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Do agglomeration and technology affect vertical integration? Evidence from Italian business groups*

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ABSTRACT

The aim of this paper is to analyse the role of technology and spatial agglomeration in decisions about vertical integration. It starts from the hypotheses that the business group, defined as a set of firms under common ownership and control, is the appropriate unit to delimit the firm's boundary. We use information drawn from input-output tables to detect the presence of positive inter-industry exchanges and whether or not activities in a group are vertically related. Accounting for endogeneity problems, we estimate Probit and Linear Probability models to empirically investigate the role of technology and spatial agglomeration on vertical integration decisions. Consistent with property rights theory, our results show that the technology intensity of acquirers matters for backward integration choices and moreover, that agglomeration plays a role in vertical integration only when it operates jointly with technology.

Keywords: : Business groups, spatial agglomeration, technology, vertical integration.
JEL: L22, R12

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Introduction

Decisions about vertical integration, i.e. control in the different stages of the production chain, constitute one of the main strategic choices made by firms. The vertical integration decision has been studied extensively from a theoretical standpoint in both the industrial organization literature and in the literature taking a transaction cost and property right perspective on which this paper mainly draws.

The industrial organization literature emphasizes the creation and exploitation of market power as one of the main motives for vertical integration in situations where markets for intermediate goods are non-competitive (Tirole, 1988). As a result, this literature focuses on forward integration and also considers forms of contractual arrangements between autonomous firms as a means of exercising vertical restraints in intermediate markets (Carlton and Perloff, 2005). In contrast, the literature on vertical integration, based on transaction cost economics (TCE) and property rights theory (PRT), emphasizes the presence of joint ownership and control rights over production activities to separate vertical integration from market transactions (Lafontaine and Slade, 2007). This literature is mostly concerned with explaining the scope and boundaries of the firm – i.e. which activities are integrated within the same ownership – and emphasizes backward rather than forward integration.

TCE (Williamson, 1985; Joskow, 1991; Lieberman, 1991) and PRT (Grossman and Hart, 1986; Hart and Moore, 1990) stress the importance of technology in influencing whether vertically related activities are brought within the boundary of the firm. Specifically, both point to the role of the technology intensity of the buyer and supplier in influencing backward integration. Backward integration is more likely for more complex inputs and when the environment in which the firms operate is more uncertain. However, TCE and PRT diverge as regards the direction of this influence. According to TCE, the supplier's technology intensity is one of the most important factors in the buyer's decision to integrate an activity while PRT predicts that where suppliers are more technology intensive, there will be less vertical integration (Whinston, 2001; Acemoglu *et al.*, 2004).

TCE also suggests a role for spatial agglomeration in vertical integration. The literature on spatial agglomeration stresses the importance of market-based relationships among firms located in clusters, based on lower transactions costs. These are explained as being due to the lower levels of opportunism between economic agents and reduced information asymmetry (Wood and Parr, 2005). Specifically, the literature on industrial districts emphasizes the role of social capital and trust in shaping vertical relationships between independent agents, underlining the co-operative nature of such relationships (Brusco, 1982; Becattini, 1992).

The main aim of this paper is to assess the role of technology and agglomeration in influencing firms' decisions to integrate production activities. In this paper, we consider ownership and control as the main feature in the definition of firms' boundaries, i.e. integration (Hodgson, 2002). Specifically, we recognize the business group, defined as a set of legal units under the same ownership and control, as the appropriate unit to delimit the firm's boundary. The characteristics of the legal units belonging to a group can thus be used to analyse some aspects of firm's organization, such as vertical integration.

To investigate the role played by technology and agglomeration in affecting vertical integration, we use the input-output table to detect whether or not activities are vertically related, and the strength of these relationships. On the basis of dyadic associations of production activities with positive intra-industry exchange, and accounting for endogeneity problems, we use binary choice models - Probit and Linear Probability models - to identify some of the factors affecting the probability of observing backward vertical integration. This is done by comparing the actual presence of vertical integration in business groups with those expected according to the input-output table, following the methodology developed in Acemoglu *et al.* (2004).

Our analysis is based on an original data-set developed by ISTAT (Italian National Statistical Institute) covering all manufacturing firms organized as joint-stock companies in 2001. The analysis refers to 8,661 manufacturing groups, controlling more than 30,000 legal units. As far as agglomeration is concerned, we use a set of dummy variables related to belonging to business groups in an industrial district, as officially defined by ISTAT. In the case of technology, we use data on technology intensity at industry level based on R&D expenditure.

The paper is organized as follows. In Section two, we briefly discuss our reasons for taking the business group as the appropriate unit to delimit firm boundaries; we then examine the theoretical predictions about the relationships between agglomeration, technology and vertical integration, and develop the research hypotheses to be empirically tested. In Section three, we describe the characteristics of the dataset and how the variables are defined and measured. Section four explains the econometric strategy adopted, presents and interprets the results of the empirical analysis, and discusses the robustness analysis. Finally, Section five presents the main conclusions and discusses the implications and limitations of the study.

Related literature and research hypotheses

The business groups as an organizational form

A business group is defined as a set of legally distinct units controlled by the same owner. Most of the literature on business groups is devoted to justifying why they exist and comparing the behaviour and performance of firms belonging to business groups with those of independent firms (Bertrand *et al.*, 2002; Feenstra *et al.*, 2003). This literature mainly focuses on financial aspects (Almeida and Wolfenzon, 2006). The pyramidal group is regarded as a financial mechanism to minimize the amount of capital needed by the ultimate owner to control business activities, i.e. as a mechanism to separate control rights, concentrated in the hand of the ultimate owner, from cash flow rights, dispersed among the minority shareholders in the companies belonging to the group.

Alongside the financial interpretation of pyramidal groups, there is another important strand of literature that focuses on organizational issues. This literature considers the group as an organizational mechanism alternative to both the internal hierarchy and the market (Goto, 1982; Kester, 1992). The theoretical approach normally used by researchers who adopt this perspective is TCE. Their work is usually aimed at explaining why the relationships among the firms belonging to a business group might be more efficient in terms of transaction/organizational costs than those in integrated firms or in market transactions between independent firms. According to TCE, business groups are a hybrid organizational form since, by definition, hierarchy is associated with a legal unit. Moreover, it considers that the business group is similar to a multidivisional firm (M-form), where the role of the central direction (the ultimate owner) is one of allocating resources to existing divisions (firms), and deciding whether they should be opened (set up or acquired) or closed (liquidated or sold) (Chandler, 1982).

By considering the group as an organizational form, we contend that ownership and control of business activities are appropriate to delimit the boundaries of the firm. We argue that this is more appropriate than using the legal boundaries, which consider individual companies without reference to their ownership and control.[1] Although the ultimate owner can intervene 'discretionally' in the main strategic decisions of the controlled companies, the contractual relationships between owner and directors are different from those between a general office and the heads of divisions. In fact, in the case of the M-form the hierarchical relationship is characterized by stronger non-contractual components, which are typical of the employee–employer relationship, while in the case of business groups the relationship between owner and the controlled companies is conditioned by the legal system. These differences are more evident in operational (i.e., day-to-day) decisions and are not significant in the case of strategic decisions such as the decisions to vertically integrate activities. In addition, the development of integrated information systems and the formation of consolidated accounts allow the economic and financial relationships within the group to be formalized. This can be interpreted as further evidence of the capability of the ultimate owner to influence not only the strategic but also the administrative functions in the controlled companies.

Taking the business group as the appropriate unit to delimit the firm's boundary, the characteristics of the legal units belonging to it can thus be used to analyse some aspects of firm behaviour and organization. Within this perspective our aim, which is different to most of the literature on this issue, is not to explain why business groups exist, but to analyse the role of spatial agglomeration and technology in determining some features

[1]. 'La dimension «entreprise» n'est plus suffisante pour analyser le système productif. De plus en plus d'entreprises s'organisent sous forme de groupes: une société appelée tête de groupe, détient majoritairement le capital d'une ou de plusieurs entreprises, appelée filiales. Ces acteurs économiques s'organisent ainsi pour des raisons d'efficacité productive, financière et fiscale. Désormais, c'est au niveau du groupe que certains indicateurs économiques deviennent pertinent, comme la concentration de l'activité' (INSEE, 2004: 5).

of firm behaviour and organization. The group form is used specifically by firms to expand control over different business activities; it is the organizational form suited to implementing diversification and vertical integration strategies (Iacobucci and Rosa, 2005; Khanna and Yafeh, 2005). This is particularly true in the case of vertical integration decisions, as the legal autonomy of firms belonging to the same group reduces the risks associated with vertical integration by facilitating the ability of controlled firms to acquire and sell in the market.

Technology, agglomeration and vertical integration

The industrial organization literature emphasizes the creation and exploitation of market power as a reason for vertical integration in the presence of non-competitive intermediate markets. Forward or backward integration can occur to acquire or prevent market power in intermediate markets (Carlton and Perloff, 2005). Most of this literature is concerned with the welfare consequences of vertical integration and, as a result, with antitrust policy towards vertical mergers. For this reason, it also considers different forms of contractual arrangements between autonomous firms as means of vertical restraints.

TCE and PRT, in contrast, emphasize the presence of joint ownership and control rights on production activities, to separate vertical integration from market transactions. These theoretical approaches are mostly concerned with explaining the scope and boundaries of the firm – i.e. which activities are integrated within the same ownership – and give specific emphasis to backward rather than forward integration. Both TCE and PRT stress the importance of technology in influencing the choice to integrate vertically related-activities within the boundary of the firm. Backward integration is more likely for more complex inputs and when the environment in which the firms operate is more uncertain. Although the assumptions and conclusions of the two theories appear very similar it has been shown that this is not always the case (Whinston, 2001; Woodruff, 2002; Whinston, 2003). According to TCE (Williamson, 1985), vertical integration results from the need to prevent *ex-post* hold-up problems resulting from transaction-specific investments. Whatever the source of the specificity, its presence allows firms at one particular stage in the production process to appropriate the quasi-rents earned by firms at another stage due to lack of alternative sources of supply or demand (Joskow, 2005).[2]

The advantages of vertical integration in reducing or avoiding the costs of market transactions must be compared with the costs of producing within the firm (cost of integration), which depend on the ability to monitor employees and to discover and spread information effectively within the organization. For this reason, the size and characteristics of the organization should influence the degree of vertical integration. Other things being equal, size and diversification should be negatively correlated with the degree of vertical integration while the implementation of decentralized (e.g., M-form) organizations is expected to be positively related to the level of vertical integration (Levy, 1985: 440). This argument is particularly relevant in our case because business groups can be considered an organizational form that allows superior coordination and control of business activities by combining decentralization of operating decisions and centralization of strategic decisions.

According to TCE, the degree of asset specificity of suppliers is the most important factor in a buyer's decision to integrate an activity (Lieberman, 1991; Whinston, 2003). Asset specificity refers to the extent to which the investment made to support a particular transaction has limited or no value when redeployed for any other purpose (Williamson, 1975, 1985). Specificity can refer to location (site specificity), the specialization of physical assets (physical asset specificity) or the specialization of human skills (human asset specificity). One of the most important factors affecting asset specificity (both physical asset and human asset specificity) is the technology intensity of production, which is related to the amount of knowledge and learning required. According to TCE we can propose that:

> H_1: *backward integration (i.e., the control of input suppliers) is positively related to the technological intensity of suppliers.*

In contrast to the TCE approach, which emphasizes *ex-post* transaction problems, PRT focuses on distortions in *ex-ante* investment. The residual rights of control guaranteed

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[2] Joskow (2005) maintains that TCE is concerned with *ex ante* and *ex post* inefficiencies arising in bilateral relationships, but recognizes that Williamson and other authors generally emphasize more *ex post* haggling and associated inefficiencies.

by ownership of assets are particularly valuable in situations of *ex-ante* incomplete contracting and *ex- post* opportunist behaviour. PRT predictions are more difficult to test empirically than TCE theory as their testing requires a great deal of information about the trading relationship between acquirer and supplier (Whinston, 2003). This is probably why much of the empirical literature on vertical integration is based on TCE and relies on single industry case studies. It is only recently that a few studies have adopted a cross-industry approach to explore the intensity and the determinants of vertical integration (Fan and Lang, 2000; Acemoglu *et al.*, 2004).[3]

Acemoglu *et al.*'s (2004) approach is particularly interesting in our context. Their objective is to assess the role of technology intensity in the vertical integration choices of firms. The assumption is that technology intensity of production, especially when captured in terms of R&D investment, is closely associated with asset specificity and will generate the types of problems in trading relationships that are highlighted by the TCE and PRT approaches. Following the PRT approach their model predicts that the technology intensity of producer and supplier has opposing effects on the likelihood of vertical integration. In the case of backward integration 'greater technology intensity of the producers should be associated with greater vertical integration, greater technology intensity of the supplier should be associated with less vertical integration' (Acemoglu *et al.*, 2004: 12). This is because within the PRT approach vertical integration affects the investment incentives of suppliers and producers; when the technology intensity of the supplier is high 'backward integration becomes less likely, because now the supplier's investment is more important, and backward integration, by reducing the outside option of the supplier, discourages her investment' (Acemoglu *et al.*, 2004: 11). Hence the proposition that:

> H_2: *backward integration (i.e., the control of input suppliers) is more likely when the producer (acquirer) is more technology intensive, and less likely when the supplier is more technology intensive.*

Finally, TCE also suggests a role for spatial agglomeration in vertical integration. The literature on spatial agglomeration stresses the importance of market-based relationships

3. 'Despite a number of well-established theories and a prominent public debate on the effect of technology and technical change on the internal organization of the firm, there is little evidence on the determinants of vertical integration' (Acemoglu *et al.*, 2004: 26).

among firms located in clusters, as a result of the lower level of transactions costs. This is generally explained as being due to the lower levels of opportunism between economic agents and fewer information asymmetries. The low level of opportunism is explained by the homogeneity of clusters in terms of local institutions, ‘culture’, social capital, language, etc. (Wood and Parr, 2005). The lack of information asymmetry is explained by spatial proximity, frequency of face-to-face contacts and, more generally, local knowledge spillovers (Breschi and Lissoni, 2001). Moreover, the literature on industrial districts emphasizes the role of social capital and trust in shaping vertical relationships between independent agents, underlining the co-operative nature of such relationships (Brusco, 1982; Becattini, 1992; Dei Ottati, 1994). In emphasizing the role of co-operation and the lack of opportunism in vertical relations between firms, this literature predicts that firms located in industrial clusters will show lower levels of vertical integration than similar non-agglomerated firms.

Within a TCE perspective, the focus on behavioural variables tends to undervalue the role of asset specificity as a determinant of transaction costs. We do not question the hypothesis that in industrial clusters the level of opportunism and information asymmetry is lower than in non-agglomerated areas. Nevertheless, according to TCE the problem is not the ‘intensity’ of opportunism or information asymmetry but whether or not they are present (Williamson, 1985). In fact, the TCE approach takes opportunism and bounded rationality of agents as an *ex-ante* behavioural hypothesis and considers the level of transaction specific investments as the main determinant of transaction costs.

The reduction in information asymmetry as a result of spatial agglomeration is theoretically well demonstrated and empirically investigated. However, its effect on the degree of vertical integration is ambiguous. Some authors maintain that face-to-face contacts, long-term supply relationships and sharing of market and technology information can favour the acquisition of firms within agglomerated area, thus substituting hierarchical governance for transactions between independent firms (Brioschi *et al.*, 2002). At the same time, there are studies that suggest that the reduction in information asymmetry should reduce transaction costs thus favouring market-based relationships between agents (Wood and Parr, 2005). Assessment of which of the above mentioned mechanisms is more important in determining the relationship between agglomeration and vertical integration must be tested empirically. So far, the empirical relationships between agglomeration, technology and vertical integration have been investigated mainly on the basis of anecdotal evidence or case studies of specific clusters (Enright, 1995). According to TCE, we propose that:

> H_3: *backward integration (i.e., the control of input suppliers) is less likely when the producer (acquirer) and the supplier are located within the same agglomerated area.*

Data and variables

Business groups: definition and characteristics

We use a data-set on business groups developed by ISTAT. Business groups are identified through control linkages between pairs of legal units, according to European level operational guidelines (Eurostat, 2003). The data-set was built considering the population of joint-stock companies in the Italian economy. The data refer to the year 2001.[4] For each legal unit belonging to a group, information is available on its activity (at five-digit level), location, number of employees, sales, ownership share, etc. The industry of the group is determined according to the activity of the largest company. As a result, manufacturing groups are identified as those groups where the largest company is a manufacturing firm. Based on these criteria, we identified 8,661 manufacturing groups. These groups control 34,358 firms, of which 28,579 are production units and the others are financial or foreign firms. We exclude the latter two types from our analysis, considering only production firms.[5]

Table 1 presents descriptive statistics about our analysis. Groups control an average of four companies each with large number of small groups having only two companies (two-thirds of the total). The presence of a large number of small groups also explains the low percentage of backward integrated groups; in fact, most of the small groups belong to traditional industries where there is high specialization along the production chain.

[4] For further information about the procedures used to develop the dataset see Cainelli *et al.* (2006).
[5] Foreign companies were excluded as the ISTAT dataset does not provide information about the sector of activity and size. This is not a major problem given that they represent a small percentage of companies controlled by Italian business groups (4.6% of the total).

Vertical integration

The boundaries of the business groups allow us to identify when different production activities are controlled by the same firm. We can detect the presence of vertical integration within the business groups using information drawn from the input-output table; this can be used to determine when activities belong to the same production chain (Fan and Lang, 2000; Acemoglu *et al.*, 2004; Acemoglu, Johnson *et al.*, 2007). For every pair of industries, *i-j*, the input-output table allows us to calculate the percentage of input of industry *i* acquired from industry *j*. For example, in a group belonging to the clothing industry (code 18) backward integration is present if the group owns a company in the textile industry (code 17) given that the input-output table shows a positive inter-industry coefficient between the two industries. According to the Italian input-output table for 2000, on average, the clothing industry acquires 46.6% of its input from the textile industry. The way we determine vertical integration in business groups is not a direct indication of how much the group actually acquires from its controlled companies; it represents the opportunity for vertical integration between the two industries (Acemoglu, Aghion *et al.*, 2007). Moreover, the control of activities within the same production chain is a sign of the possibility to supply some of its own input and of an interest in acquiring production know-how in forward or backward activities.

We use as our unit of analysis the dyadic association of activities within the same group. Specifically, we analyse the factors affecting the probability of observing backward integration: i.e. the control of vertically related industries by the same owner. The Italian input-output table for 2000 contains the value of intermediate exchanges between 58 branches of economic activity, 22 of which are manufacturing activities. Indicated by $j=1,2,\ldots,22$ and $i = 1,2,\ldots, 22$ for the manufacturing industries, we calculate the index b_{ij} as the share of intermediate consumption of industry *i* supplied by the industry *j*, so that for each *i* $\sum_j b_{ij} = 1$. Combining the 22 manufacturing industries and the 21 potential supplier industries (excluding intra-industry exchanges) results in 462 industry pairs. The larger is b_{ij}, the larger is the share of input requirements controlled by the producer in industry *i* in the case of integration with industry *j*; that is,

b_{ij} is an index of the quantitative relevance of backward integration. Of the 462 potential backward relationships 77 are null while the others show a positive value.

In our analysis, we compare the actual choices of groups in controlling activities along the production chain with the potential scope for vertical integration derived from the input-output table (Acemoglu *et al.*, 2004). There are 385 industries pairs for which the input-output table indicates the presence of inter-industry transactions. Combined with the 8,661 manufacturing groups that gives us 155,711 observations at group-industry pair level. For example, the clothing industry acquires input from 18 other industries, ranging from the textile industry, representing 46.63% of the clothing producers' input, to the motor vehicles industry, representing the 0.02% of the clothing producers' input. Given a business group belonging to the clothing industry, we can attribute to it the 18 potential pairs for backward integration and then observe which are present or not. This results in a dummy, db_{ij}, equal to 1 if backward integration is present and 0 otherwise. Therefore, a clothing group owning companies in all the 18 supplying industries would have a vector of 18 1s. Obviously, the number of industry pairs for which positive input-output relations are observed depends on the industry, ranging from 12 in the case of energy to 19 in the case of the food industry.

Other variables

As a proxy for the technology intensity of production, we use R&D expenditure divided by value added for the Italian manufacturing industry in the year 2000. Data are drawn from OECD (STAN ANBERD).

To capture district-specific agglomeration forces, we use a dummy variable indicating if a business group belongs to an industrial district or not. A group is classified as belonging to a specific industrial cluster if its largest company is located within that cluster, and operates in the same specialization industry of the cluster.

The industry specialization of the district is used to construct seven district dummies referring to specific industrial districts: that is, (i) food; (ii) textile and clothing; (iii) leather and footwear; (iv) furniture; (v) mechanical industries;[6] (vi) paper and printing, and (vii) other industries.

[6] Mechanical industries include codes from 28 to 35 (see Table 1).

Industrial clusters are identified according to the ISTAT (ISTAT, 1997) procedure which takes the local labour systems (LLS) as the unit of analysis and identifies 199 industrial clusters within the 784 LLS that comprise the Italian territory. The statistical procedure involves two steps. First, the national territory is divided into 784 LLS which are groupings of contiguous municipalities that are characterised by a high degree of commuting by the workforce. Second, industrial districts are defined as those LLS that satisfy the following criteria: (i) percentage of employees engaged in manufacturing compared to total non-agricultural employees higher than the national average; (ii) specialization in one particular manufacturing industry, and (iii) a higher that the national average percentage of workers in firms with less than 20 employees (Cannari and Signorini, 2000). This methodology identifies 199 industrial districts.

As suggested by Brusco *et al.* (1996: 19) this methodology has some limitations. First, the identification of an industrial district cannot be limited to a pure statistical exercise, since an industrial district is not only a production system but also a set of social relationships and a system of political and cultural values. In the literature on industrial districts, these latter are usually referred to as the social dimension (Dei Ottati, 1994). Second, problems arise when a geographic area is characterized by the prevalence of mechanical industries, which implies multi-faceted sub-contracting systems spread across a number of industries; this makes it more difficult to identify mechanical districts on the basis of a predominant industrial sector. Finally, the identification of industrial districts relies mainly on arbitrary, pre-defined threshold values that sometimes generate results that run counter to popular perceptions, excluding geographic areas that historically have been considered industrial districts. For these reasons, some more recent studies test alternative district/agglomerations definitions, based on more complex and sophisticated statistical algorithms (Cannari and Signorini, 2000; Iuzzolino, 2005). The results of these studies are interesting, but the official definition of Italian industrial district adopted by ISTAT continues to be based on the previously described statistical procedure.

We use various controls to take account of the presence of scale economies and market power. The first refers to the size of the group in terms of employees and is intended to capture market power as well as financial and organizational capabilities. We expect this variable to positively affect the ability of firms to integrate vertically. We use another variable for the industry as a whole, which is intended to capture economies of scale; it is measured as the average size of firms in the industry, in terms of the numbers of employees.

Econometric modelling and estimates

The modelling strategy

For our empirical analysis, we identify the factors affecting the probability of observing backward vertical integration along the production chain. The econometric analysis is based on a Probit specification as follows:

$$\Pr(Y = 1 | X) = \Phi(X'\beta)$$

where Φ is the cumulative distribution function of the standard normal distribution, and Y_i is a dummy variable taking the value 1 if we observe backward integration and 0 otherwise. X denotes the regressors. The latter includes the constant term and several variables at group, producing and supplying industry levels.

The independent variables used in the regression are: i) R&D intensity of the producing (acquiring) sector, measured as the ratio of R&D investment on value added (*resacq*); ii) R&D intensity of the supplying sector, measured as the ratio of R&D investment on value added (*ressup*); iii) share of costs of the producing sector acquired from the supplying sector (s_{jk}); iv) size of the group as number of employees (*size*); v) average size of firms in the producing sector (*sizeacq*); vi) average size of firms in the supplying sector (*sizesup*). To this specification we added a dummy variable for all the Italian industrial districts, and six district dummies referring to the specialization industry of the district.

It should be noted that we first attempt to control both for (potential) endogeneity problems in the agglomeration variables and technology intensity in the producing and supplying industries by assuming that the probability of observing backward integration at time *t* depends on these variable at time *t-1*. Accordingly, our proxies for spatial agglomeration refer to 1991, while the other covariates refer to 2000 and our dependent variable refers to 2001. In Section 4.3. we propose a more formal and satisfactory treatment of these econometric problems, using Instrumental Variable (IV) methods.

Econometric estimates

The results of our analysis are presented in Table 4. The findings reported in column 1 and 2 show a positive and significant association between technology intensity and the probability of observing backward integration. Similar to Acemoglu *et al.*,'s (2004) results, the coefficient for the technology intensity of the acquiring industry (*resacq*) shows a positive and statistically significant value; moreover, it is remarkably stable across specifications. In contrast, the coefficient for technology intensity of the supplying sector is unstable to the introduction of other industry characteristics and never statistically significant. The other coefficients show the expected signs. The coefficient of the share of costs is significant and positive while the average size of firms in the supplying industry (which captures the intensity of industry scale economies) is highly significant and negative. Size of groups shows a positive and significant statistical association with the probability of observing backward integration. As far as agglomeration is concerned, we find that the coefficient of the overall district dummy is positive and statistically significant. It is also stable across different specifications. This result does not support the hypothesis that agglomeration of production activities tends to reduce the degree of vertical integration. On the contrary, it could be interpreted as evidence of a higher level of transaction costs within these agglomerated areas. Since technology could play an important role in this regard, we developed the analysis further to take account of the specialization sectors of industrial districts. The results show that the industry specialization of districts plays a role in these processes. In fact, we find a higher probability of backward integration in textiles, mechanical, and other manufacturing districts, while in the case of food and partially in the case of leather districts, agglomeration plays no role. Alongside the explanation related to technology, and thus to asset specificity, this result can also be explained on the basis of different degrees of heterogeneity of districts in terms of concentration and hierarchisation.

Overall, our empirical results do not confirm the hypothesis, derived from TCE, according to which the probability of observing backward integration is positively related to the technology intensity of the supplier. On the contrary, we find that backward integration is more likely when the acquirer is more technology intensive, as suggested by the PRT.

Levy (1985) proposed the hypothesis that the technology intensity of the acquirer sector does not matter *per se*, but only as a proxy for the degree of asset specificity of the supplier sectors. This is because 'research intensive industries … tend to involve specialized inputs' (Levy, 1985: 439). Therefore, the positive association between the technology intensity of the acquirer and the presence of vertical integration should also be interpreted as supporting the conclusions of TCE. We disagree with this interpretation as our empirical evidence show a negative relation between the technology intensity of acquires and supplier sectors (see Table 3).

Also, in the case of agglomeration, our empirical results challenge the hypothesis derived from TCE that firms belonging to industrial clusters are expected to show a low degree of backward integration as a result of the lower level of transaction costs sustained by firms operating within the same agglomerated area (industrial districts). This is the result of the lower level of opportunism of agents in agglomerated areas given cultural homogeneity and the reduction in information asymmetry. As discussed in Section 2, we suggest that it is not the degree of opportunism that matters, but its presence, and that it is the level of transaction specific investment that matters most. In fact, the agglomeration variable shows a significant association with the presence of backward integration in the case of mechanical districts rather than industrial districts characterized by the presence of firms operating in traditional (low tech) industries. Overall, our empirical results show that it is technology rather than agglomeration that plays the main role in influencing the decisions of firms on whether or not to integrate activities along the production chain.

The control variables show the expected signs. The intensity of the input-output relation is positively associated with the probability of observing backward integration. This is explained by the fact that the greater the importance of a specific input within the firm's costs, the greater will be the incentive to control the supply of this input. The size of supplier firms (used as a proxy for the presence of scale economies) shows a negative association with the presence of backward integration. This result is in accordance with the traditional theory of vertical integration according to which achievement of economies of scale in the different phases of the production chain is the main motive for externalizing activities (Stigler, 1951).

The theoretical explanations for the positive association between the size of the group and the probability of observing vertical integration vary. On the one hand, this positive association suggests that size allows managers and entrepreneurs to relax managerial and financial constraints, thus increasing the probability of expanding the activities under their control. On the other hand, it could be that the larger the final output, the greater the need for the firm to control the supply of its input (Chandler, 1990).

Robustness analysis

In the previous section, we showed that there is a statistical association between vertical integration and technology intensity in the producing and supplying industries. These associations do not necessarily correspond to causal relationships between these two phenomena. In fact, as suggested by economic theory, vertical integration can affect technological intensity, thus generating a classical reverse causality problem. The presence of endogeneity – that is, one or more explanatory variables correlated with the error term – can generate biased and inconsistent estimates of the coefficients under investigation.

So far we have attempted to deal with this problem imposing a time lag between the dependent and independent variables. We are aware that this approach is rather naïve. For this reason, in this section we adopt a more 'robust' econometric approach which consists of using an IV strategy, where instruments are correlated with endogenous variables, but uncorrelated with the error term. The variables that would satisfy these conditions are shares of innovative firms on total firms in the producing and supplying industries (*limpinni* and *limpinnj*). Note that these instruments are not perfect, but are useful to eliminate reverse causality problems. Using these two instruments, we test the presence of endogeneity of technology intensity in the producing and supplying industries, using a test of (weak) exogeneity for Probit models, proposed by Smith and Blundell (1986).[7] Under the null hypothesis that the model is appropriately specified with all explanatory variables as exogenous, the test obtained a $\chi^2(2)$ value of 115.75 and p-value of 0.000. The null hypothesis of exogeneity of these two covariates can be rejected, suggesting that IV methods are suitable to estimate our models.

[7] This test is implemented using the 'probexog' STATA command.

To account for these endogeneity problems in the technology intensity indicators, we estimate our base line specification using the IV Probit model proposed by Newey (1987). This model fits Probit models when one or more of the regressors are endogenously determined. By default, it uses maximum likelihood estimation methods. The results of this analysis are presented in Table 5 and are consistent with those obtained using simple Probit models, thus confirming the economic interpretation of these phenomena. The exogeneity problem is also confirmed by the Wald exogeneity test (p-value: 0.044) showing that the null hypothesis that technology intensity variables are not correlated with the error term can be rejected. .

We complete our robustness check using a Linear Probability (LP) model and testing for non-linearity. In both cases we find confirmation of the previous analysis. Using a LP model, the sign and the statistical significance of the variables of interest does not change. Finally, using Wald-type tests of non-linear hypotheses, in which p-values are based on the 'delta method' (an approximation appropriate for large samples), we accept the null hypothesis of linearity against the alternative of a quadratic relation (these results are not shown, but are available on request). In other words, this analysis confirms that the linear specification adopted is appropriate.

Conclusions

This paper set out to empirically analyse the relationships between technology, spatial agglomeration and vertical integration. Despite the relevance of this line of research, only a few contributions so far provide insights on this topic. Specifically, while there are several theories about the effect of technology and technological change on the internal organization of firms, there is little empirical evidence on the relation between technology and vertical integration (Acemoglu *et al.*, 2004: 26).

Taking the business group as the appropriate unit to delimit the firm's boundary, our work makes three contributions to this literature. First, it shows that vertical integration is influenced by technology as the technology intensity of the buying industry plays a positive role in influencing backward integration. This result is in accordance with the hypothesis derived from the PRT (Acemoglu *et al.*, 2004). In contrast, the technology intensity of the supplier has no statistically significant influence on the probability of observing backward integration. This result lends no support to the hypothesis, derived from TCE, suggesting a positive relation between the technology intensity of suppliers and the presence of vertical integration.

Second, we detect the influence of spatial agglomeration on firms' vertical integration decisions. We show that belonging to a specialized cluster – in our case an industrial district – can have a positive impact on vertical integration: that is, on the control of the different stages of the production chain. This result is also at variance with the hypothesis derived from TCE according to which low transaction costs – and thus a low level of vertical integration – should be observed within agglomerated areas.

Finally, we show that this result is not homogeneous across clusters, but is strongly affected by the industry in which the cluster specializes. Specifically, the positive influence of agglomeration forces in determining vertical integration is particularly significant for mechanical districts, but not for clusters specializing in 'traditional' industries. Our findings show that the hypothesis that lower transaction costs within industrial clusters favours vertical disintegration is not consistent with the evidence, especially with regard to mechanical districts. This points to the important role of technology rather than agglomeration in influencing the vertical integration choices of firms.

This paper is among the few that attempt to analyse the determinants of vertical integration choices using large data sets rather than firm or industry case studies. As such it has some limitations, mainly related to the availability of data. The most important of these is the use of cross-section data. We control for endogeneity problems in the technology intensity variables in two ways: (i) by assuming a time lag between dependent and independent variables and (ii) by adopting an IV strategy.

We detect the presence of vertical integration in business groups by observing the activities they control and assessing the intensity of supplier-acquirer relationships using the coefficients taken from input-output tables. In doing so, we are not measuring the effective presence of exchanges within the group but whether the group can potentially supply some of its input from controlled companies. We do not think that this is a major limitation for two reasons: on the one hand, it is plausible to assume that if a firm controls an activity along the same production chain this is with the aim of controlling the supply of some input; and, on the other hand, despite the actual amount of exchanges within the companies of the group, the control of vertically integrated activities signals the interest of the firm in acquiring technical knowledge in those activities, which can be considered an important move in a vertical integration strategy. Moreover, the use of this methodology allows us to study vertical integration choices based on a large data set. Despite these possible limitations we think that the empirical results presented here make a contribution to our understanding of the determinants in the vertical integration choices of firms, and give a basis on which the analysis can be further refined at both empirical and theoretical levels.

Finally, the implications of our study from the business and policy perspectives are also interesting. Business groups have been used here as unit of analysis in examining Italian manufacturing but business groups are not peculiar to certain industries or countries; they are the organizational form typically adopted by entrepreneurs and managers to maintain and expand their control over business activities and the main trend in organization design since the 1970s has been towards enhancement of the operative autonomy of organizational units. In this context, the group has emerged as an organizational form specifically adapted to coping with the new conditions of markets and technology. The second implication concerns the role of agglomeration forces as determinants of firms' organisation. This topic has received little attention in the management and economics literature but seems important for understanding the factors behind the evolution of firm boundaries.

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Table 1 – Statistics on business groups by industry

Code	Industry	Groups		Size of groups		Backward integrated groups %
		N.	%	N. of companies (average)	N. of employees (average)	
15	Food products and beverages	643	7.4	4.6	189.0	5.6
17	Textiles	549	6.3	3.6	164.4	4.4
18	Clothing	357	4.1	4.3	144.1	16.8
19	Leather and leather products	281	3.2	3.3	121.8	8.5
20	Lumber and wood products	158	1.8	3.0	92.4	8.9
21	Pulp, paper and paper products	157	1.8	3.5	199.2	3.8
22	Printing and publishing	523	6.0	3.9	122.1	4.0
23	Petroleum refining and related industries	35	0.4	6.8	347.1	0.0
24	Chemicals and allied products	443	5.1	3.9	299.7	6.3
25	Rubber and plastic products	523	6.0	3.7	127.3	16.4
26	Non-metallic mineral products	524	6.1	4.7	246.3	11.5
27	Primary metal industries	226	2.6	4.4	377.9	4.4
28	Fabricated metal products	1,131	13.1	3.2	96.8	9.2
29	Industrial machinery and home appliances	1,375	15.9	4.2	198.7	26.8
30	Office machinery and computers	70	0.8	3.1	82.7	27.1
31	Electrical equipment and apparatus	395	4.6	5.1	197.7	19.5
32	Electronic equipment and components	183	2.1	7.7	696.4	24.0
33	Measuring and controlling instruments	242	2.8	3.1	161.8	21.5
34	Automobiles and components	177	2.0	3.3	529.9	39.5
35	Other transportation vehicles	118	1.4	3.2	176.8	32.8
36	Other manufacturing industries	551	6.4	3.1	106.4	17.8
Total		8,661	100.0	4.0	189.1	14.3

Table 2 – Descriptive statistics for industry characteristics

Code	Industry	R&D on value added (%) – 2000 (1)	R&D per employee (thousands Euros) - 2000 (2)	Share of innovative firms on total (%) - 2000 (2)	Average size of firms (employees) - 2001 (3)
15	Food products and beverages	0.4	7.5	38.2	6.7
17	Textiles	0.1	6.5	28.7	10.5
18	Clothing	0.1	3.7	20.3	6.8
19	Leather and leather products	0.1	4.4	22.5	9.1
20	Lumber and wood products	0.1	8.4	39.4	3.7
21	Pulp, paper and paper products	0.1	10.2	35.8	18.3
22	Printing and publishing	0.1	9.7	34.5	6.5
23	Petroleum refining and related industries	2.5	2.8	43.0	58.4
24	Chemicals and allied products	4.7	14.3	51.2	35.0
25	Rubber and plastic products	7.1	4.9	54.7	16.3
26	Non-metallic mineral products	0.3	5.2	44.0	9.5
27	Primary metal industries	0.4	5.2	44.1	41.7
28	Fabricated metal products	0.3	5.9	39.1	7.3
29	Industrial machinery and home appliances	0.3	6.1	44.8	14.3
30	Office machinery and computers	7.4	17.6	82.4	11.9
31	Electrical equipment and apparatus	1.9	5.6	35.9	11.4
32	Electronic equipment and components	18.3	59.5	61.8	12.2
33	Measuring and controlling instruments	5.0	11.5	73.3	5.1
34	Automobiles and components	9.5	11.6	42.0	98.4
35	Other transportation vehicles	11.0	17.7	31.7	21.7
36	Other manufacturing industries	0.2	4.0	37.6	6.0

Sources: (1) OECD, STAN ANBERD, 2006
(2) ISTAT, L'innovazione nelle imprese italiane negli anni 1998-2000
(3) ISTAT, Censimento dell'industria

Table 3 – Correlation matrix of explanatory variables

	1	2	3	4	5	6
1	1					
2	-0.0411	1				
3	0.0161	-0.0338	1			
4	0.0845	-0.0071	-0.0082	1		
5	0.5205	-0.0205	-0.0113	0.1522	1	
6	-0.0125	0.4901	0.1182	-0.0063	-0.0301	1

1 - R&D on value added of buyer sector
2 - R&D on value added supplier sector
3 - Share of input of sector *i* bought by sector *j*
4 - Size of group
5 - Average size of firms in buyer sector
6 - Average size of firms in supplier sector

Table 4 - Backward integration, R&D intensity and spatial agglomeration

Estimation method	(1) Probit		(2) Probit		(3) Probit		(4) Probit	
	Coeff.	*t-values*	*Coeff.*	*t-values*	*Coeff.*	*t-values*	*Coeff.*	*t-values*
	Dependent variable: db_{ij} (presence of backward integration)							
s_{jk}	0.022**	3.73	0.025**	4.04	0.025**	4.42	0.025**	4.05
ln(*resacq*)	0.064**	3.55	0.047**	2.45	0.049*	2.01	0.046**	2.36
ln(*ressup*)	-0.017	-1.18	-0.016	-1.10	0.012	0.76	-0.016	-1.11
Dis	0.063**	3.20	0.060**	3.10	0.060**	3.01	--	--
ln(*size*)	--	--	0.219**	20.25	--	--	0.219**	20.21
ln(*sizeacq*)	--	--	--	--	0.072	1.11	--	--
ln(*sizesup*)	--	--	--	--	-0.141**	-3.31	--	--
Dis_food	--	--	--	--	--	--	-0.001	-0.02
Dis_tex	--	--	--	--	--	--	0.052	1.50
Dis_lea	--	--	--	--	--	--	-0.019	-0.33
Dis_mech	--	--	--	--	--	--	0.097**	3.23
Dis_oth	--	--	--	--	--	--	0.052*	1.62
N. Obs.	155,671		155,671		155,671		155,671	
Clustering	369 industry pairs		369 industry pairs		369 industry pairs		369 industry pairs	
Pseudo R^2	0.029		0.092		0.036		0.093	

Note:
Regressions include a constant term. Standard errors are robust to heteroskedasticity and clustered at industry pair level.
Legend: ** significant at 5%; * significant at 10%.

Table 5 - Backward integration, R&D intensity and spatial agglomeration: robustness checks

Estimation Method	(1) IV Probit		(2) Linear probability model		(3) Linear probability model IV	
	Coeff.	*t-values*	*Coeff.*	*t-values*	*Coeff.*	*t-values*
s_{jk}	0.026**	4.01	0.001**	2.61	0.018**	2.61
ln(*resacq*)	--	--	0.001**	2.15	--	--
ln(*ressup*)	--	--	-0.0006	-1.12	--	--
^ln(*resacq*)	0.073**	2.76	--	--	0.002**	2.63
^ln(*ressup*)	0.033	1.36	--	--	0.001	1.15
ln(*size*)	0.216**	19.69	0.011**	11.02	0.010**	11.30
Dis_food	-0.003	-0.06	-0.001	-0.91	-0.001	-0.90
Dis_tex	0.069**	2.07	0.001	0.78	0.001	1.17
Dis_lea	0.008	0.16	-0.002	-0.97	-0.001	-0.67
Dis_mech	0.096**	3.11	0.003*	1.89	0.003*	1.87
Dis_oth	0.059*	1.77	0.001	0.78	0.001	0.92
N. Obs.	155,671		155,671		155,671	
Clustering	369 industry pairs		369 industry pairs		369 industry pairs	
Wald text of exogeneity (p-value)	0.044		--		--	

Notes:
(a) The regression also includes a constant term. Standard errors are robust to heteroskedasticity and clustered at the industry pair level.
(b) Intrumented: ln(resacq); ln(ressup)
(c) Intruments: b_{ij}, ln(size), Dis_food, Dis_tex, Dis_lea, Dis_mech, Dis_oth, limpinni, limpinnj
Legend: ** significant at 5%; * significant at 10%