and Gamberla (1990) provide further evidence showing that firms that conduct more R&D increase their ability to exploit external sources of knowledge. Moreover, they show that some external sources of external knowledge tend to be complementary.

Nelson (1992) shows that the learning capacity can be influenced by the awareness of technological opportunities. As a consequence, he suggests that innovative activity might depend on what firms think they can do with the new solutions. The existence of a clear strategic orientation can encourage innovations (Bocquet et al., 2007). Another important aspect well discussed in the literature concerns the features of knowledge that can be highly tacit (Nelson, Winter, 1982), sticky (Hippel, 1984) and complex. A corollary is that the transfer of knowledge is often difficult and costly. It requires an organization's system, habit of coordinating and managing tasks (Teece, 1996).

Concerning the sectoral effect, some empirical studies on the sources of innovation have shown the remarkable difference of patterns (Pavitt, 1984, Von Hippel, 1988, Archibugi et al. 1991). Traditional industries tend to use external sources while science-based industries use internal sources such as R&D and design. In the same vein, researchers have shown that significant non-R&D innovative activities are carried out to a greater extent in smaller firms and in traditional industrial sectors (Pavitt et al. 1997, Acs, Audrestch, 1990, Archibugi et al., 1995, Malerba, Orsenigo, 1997). In their empirical study applied to small firms, De Jong and Marsili (2005) do not find a clearcut relation between industrial sectors and clusters of firms. For them, this result may reflect the high level of aggregation of sectors used in their analysis.

Finally, the neo-schumpeterian approach of innovation gives us new arguments concerning the ability to innovate of small firms. Following this literature, small size is not an obstacle to innovation. As mentioned by Teece (1996), "even in the absence of adequate internal cash flow, firms need not go to the capital market to find the requisite financing (…) With inter-organizational arrangements, there is the possibility that the capital requirements associated with a new project could be drastically reduced for innovator".

All these arguments allow us to complete the specification of the three types of subcontracting firms in terms of potential sources of knowledge and in terms of profile, mainly through their size, their R&D budget and their industrial affiliation. Concerning the suppliers operating in the market of standard inputs, as suggested before, they have no privileged relations with partners. A corollary is that they can benefit from market connections. According to the literature, firms can develop new products or processes if conditions of appropriability are favourable. A main aspect resides in the possession of a learning capacity. However, since most of the subcontracting sectors are traditional ones, the main potential sources will tend to be external. Pure subcontractors are clearly poor innovative firms. They are highly dependent on their contractor. Since they are mainly cost-oriented and have no internal resources for being good at interacting, they should use a very few number of external sources of knowledge. Finally, the partners have organisational competences to manage their inter-firm relationships (coordinative routines). Their sources of knowledge are internal. They can develop their internal resources by interacting with their partners and other "institutions" to access complementary forms of knowledge.

Table 1 summarizes the theoretical dimensions explaining the nature of subcontracting relations and their potential link with their innovative activity.

Table 1.Theoretical foundations to link the nature of the subcontracting firms and their innovative activity

	Transaction cost approach		**Evolutionary theory**
Theoretical dimensions explaining the nature of subcontracting firms	SUPPLIERS	PURE SUBCONTRACTORS	PARTNERS
Main objective of inter-firm relations	To buy a standard input	To produce at lower cost	To produce complementary resources and forms of knowledge
Degree of specificity of the transaction	Low	Average	High
Frequency of the transaction	From low to high	High	High
Uncertainty	Low	From low to average	From average to high
Main coordination mechanisms and types of incentives	Prices	Arms' length contracts and market-like incentives	Contractual mechanisms and coordinative routines
Duration of contracts	Not concerned or short-term contracts	Short-term or medium term contracts	Long-term contracts
Degree of interdependance	Not concerned or low	Low	High
Resources complementarity	Not concerned	Not concerned	Strong
Competences/capabilities	Not concerned	From not concerned to low	High
Number of potential sources of innovation	Few number	Few number	Several
Type of potential sources of innovation	External	External	External and internal
Theoretical links with the innovative activity of subcontractors (intensity and types)	**Low, process or product improvements or High, process or product developments**	**Low, process improvements**	**High, process and product developments**

This theoretical discussion leads us to formulate the following propositions:

P1 – Taken together, the transactional and competence perspectives provide a comprehensive setting of the different natures of inter-firm relationships that may support innovative activity within the subcontracting industry. Since the innovative activity can be characterized by the intensity of innovation (improvement and/or development) and the type (process or product), we expect that there are differences among the types of subcontracting firms in their ability to innovate.

P2 – Following the evolutionary and neo-schumpeterian approaches, this ability to innovate does not only depend on the nature of inter-firm relationships. The absorptive capacity of the firm and its characteristics may affect the intensity and the types of innovation. We expect a significant effect of these variables on the firm's innovative activity. In this case, we can consider that the firm has an autonomous capacity to innovate.

3. Data and Procedure

In this section, we present the data, the empirical procedure and the variables used in the cluster analysis.

3.1 Data

The empirical analysis is based on firm data collected in 2007 using a specially designed questionnaire. Questionnaires were e-mailed to the principal unit of each firm with more than two employees operating in industrial subcontracting sectors. All establishments operate in the French Sillon Alpin. The respondents were the top managers of these establishments. They were asked to provide information about the firm's profile. One central part of the questionnaire was about subcontractors' relationships, mainly the one with the most important contractor. Another part was about their activity of innovation. We obtained 111 exploitable questionnaires. As shown in Appendix 1 the final data set is representative of the industrial establishments across the 4 sectors and the 3 size classes.

3.2 Empirical procedure

We conducted a classificatory procedure directly at the firm level to reflect firms' heterogeneity within the subcontracting industry. We made an exploratory test of the role of inter-organisational linkages on the innovative activity of firms.

The theoretical analysis leads us to predict that three natures of firms characterized by their relation with their principal partner can coexist in the subcontracting industry. We expect that these different firms have different intensity and types of innovation. In step 1, we implemented a non-hierarchical cluster analysis to classify our firms with respect to their subcontracting relations (TYPOST). In step 2, we built two scales of innovation (SCALE1 and SCALE2). The first scale measures the willingness of the subcontractor to innovate in the last three years. It combines the intensity (improvement and development) and the type of innovations (process and product) he tried to introduce during the last 3 years. The second scale of innovation introduces the innovations that have been introduced successfully in the last three years. Step 3 explores the link between subcontracting firms (TYPOST) and their intensity and types of innovation (SCALE 1 and SCALE 2). We base the test on a one-way analysis of variance (ANOVA) to observe whether the different subcontracting types are statistically different. Other variables, related to the knowledge sources used by the firm and its profile, have also been introduced as traditional determinants of innovation at the firm level.

3.3 Variables definition

We define first the independent variables: the variables used in the classification procedure and variables which stand as main determinants of firms' innovative activity. Secondly, we define the two scales of innovation (dependent variables).

3.3.1. Independent variables: the "determinants" of innovative activity

- The subcontracting firms' types:

Our survey data describe the subcontracting collected activity (See Table 2). We ask each respondent to give some general information about their production activity in the subcontracting field. We then focus on the nature of their collaboration with their main partner.

Table 2. Variables describing the subcontracting activity

Subcontracting variables used in cluster analysis	Measurement scale	Value range
DUREEP: Predictability of the agreement	Ordinal	1,3 1= less than 1 year; 2= From 1 year to 3 years; 3= More than 3

		years
FREQ : Frequency of the renegotiation	Ordinal	1,3 1=never; 2=every year; 3= every two year
VOLP_C : Share of the main contractor in the total volume of production (%)	Ordinal	1,3 1= Less than 20; 2= From 20 to 50; 3= More than 50
NDO_C : Total number of contractors	Ordinal	1,4 1= less than 10; 2= From 10 to 49 3= From 50 to 100; 4 = more than 100
CONTREX : contract of exclusivity	Nominal	1,2 1= no ; 2=yes
STCAPA : capacity subcontracting	Nominal	1,2 1= no ; 2=yes
STSPE : specialized subcontracting	Nominal	1,2 1= no ; 2=yes
STRAT : strategic subcontracting for the contractor	Nominal	1,2 1= no ; 2=yes
AUCUNE : the subcontracting agreement is not written, not strategic, does not imply cooperation nor co-investment	Nominal	1,2 1= no ; 2=yes
CONFLIT : Subcontracting relations with conflicts	Nominal	1,2 1= no ; 2=yes
CONDDO : conditions fixed by the contractor	Nominal	1,2 1= no ; 2=yes
FORM : formalisation of contracts with contractors	Nominal	1,2 1= no ; 2=yes
LJAT : Just-in-time	Nominal	1,2 1= no ; 2=yes
PP : quality circles, management by projects	Nominal	1,2 1= no ; 2=yes
CERT : certification and quality tools	Nominal	1,2 1= no ; 2=yes
Other strategy-related variables used to characterize the clusters	**Measurement scale**	**Value range**
ORC: strategic orientation: cost-reduction	Nominal	1,2 1= no ; 2=yes
ODIVER: strategic orientation: market diversification	Nominal	1,2 1= no ; 2=yes

Since many variables describe the nature of the subcontracting activity, we conducted a principal component analysis with 15 variables {DUREEP, FREQ, VOLP_C, …}. We obtained four factors accounting for 55% of the total variance. We then performed a non-hierarchical cluster analysis (TYPOST) based on the factor scores. In order to determine the final number of clusters, we used the three usual criteria. The statistical accuracy of the classification was measured by the ratio of within-cluster and between clusters variance (Fisher's test). We checked both the number of firms per cluster and the economic significance of the clusters identified. According to these criteria, the version with three classes was preferred. To interpret the three clusters, we calculated the mean of each variable in each cluster. Two variables STCAPA and JAT had been removed because they were not significant. More description of these clusters had been done using two other illustrative variables (ORC and ODIVER) (See Table 3).

Table 3 illustrates the three types of firms with respect to their inter-firm relation with their main contractor/partner. In cluster 1, we find 29 "suppliers". They have declared not to be on concerned with any partners or contractors (means near 0 for NDO and VOLP-C). Since they operate in the market of standard inputs and do not have any privileged collaborations, their main objective is to minimize their costs (ORC). We note that some of them can have a contract of exclusivity if they provide "specialized" inputs (CONTREX). Cluster 2 (58 firms) is made of "pure subcontractors". They are the most dependent on their main contractor who represents from 20% to 50% of their total volume of production (VOLP-C). The contract is not written, not strategic and does not imply any cooperative dimension or investment (AUCUNE). The predictability of the arrangement is very short, less than one year (DUREEP). They are in a

situation of dependence and they try to free themselves of it by looking for new markets (ODIVER). They submit to the requirements of the main contractor (CONDDO) who exerts an intensive pressure with frequent renegotiations (FREQ). We are in the quasi-market zone where subcontracting is used as a flexible and cost-minimizing tool. Cluster 3 is made up of 24 firms which are "partners". They are in charge of a specialized production (STSPE) that appears to be strategic for the partner (STRAT). The collaboration with the partner is based on a long-term contract (DUREEP, FORM) supported by specific organizational practices and routines (CERT, PP). The renegotiation of a contract is rare (FREQ). Conflicts can occur in the case of bilateral contracts (complementarity of resources and assets). The significance of this variable is certainly the signal of problems of knowledge transfers such as uncontrolled spillovers (Teece, 1996). The main partner represents less that 20% of the total volume of their production and they have more partners than cluster 2.

These results validate the first part of proposition 1: taken together, the transactional and competences perspectives provide a comprehensive setting of the different natures of inter-firm relationships.

Table 3. Interpretation of subcontracting firms' types[7]

		DUREEP	CERT	PP	FORM	CONFLIT	CONDDO	AUCUNE	STRAT	STSPE	CONTREX	NDO_C	VOLP_C	FREQ	ORC	ODIVER
Cluster 1. Suppliers	Moyenne	,24	1,38	1,07	1,38	1,03	1,07	1,03	1,00	1,03	1,14	,34	,34	,3103	**1,86**	1,45
	N	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
	Ecart-type	,636	,494	,258	,494	,186	,258	,186	,000	,186	,351	,974	,814	,8063	1,187	1,152
Cluster 2. Pure subcontractors	Moyenne	1,24	1,47	1,02	1,07	1,02	**1,45**	**1,45**	1,05	1,79	1,00	2,28	**1,71**	1,896	1,19	**2,19**
	N	58	58	58	58	58	58	58	58	58	58	58	58	58	58	58
	Ecart-type	1,097	,503	,131	,256	,131	,502	,502	,223	,409	,000	1,167	,879	1,372	1,191	1,051
Cluster 3. Partners	Moyenne	**1,92**	**1,75**	**1,42**	**1,58**	**1,29**	1,33	1,13	**1,46**	**1,92**	1,04	**2,50**	1,38	**2,291**	1,25	1,63
	N	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
	Ecart-type	,881	,442	,504	,504	,464	,482	,338	,509	,282	,204	1,351	,770	1,122	1,189	1,313
Total	Moyenne	1,13	1,50	1,12	1,26	1,08	1,32	1,27	1,13	1,62	1,05	1,82	1,28	1,567	1,38	1,87
	N	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111
	Ecart-type	1,113	,502	,323	,441	,274	,470	,446	,333	,487	,208	1,454	1,011	1,411	1,214	1,176

[7] For all comparisons of variance, Fisher test is significant at the 0.000 level and indicates a good differentiation of the firms.

- Other explanatory variables: The knowledge sources and the profile of the firm (See Table 4)

- The knowledge sources

Apart from inter-firm relationships, other sources of knowledge are seen as major determinants of the innovative activity. The neo-schumpeterian litterature allows us to make a theoretical distinction between the internal sources and the external sources of knowledge and the number of sources that can be used by the different types of firms. In the questionnaire, we introduced an initial menu of 14 potential sources[8]. The 4 internal sources were: R&D department or design centre of the establishment; R&D department or design centre of the group; training of employees; recruitment of new employees. The 10 external sources were: research consortium, consultancy firms specialized in innovation and technology transfer; public research institution; institution of technology transfer; professional associations; asset acquisition (patent, licence, equipment …), part-time integration of competences, firms with R&D activity; firms without R&D activity; other sources. One important limitation concerns the small number of observations in each of these indicators. A majority of firms have declared to use no source. To overcome this difficulty, we decided to construct three new measures. The first one is NSOUR which is the sum of the sources used by each firm. The second one is SOIN defining the total of internal sources used. Similarly, we added the external sources used to obtain the variable SOEXT.

- Profile of the firm

Six variables have been selected to qualify the profile of the firm. Five variables are considered as traditional determinants of the innovative activity of the firm: number of employees (EFF), independence of the firm (STAT), market power (PM), share of the turnover dedicated to R&D (CARD) and industry affiliation (APET_T). We added the variable POSR to define the position occupied by the firm in its branch of activity.

Table 4. Definition of the other explanatory variables

Variables describing knowledge sources	**Measurement scale**	**Value range**
NSOUR: Total number of sources used by firms	Metric	(0,10)
SOEXT: Number of external sources	Metric	(0,7)
SOIN: Number of internal sources	Metric	(0,3)
Variables describing firms' profile	**Measurement scale**	**Value range**
EFF: number of employees of the establishment	Metric	0,200
STAT: independence of the firm	Nominal	1,2 1=independent; 2= not independent
PM: market power	Nominal	1,2 1= strong; 2=weak
APET_T industry affiliation	Nominal	1,5 1= precision turning 2=engineering industry; 3=metals industry (treatment); 4=Sheet metal work/piping; 5=Others
POSR position in the branch of activity	Nominal	1,5 1=supplier ; 2=producer, contractor 3= assembleur, équipementier, monteur 4= subcontractor ; 5= retailer,

[8] Some sources have been regrouped to obtain a menu of 10 potential sources.

		trader
CARD_C: R&D budget (% of the turnover)	Ordinal	0,2 0= no R&D budget; 1= less than 5% 2= more than 5%
ORETD: strategic orientation = R&D development	Ordinal	0,4 0= Non response 1=Rank 1 2=Rank 2 3=Rank 3

3.3.2 Dependent variables: the ability to innovate (See Table 5)

NPROC (number of innovative manufacturing processes introduced in the last three years) and NPROD (number of innovative products introduced in the last three years) are standard measures of innovation but they measure effective innovative activity. In that sense, non innovative firms are natural non respondents for these indicators. As a significant number of subcontracting firms are non innovative (clusters 1 and 2 = 78%), we decided to build up special scales designed to capture the firm's willingness and ability to innovate. The respondent was asked to answer the following question: "Did you try to develop new ideas, new processes, new products in your establishment during the last three years?" The respondent had the choice between different items such as: no, yes; to improve existing products; to develop new products (radically innovative); yes to improve existing processes; yes, to develop new processes (radically innovative). We dichotomized these variables and constructed a first scale of innovation that measures the firm's "willingness" to innovate. This first scale is the sum of the "yes" responses to the dichotomized items. The responses were weighed giving a bigger weight to radical innovations over improvements. This scale is not sufficient to capture the ability of subcontracting firms to innovate. Thus we constructed another scale of innovation in which the rate of success related to the innovations implemented by the firm was taken into account. We used NPROC and NPROD to control the validity of the two scales we constructed. The correlation analysis confirms the robustness of our two scales of innovation (Appendix 4). Further, a comparison of means[9] shows that the firms that have developed the largest number of new products are the ones that have declared to have developed new solutions (new product or new process)[10].

Table 5. Definition of the two scales of innovation

Variables describing the firms' innovative activity	**Measurement scale**	**Value range**
SCALE1: Willingness to innovate	Metric	0,10 0: no innovative activity 2: process or product improvement 3: process and product improvements 4: process or product development 5: product improvement and product development 6: product and process developments 7: product development, product improvement and process improvement 8: product development, process development and product or process improvement 10: total innovative activity

[9] For all comparison of variances, the Fisher test is significant at the 0,00 level. Tables are available on request.

[10] The most innovative firms have developed on average 4.33 new products or 4.28 new processes

SCALE2: Ability to innovate	Metric	0,4 SCALE 1* rate of success

4. Empirical results: the innovative activities of firms within the subcontracting industry

In this section, the two propositions formulated in the theoretical part of this paper are tested. An analysis of variance (ANOVA) is conducted to test whether the three clusters of firms have significantly different means for the two scales of innovation. Some other tests are conducted to catch deeper insights on the statistic relations between the nature of subcontracting firms and their innovative activity (Correlation analysis and chi square test).

The results are unequivocal. We can reject the null hypothesis of equality of means for both scales. Clusters 1 and 2 score lower on the two scales measuring innovative activity. They are non-innovative firms because their innovative activity is mainly on product or process improvements.

For the suppliers (cluster 1), this result may suggest that they operate in sectors where the appropriability regime is too weak to fully exploit the benefits of innovative activity. Their score in SCALE2 reveals that they succeed quite well when they want to make progress (in more than 50% of the cases). A first explanation comes from adequate competition pressures in the market of standard inputs. More interestingly, the strategy-related variable ORC, though only significant at the ? =0.09 level, shows that the ability to improve solutions is also due to the existence of a clear strategic cost-orientation11 (ORC). This means that firms logically prefer to improve their processes rather than their products.

In cluster 2, pure subcontractors share the same ability to improve solutions. This result is consistent with the prediction of the transaction cost theory where "accumulation of knowledge can only exist through passive learning-by-doing processes, as a by-product of the division of labour (Cohendet, Llerena, 2005)". They obtain a good score on SCALE2 due to the existence of high market-like incentives. Pure subcontractors aim to find new markets, certainly to reduce their dependence on their main contractor. This result leads us to conclude that these two clusters of firms show the same ability to innovate. Concerning the sources of knowledge they used, there is no surprise. They only use one source on average. A small difference concerns the degree of openness which is higher for suppliers because of their upstream position in their branch of activity (POSR). Firms in cluster 2 have less external opportunities, are constrained by their situation of dependence with respect to their main contractor. We note that the firms' size has a significant impact both on the nature of the firms and their innovative activity (See. Appendices 2 and 4). Suppliers and pure subcontractors are micro-firms (respectively, 24 and 17 employees on average). All things considered, the nature of their inter-firm relationships, the nature of their environment (unfavourable conditions to innovate), their strategic orientation (not oriented towards a knowledge priority), their small size, we can conclude that they do not possess internal resources to innovate and are not able to compensate this lack by absorptive capacities.

[11] We must be cautious because the chi square-tests are not significant at the α=0.05 level:
TYPOST * ORC: Chi square value = 10,876; ddl=6; sig=0,09
TYPOST * ODIVER – chi-square value=12,107; ddl=6; sig=0,06

In cluster 3, firms are "quasi-integrated partners". Their distinctive competences are key determinants of inter-firm relations. Table 6 confirms the innovativeness of these firms. They intend to develop new products or processes (score of 4 on the scale1 of innovation). We note that their rate of success (50%) is lower than the rate of success of the two other clusters. It is not surprising since it is easier and less risky to improve existing solutions than to develop new products or processes. Their small size (38 employees on average) does not hamper their ability to innovate. This is consistent with the neo-schumpeterian literature's argument. To innovate, they tend to use more sources of knowledge than other firms. Internal sources are the dominant ones and show that they possess their own internal resources to innovate. As suggested in the theoretical part, they can also benefit from external inter-firm relations as a "quasi-internal market of knowledge". We have shown that inter-firm agreements are an efficient way to access to complementary forms of knowledge even when asset specificity is concerned. In terms of position in their branch of activity, they rather declare to be "subcontractors" (as firms belonging to cluster 2). More than simple contractors, their performance in terms of innovation suggests that they can be considered as partners in the sense of the competence perspective.

These results are consistent with our first proposition. Different inter-firm relationships coexist in the subcontracting industry and play a significant role on manufacturers' innovative activity.

Table 6. Anova test for comparison of means of innovation output measures in the different clusters of firms

		SCALE1	SCALE2
Cluster 1 : Suppliers	Mean	2,2069	,6379
	N	29	29
Cluster 2 : Pure subcontractors	Mean	2,2759	,6310
	N	58	58
Cluster 3 : Partners	Mean	4,0000	1,1125
	N	24	24
Total	Mean	2,6306	,7369
	N	111	111
F test		0.015	0.023

We try to refine these results by testing the second proposition identifying the role of traditional determinants on the firms' innovative activity independently from subcontracting modes. In that sense, we attempt to assess to what extent firms can gain autonomy from their inter-firm relationships and have their own internal resources to innovate.

The ANOVA tests show that means are significantly different on SCALE1 and SCALE2 for the following independent variables: CARD (R&D budget), PM (insufficient market power) and STAT (independence of the firm), ORETD (R&D development priority) (See Appendix 6). The firms that allocate more than 5% of their turnover to the R&D budget have the best score in the scale of willingness to innovate. They have been looking for product development and improvement in the last three years. This willingness to exploit existing solutions and to explore new ones may be risky. We observe that their rate of success is lower than other firms. The "status" of firms (independent firms or subsidiary of a group) shows that firms that are subsidiaries are better innovators than other firms. This gives

credit to the Schumpeterian thesis: they have a privileged access to internal financial resources from their group. The variable PM is also significant meaning that firms that declare to have an insufficient market power are more oriented towards improvements than radical innovations. In contrast, the perception of a great market power is linked with process or product developments. If all these results tend to confirm the Schumpeterian view of innovation namely that small firms have no chance to innovate, the conclusion is not definitive. We observe that firms whose first strategic objective is to develop the R&D resources are intensive innovators as well. This is in line with the neo-schumpeterian approach which considers that strategic and organizational capabilities are major determinants of innovation. In other words, market power is not the sole relevant determinant factor to explain innovative activity.

We could not find a significant relation between innovation and firms' industrial affiliation. Different tests have been made according to different levels of aggregation (sub-sectors and sectors). None of them were significant. We interpret this result as the existence of very similar technological conditions.

To sum up, these results confirm proposition 2. Apart from inter-firm relationships, some firms can gain autonomy in their ability to innovate allocating their own financial resources to innovation and formulating a clear strategic vision. Market power is also a source of innovation.

5 Conclusion

This paper aimed to give a full description of the innovative nature of firms operating in the subcontracting industry. Firstly, subcontracting firms have been defined according to the nature of their inter-firm relationships. We have identified and characterized three different types derived from the contractual and competence perspectives of the firm: suppliers, pure subcontractors and partners. Secondly, the neo-schumpeterian approach of innovation has been mobilized to complete the description of subcontracting types. This enabled us to clarify the nature of subcontracting firms in its innovative dimensions. The empirical test has confirmed the two main theoretical propositions. The nature of inter-firm relationships is a main source of inter-firm differences in innovative activity within the subcontracting industry. Suppliers (cluster 1) and pure subcontractors (cluster 2) are non innovative firms. Their ability to innovate aims at improving existing processes. The empirical test provided also evidence that small firms can be innovative firms. "Partners" (cluster 3) are innovators developing products or processes even if they are small firms (less than 50 employees). Apart fromthese inter-firm relationships, we observe that some firms are more able than others to develop their own ability to innovate benefiting from larger internal resources. The others remain in a vicious circle. Suppliers are constrained by specific market conditions and technological regime that hamper their innovative activity. Their cost-oriented strategy and their small size make us believe that they do not have the ability to interact with other agents. The unique source of knowledge they use confirms this aspect. For pure subcontractors, the story is quite the same. They differ only in terms of dependence on their main contractor. Their high dependence represents a major obstacle for innovation.

At the regional level, this research has shown that most firms (78%) of the subcontracting industry are non-innovative firms. We have also produced first evidence on factors hampering innovation. It is something to go further exploring

the qualitative comments of manufacturers on this particular topic. We have this information in our dataset. Such information can have real implications in the implementation of future public policies designed for this population of firms.

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Appendix 1. The survey, summary characteristics

Industrial subcontracting sectors	Parent population : N (%)	Respondents : N (%)
Stamping, metal cutting and forming, metal finishing,	243 (19,3)	14 (12,6)
Bar-turning	335 (26,5)	34 (30,6)
Engineering industry	398 (31,5)	32 (28,8)
Other subcontracting activities	286 (22,7)	31 (27,9)
Total	1262(100,0)	111 (100)

chi2 value = 7,46, ddl = 4, sig.=0,11

Firm size (number of employees of the establishment)	Parent population : N (%)	Respondents N (%)
Less than 10	566 (44,8)	55 (49,5)
10 to 50	623 (49,4)	47 (42,3)
More than 50	71 (5,6)	9 (8,1)
NR	2 (0,2)	
Total	1262(100,0)	111 (100)

chi2 value = 2,70, ddl = 2, sig.= 0,26.

Appendix 2. Anova test for comparison of means of knowledge sources and profile measures in the three clusters of firms

		NSOUR	SOEXT	EFFE
Cluster 1: Suppliers	Mean	1,3793	,7586	23,45
	N	29	29	29
Cluster 2 : Pure subcontractors	Mean	1,1207	,5517	16,79
	N	58	58	58
Cluster 3 : Partners	Mean	1,8333	1,1667	37,92
	N	24	24	24
Total	Mean	1,3423	,7387	23,10
	N	111	111	111
F Test		0.018	0.027	0.049

Appendix 3. The three clusters according to their position of the branch of activity

		Classe d'affectation (nuées dynamiques)			Total
		Cluster 1 : Supppliers	Cluster 2 : Pure subcontractors	Cluster 3 : Partners	
POSR	1,00	12	21	3	36
	2,00	7	5	1	13
	3,00	0	0	3	3
	4,00	10	32	16	58
	6,00	0	0	1	1
Total		29	58	24	111
Chi square of Pearson 26.675 - ddl=8 – Sig.= (0.001)					

Appendix 4. Significantly correlated variables to the two output measures of innovation

	SCALE1	SCALE2

PROD_C	Cor. Coef	,383(**)	,333(**)
	Sig.	,000	,000
	N	111	111
PROC_C	Cor. Coef.	,389(**)	,371(**)
	Sig.	,000	,000
	N	111	111
NSOUR	Cor. Coef.	,447(**)	,428(**)
	Sig.	,000	,000
	N	111	111
SOEXT	Cor. Coef.	,411(**)	,410(**)
	Sig.	,000	,000
	N	111	111
SOIN	Cor. Coef.	,336(**)	,314(**)
	Sig.	,000	,001
	N	111	111
EFFE	Cor. Coef.	,295(**)	,336(**)
	Sig.	,002	,000
	N	111	111

** Correlation coefficient (Cor. Coef.) with a two-tailed observed significance level < 0.01 level (bilatéral).

Appendix 5. Anova test for comparison of means of the knowledge sources measures (NSOUR, SOEXT, SOIN) in the two output measures of innovation

		NSOUR					
		0	1	2	3	Total	F-test
SCALE1	Mean	0,8519	2,725	2,6522	4,7143	2,6306	
	N	27	40	23	21	111	0.000
SCALE2	Mean	0,2111	0,7925	0,7609	1,281	0,7369	
	N		40	23	21	111	0.000

		SOEXT							SOIN				
		0	1	2	3	4	Total	F-test	0	1	2	Total	F-test
SCALE 1	Mean	1,6786	3,2703	3,6667	4	7	2,6306		1,8776	2,6744	4,4737	2,6306	
	N	56	37	12	3	3	111	0.000	49	43	19	111	0.001
SCALE 2	Mean	0,4661	0,9324	0,9417	1,2	2,1	0,7369		0,5184	0,7837	1,1947	0,7369	
	N	56	37	12	3	3	111	0.000	49	43	19	111	0.003

Appendix 6. Anova test for comparison of means of the firms' profile measures (CARD_C, STAT_T, PM, ORETD) in two output measures of innovation

		CARD_C					STAT_T				
		0	1	2	Total	F-test	0	1	2	Total	F-test
SCALE1	Mean	2,0349	4,3077	5,0833	2,6306	0.000	0	2,25	4,2727	2,6306	0,003
	N	86	13	12	111		1	88	22	111	
SCALE2	Mean	0,5698	1,2923	1,3333	0,7369	0.000	0	0,6364	1,1727	0,7369	0,007

	N	86	13	12	111		1	88	22	111	

		PM				ORETD					
		1	2	Total	F-test	0	1	2	3	Total	F-test
SCALE1	Mean	2,2667	4,1905	2,6306	0.002	2,1944	4,2667	3	2,8667	2,6306	0.042
	N	90	21	111		72	15	9	15	111	
SCALE2	Mean	0,6278	1,2048	0,7369	0.001	0,6125	1,2	0,8556	0,8	0,7369	0.048
	N	90	21	111		72	15	9	15	111	