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Heterogeneity and Specificity of Knowledge

A Model of Governance Choice

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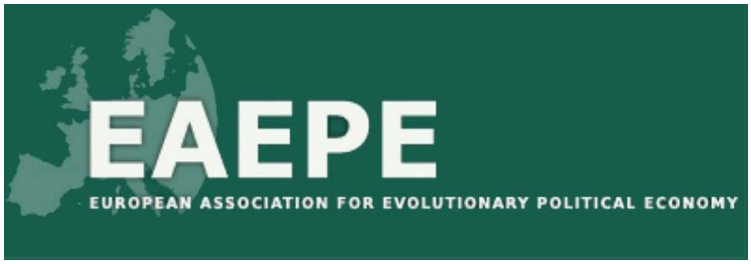

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Abstract

In this paper, we explore the role of the heterogeneity of knowledge sets involved in the production in determining the governance choice of firms. Drawing on Williamson's 1991 model, we extend his analysis by including the effects of the interaction between different sets of knowledge on the learning processes enabled by the interaction between firms under different institutional arrangements. This allows us to highlight how non-opportunism-based concerns may affect the choice between *market*, *integration* and *alliances*. We develop a model that shows how the discrete choice between the different institutional alternatives changes as the levels of specificity and heterogeneity of the knowledge sets vary. Therefore, we study how the inclusion of knowledge-based concerns as a determinant of the governance form leads to conclusions about the convenience of the institutional alternatives that are different from, and complete, those put forward by Williamson. This way, the paper has the aim of concurring to the building-up of schemes that consider the understanding of the complementarities between the transaction-cost economics and the knowledge-based approach as a new challenge for industrial economists and managerial scholars.

J.E.L. Classification Numbers: D23, D83, L23.

Keywords: Governance, Knowledge, Learning, Cognitive Distance.

1. Introduction

This paper studies the determinants of the governance form characterizing the interaction between firms. We mainly refer to the insights provided by two important approaches emerged in industrial economics and management science: the Transaction Cost Economics (TCE hereafter) and the Resource-Based and Knowledge-Based Views (RBV and KBV). The main difference between these approaches can be traced back to the fact that, as Williamson (1999: 1087) pointed out, «[TCE] gives greater prominence to (…) transaction cost economising», while «[RBV and KBV] give greater prominence to organization theory, where the importance of process is especially featured».

RBV and KBV pose the emphasis on coordination problems deriving from managing the interaction between, respectively, resources (Barney, 1991, 2001; Wernerfelt, 1984; Eisenhardt and Schoonhoven, 1996; Das and Teng, 2000), and knowledge attributes (Nonaka, 1994; Spender, 1996; Grant, 1996; Conner and Prahalad, 1996; Kogut and Zander, 1996; Contractor and Ra, 2002; Grant and Baden-Fuller, 2004) rather than on opportunism-based concerns as the main determinant of the governance choice.

Indeed, according to the claims of its critics, TCE approach would be limited by «[its] primary focus on single transaction as unit of analysis» (Doz and Prahalad, 1991: 148) rather than on the importance of organizational processes (Kogut and Zander, 1996), and by the idea that the characteristics of assets rather than those of resources and/or knowledge attributes are determinant in shaping governance forms (Eisenhardt and Schoonhoven, 1996; Grant and Baden-Fuller, 2004).

In particular, taking TCE perspective would reduce the possibility to analyse the influence of technological and functional complementarities and interdependencies on the choice of governance, where this would be a strong limitation in a context in which, as noted by Langlois and Foss (1997: 215), «the structure of similarity and complementarity among the various capabilities [and resources] in the economy affects the pattern of organization in ways not fully explicable in terms of the costs of transacting».

The debate between TCE and its critics is played also in the empirical playground. For instance, David and Han (2007) provided an empirical test of TCE arguments, confirming the role of specificity in explaining governance choices, Conner and Prahalad (1996), while Gulati and Singh (1998) provided an empirical confirmation of the role of non-opportunism-based motivations. Grant and Baden-Fuller (2004), based on a large number of interviews and talks with managers of large U.S. companies, found that concerns coming from the need of integrating knowledge affect the -governance choice independently of asset specificity. Gulati, Lawrence and Puranam (2005), finally, stressed a large effect of the interdependency of resources on the form of coordination.

Therefore, empirical testing seems to support both perspectives, preventing anyone to have the last word within the debate, and calling for the need to develop schemes aimed at matching both perspectives up under the same roof. Though we focus on knowledge attributes rather than on assets characteristics, this work moves in the direction of the compromise. Indeed, we present a model that permits to acknowledge the role of both specificity and heterogeneity of knowledge attributes in determining the governance choice. Even though the model keeps a static perspective, the inclusion of the effect of heterogeneity of knowledge allows us to provide some extension of the traditional TCE model, making it more comparable with the dynamic logic of the KBV and RBV.

Indeed, we start from Williamson's 1991 formulation, keeping its fundamental structure and the methodological approach based on the «analysis of discrete structural alternatives».[1]

We define a decisional environment where the firm chooses among the different governance forms by comparing the costs related to each institutional alternative. Costs are assumed to depend the heterogeneity and specificity that characterise the cognitive resources involved in the productive process.

The main assumption is that the heterogeneity between the knowledge sets of the firm involved in the transaction tends to modify the way knowledge transfer and learning processes are enabled in each governance form. The learning processes affect in turn firms' productivity, and thereby, the costs. We numerically solve the model in order to analyse how, as heterogeneity varies, the areas of convenience of governance form vary in the space of specificity, showing how a given value of specificity may involve different governance choices according to the level of heterogeneity.

This analysis pursues two aims. Firstly, it allows us to stress which are the effects of the heterogeneity on the choice of the governance form, contributing to explain the evolution of the organization of the industry in modern productive systems (specialization, raising impact of alliances, role of the market). Secondly, it allows us to highlight which are the theoretical implications of including KBV and RBV insights in the original TCE framework.

The paper is structured as follows. Section 2 is devoted to the definition of the decisional environment and relevant variables, particularly, coordination and production costs functions. Section 3 reports the results of the simulation and Section 4 concludes.

2. Decisional environment and definition of variables

The decisional environment is characterised by the presence of a firm producing a (given amount of a) final good by employing an intermediate good in a productive process characterised by constant return to scale. The production of each kind of good involves the holding of a peculiar set of cognitive resources.

The firm has to choose between (1) acquiring the intermediate good in the market, (2) internally producing it, or (3) accessing it in the context of an alliance with another firm. Evidently, each alternative involves a different mechanism through which the different sets of cognitive resources needed to produce the final good are integrated and interact.

Coherently with the comparative approach, three different average cost functions exist, which refer to the different forms of governance, and have their trend affected by the level of specificity and heterogeneity of the competences. We suppose that the firm chooses the institutional arrangement which grants the lowest total average cost connected with the production of the final good.

[1] In this context, the comparison between the costs connected with the different forms of governance cannot be achieved by taking into account the trend of a generic cost function with respect to the variation of some parameters, but it has to be achieved by taking into account different cost functions for each institutional alternative. Williamson (1991: 270) supports the efficiency of such a methodology with respect to traditional marginal analysis because «firms are not merely extensions of market but employ different means», and «discrete contract law differences provide crucial support for and serve to define each generic form of governance».

Generally, we assume that total costs can be decomposed into coordination and production costs. Particularly, coordination costs, as in Williamson's 1991 model, are affected by the level of specificity that characterises the different sets of competences, while production costs are affected by the level of their heterogeneity.[2]

The heterogeneity of competences (*D*) is defined as the degree of cognitive proximity (or distance) that exists between two different sets of cognitive resources (Nooteboom, 1999, 2000; Wuyts et al., 2005).

The specificity of competences (*S*) is instead defined as the «bilateral dependency degree». Indeed, «although asset specificity can take a variety of forms, the common consequence is this: a condition of bilateral dependency builds up as asset specificity deepens» (Williamson, 1991: 282). This definition, conceptually broader than that previously provided by Williamson (1975, 1985) himself in terms of the «possibility of alternative use», reflects the need for including into the analysis the fact that transactions also involve transfer and mutual adaptation of immaterial factors.

In fact, following Williamson (1991), the degree of specificity would be linked to the need for adaptation of the different resources within the given production process. Such a conceptualization of specificity, as the author himself argues, can be extended to resources that cannot be immediately defined as physical assets, that is, in the context of our work, to the sets of knowledge involved in the production.

2.1 Coordination Costs

Coordination costs represent the expenditure the firm bears in order to build-up and keep the governance structure of transactions. The term 'transaction' has to be intended in its broadest sense, including also intra-firm exchanges. Following Williamson (1975, 1985, 1991, 2001), each form of governance can be thought of as a different combination of agreements and contracts, the writing down and control of which generate different costs according to the characteristics of the transaction.

Each discrete institutional alternative involves a different trend of coordination costs in the space of specificity. Therefore, each governance form imposes to the firm a different coordination costs function with respect to the trend of specificity. Notably, by simplifying Williamson's 1991 formulation without altering its fundamental elements, we can express the three coordination costs functions (for Market [C_{C_M}], Integration [C_{C_I}], and Hybrids [C_{C_H}]) in terms of the level of specificity (*S*) as follows (a graphical representation is provided in figure 1):

$$C_{C_M} = a + bS, \quad (1)$$

$$C_{C_I} = B, \quad (2)$$

$$C_{C_H} = c + dS. \quad (3)$$

[2] In Williamson (1991) heterogeneity of immaterial assets tends to emphasize the need for mutual adaptation and, thereby, to increase the incidence of specificity on coordination costs. Therefore, the sharp distinction we made between the effects heterogeneity (on production costs) and specificity (on coordination costs) does not fully reflect the original idea of Williamson. However, as the aim of the paper is to stress the implications of the introduction of the productivity effects of heterogeneity, we decided to not to take into account the effects of heterogeneity on coordination costs.

In order to keep us coherent with Williamson's hypotheses, we must have $a < c < B$ and $b > d$. Parameters a, c and B represent the part of coordination costs that are independent of the level of specificity and that are connected with the building up of the transactional environment.

In particular, the former relationship implies that specificity-independent coordination costs connected with market transactions are supposed to be the lowest, while the specificity-independent costs for integration are higher than those connected with hybrids. b and d measure the response of the trend of the coordination costs to variations in the level of specificity respectively for hybrids and market transaction. It follows that specificity affects coordination costs related to market in a more intense way with respect to hybrids.

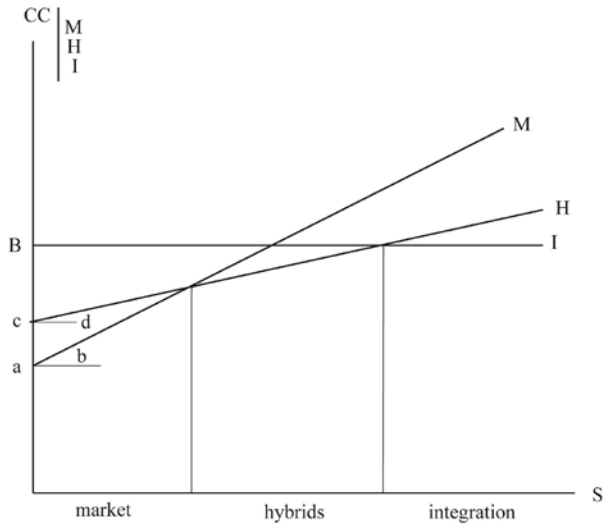

Figure 1: Coordination costs

In the Williamson's formulation, the choice of firm (represented on the horizontal axis) is determined through a comparison between the trends of the different coordination cost functions. The firm chooses the form of governance that, for a given level of specificity, allows it to have lower coordination costs.

The relative trend of the functions referred to market, integration and hybrids reflects the idea, generally accepted in this field of literature, and empirically confirmed by David and Han (2007), that hybrids are to be considered as an intermediate governance form between market and integration when specificity is taken as reference variable (Richardson, 1972; Williamson, 1991; Nooteboom, 1999, 2000).

As Williamson (1991: 283) argued, «the hybrid mode is located between market and hierarchy with respect to incentive, adaptability, and bureaucratic costs. As compared with market, the hybrid sacrifices incentives in favour of superior coordination among the parts. As compared with hierarchy, the hybrid sacrifices cooperativeness in favour of grater incentive intensity». In other words, contractual forms and informal elements of governance (Powell, 1990; Grandori, 1999; Baker, Gibbons and Murphy, 2002; Poppo and Zenger, 2002; Levin, 2003) that characterise hybrids allow this governance form to guarantee, at the same time, higher flexibility than integration (and, thereby, a higher efficiency for low levels of specificity) and

higher capability to manage opportunism than market (involving a lesser sensitivity of the trend of coordination costs with respect to specificity).

2.2 Production costs

Each governance form involves a different mechanism through which the different sets of cognitive resources are integrated and interact in the production process (Nooteboom, 1999, 2000).

When the market is chosen as the institutional environment of the transaction, the different sets of cognitive resources do not interact because the intermediate good is separately produced by another firm.

In case of integration, the firm producing the final good has to integrate within the same organizational structure the different sets of cognitive resources that are related to the production of both the final and the intermediate good: this involves some interaction between the cognitive resources involved in the productive process.

Finally, when the transaction is carried by means of an alliance agreement, while the goods are separately produced by the firms involved, the different sets of cognitive resources interact and some knowledge transfer emerges (Powell, 1990; Antonelli, 2005; Mowery, Oxley and Silverman, 1996).

Mainly, we argue that the different mechanisms of integration of the sets of cognitive resources involve different typologies of interaction between them. The learning processes that are eventually enabled by the interaction affect the productivity, and, consequently, production costs.

In the following paragraphs, we discuss the determination of the production costs for each of the institutional alternatives, then, we compare the trends of production costs as functions of the heterogeneity of the cognitive resources.

Market

The standard market transaction is characterized by a not-structured relationship between the firm producing the final good and the firm producing the intermediate good. We assume that the (constant return to scale) production function of the final-good firm is defined as $y = \lambda k$ where y is the output, λ is a technological factor that linearly affects the level of production and k is the intermediate good. The production function of the intermediate-good firm is a constant return to scale function of labour services:[3] $k = l$, where l represents labour services.

Let's normalize to 1 the price of the final good and indicate with w and z, respectively, the unit wage and the mark-up that the firm operating in the intermediate-good market charge on costs. It follows that the market price of the intermediate-good firm, p_M, is given by $p_M = (1+z)w$. Under these hypotheses, the production cost function of the final-good firm when it buys the intermediate good in the market can be represented as follows:

$$C_{P_M} = \frac{p_M}{\lambda} = \frac{w(1+z)}{\lambda}. \tag{4}$$

[3] This assumption permits to avoid the inclusion of another firm in the context of analysis.

Eq. (4) indicates that production costs are increasing in the price of the intermediate good, while are decreasing in the technological progress of the final-good production function.

Integration

Integration emerges when the final-good firm decides to produce also the intermediate good.

This choice affects the productivity of the production processes of both goods through two mechanisms. The first is related to the transfers of knowledge and to the learning processes. Indeed, the interaction between different sets of cognitive resources implies some intra-organizational transfer of knowledge and learning processes which modify the productivity that characterises the production processes of both the final and the intermediate goods. In this context, following Nooteboom (1999, 2000) and Wuits et al. (2005), we assume that the effect of learning processes on productivity are positive and initially increasing and then decreasing in the level of cognitive distance. The second mechanism considers the effect of heterogeneity on the efficiency of organizational processes. Indeed, the capability to manage in the same organizational structure processes that call for increasingly heterogeneous cognitive resources tend to be decreasing in heterogeneity (Hamel and Prahalad, 1990).

The first mechanism implies that the production processes of both goods are affected by the functions $\psi(D)$ and $\xi(D)$, respectively for the production of the final and intermediate good, which are increasing for low values of D and then decreasing. The second mechanism implies the need for defining some functions, $Q(D)$ and $J(D)$, respectively for the production of the final and intermediate good, which measure the loss of productivity related to the negative effect of the heterogeneity on the efficiency of organizational processes. Obviously, the loss of productivity is increasing in the cognitive distance.

The production function of the two goods become $y = \lambda [1 + \psi(D) - Q(D)] k$ and $k = [1+ \xi(D) - J(D)]l$. As the final-good firm does not have to pay any mark-up for the intermediate good, the production cost function in case of integration, C_{P_I}, is defined as follows:

$$C_{P_I} = \frac{w}{(1+\xi(D)-J(D))(1+\psi(D)-Q(D))\lambda}. \quad (5)$$

Eq. (5) indicates that production costs are affected by the trend of the functions that represent the positive effects of learning on the productive processes of the final and intermediate good ($\psi(D)$ and $\xi(D)$) and the negative effects of the organizational inefficiencies ($Q(D)$ and $J(D)$).

Hybrids

Hybrids emerge when the final-good firm interacts within a cooperative relationship with the intermediate-good firm. Formally we assume that, with respect to the market case, such institutional arrangement affects the productivity of the final-good firm and the price at which such firm buys the intermediate good.

As it was in case of integration, we suppose that the effect of heterogeneity on productivity is positive but not always increasing in heterogeneity. Differently from

integration, however, in case of hybrids the firm has not to sustain the burden of the loss of productivity related to the higher complexity of organizational processes.

Specifically, the production function of the final-good firm is given by $y = \lambda(1+\chi(D))k$, where $\chi(D)$ is initially increasing and then decreasing in *D*. The other hypothesis concerns the price of the intermediate good. We assume that the final-good firm pays a price, p_H, higher than the market price in order to tie the relationship with the other firm. It follows that $p_H = \mu p_M$ with $\mu > 1$.

Consequently, the production cost function under hybrids, C_{P_H}, is:

$$C_{P_H} = \frac{p_H}{\lambda(1+\chi(D))} = \frac{\mu w(1+z)}{\lambda(1+\chi(D))}. \quad (6)$$

Eq. (6) shows that the price of the intermediate good increases the cost of production of the final good, while the positive effect of learning on productivity ($\chi(D)$) tends to reduce it.

Graphical representation of production costs

In the previous paragraphs, we derived the functions that determine the trend of production costs for each institutional alternative. Figure 2 provides a graphical representation of them.

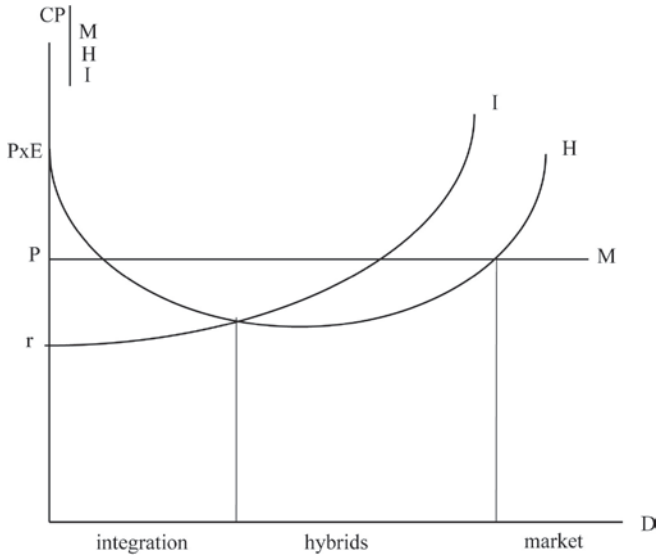

Figure 2: Production costs

Taking into account only the effect of the heterogeneity of the cognitive resources, it is possible to trace a trend of the convenience of the different institutional alternatives that is coherent with the results provided by Grant and Baden-Fuller (2004). Notably, integration is convenient for low levels of cognitive distance, while the market is preferred for high levels of heterogeneity. Hybrids are chosen for intermediate values of cognitive distance.

This representation is in line with two of the main arguments of the RBV and KBV literature. Indeed, the fact that integration is chosen when cognitive distance tend to be low would support the need for a cognitive specialisation put forward by Hamel and Prahalad (1990). Furthermore, this results would confirm the claims of the literature sustaining that hybrids emerge as response to the consequences of a raising heterogeneity of the cognitive resources involved in the processes. Indeed, while the increment of cognitive distance tends to erode away the scale economies of cognitive scope within the firm (Nooteboom, 1999), the market fails to provide the communicative and interactive structure the firms need in order to efficiently manage the informative flow (Powell and Grodal, 2006) and the increasing complexity of organizational processes (Sorenson, Rivkin and Fleming, 2006).

3. Numerical Simulation

In this section, we run a numerical simulation of the model in order to determine how heterogeneity and specificity affect the governance choice. The firm chooses the governance form that grants the lowest total cost (the sum of production and coordination costs). Therefore, we calculate the threshold values of specificity that mark the choice between the different governance structures and analyse how such thresholds change as the level of heterogeneity varies.

This exercise allows us to show how specificity and heterogeneity contribute to determine the governance form. Firstly, we present the parameterization of the model, then, we present the results of the simulation.

3.1 Parameterization

In this paragraph, we define the functional form of the previous implicit functions and assign a numerical value to each parameter. The stylized framework has been defined so as to assure that, for medium values of heterogeneity, the model provided results that were similar to those reported in Williamson (1991). Notice that the proportion between coordination and production costs is not relevant for the results. Indeed, whatever the weight assigned to the two types of costs, the relative convenience between the different institutional arrangements does not change. For example it is not important identify the exact values of *a*, *B*, and *c*, but their difference are supposed to be not so high as to make the role of heterogeneity and specificity irrelevant. Our model, however, is sensitive to the spread between the costs connected with each institutional alternative for each kind of cost (coordination and production).

For sake of simplicity, the productivity effects that are related to the knowledge exchange are supposed to be equal. The same assumption is made also for the productivity effects that are related to the increment of organizational complexity.

Specifically:

$\xi(D) = \psi(D) = \chi(D) = fD - gD^2$ with $f, g > 0$.

$J(D) = Q(D) = hD^{\rho}$ with $\rho \geq 0$.

It follows that the total cost functions of the three governance structures are given by:

$$C_M = \frac{w(1+z)}{\lambda} + a + bS, \tag{7}$$

$$C_I = \frac{w}{\left(1 + fD - gD^2 - hD^{\rho}\right)^2 \lambda} + B, \tag{8}$$

$$C_H = \frac{\mu w(1+z)}{\lambda\left(1 + fD - gD^2\right)} + c + dS. \tag{9}$$

Equation (7) represents the total cost under the market structure, equation (8) represents the total cost under the integration structure and equation (9) the total cost under hybrid structure.

Table 1 reports the value of each parameter of the model. In particular, we set *f* and *g* taking under control that the influence of *D* was not too high and not too low with respect to other elements, and that the effect of learning processes on productivity was maximum for mean levels of cognitive distance. Furthermore, an increase in *D* implies a decrease in the efficiency of the organizational process. We decided to specify this influence as linear and we set *h* so that the maximum benefit on productivity in case of integration occurs when heterogeneity is about 0.3. Finally, mark-up was set to fit estimates concerning US and UK sectors (Martins et al., 1996).

λ = 1	μ = 1.13	h = 0.12
w = 1	c = 20.92	ρ = 1
z = 0.1	d = 0.7	B = 21.55
a = 20.2	f = 0.15	b = 3
	g = 0.15	

Table 1: Parameterization

Moreover, specificity and heterogeneity range between 0 and 1.

3.2 Results

Under the parameterization previously presented, we compare the average total cost under the three governance forms and calculate the threshold values of specificity that determine when a form of governance becomes the most convenient. We repeat the investigation for different values of heterogeneity. Thus, we verify how heterogeneity affects the choice of the institutional arrangement.

In order to make clearer how the areas of convenience are obtained, it is useful to start with a two-by-two comparison of the different governance forms. The results are reported in table 2.

The table shows the threshold values of specificity that determine a change in the governance choice. The results are reported according to the following criterion: for values lower than that reported in each cell, the firm prefers the first governance form mentioned in the title, while, for values higher than that reported in the cell, the firm prefers the second form mentioned in the title.

level of heterogeity (D)						
0	0.1	0.3	0.5	0.7	0.9	1
market vs. hybrids						
0.38	0.37	0.36	0.36	0.36	0.37	0.38
market vs. integration						
0.42	0.42	0.42	0.43	0.45	0.49	0.51
hybrids vs. integration						
0.55	0.57	0.62	0.68	0.77	0.89	0.97

Table 2: Threshold values of specificity

Looking at table 2, some insights concerning the way heterogeneity affects the governance choice clearly emerge.

In the choice between market and hybrids we know that the former is preferred for low values of specificity. The threshold value of specificity, though substantially stable, is initially decreasing and then increasing in heterogeneity. This is due to the positive effects of learning processes on the productivity under hybrids.

In the choice between market and integration, the former is preferred for medium values of specificity. The threshold value of specificity is initially almost stable and then increases as heterogeneity raises. This is due to the fact that the higher the heterogeneity, the higher the cost the final-good firm has to bear in order to integrate the production of the intermediate good.

In the choice between hybrids and integration, the latter is preferred for high values of specificity. The table shows that the higher the level of heterogeneity the higher the threshold value of specificity that shifts the firm convenience from hybrids to integration. This emerges because, as compared with hybrids, integration has to bear also the negative productivity effect connected with the raising of organizational complexity.

	level of heterogeity (D)							benchmark
	0	0.1	0.3	0.5	0.7	0.9	1	
market	0.38	0.37	0.36	0.36	0.36	0.37	0.38	0.39
hybrids	0.18	0.20	0.26	0.33	0.41	0.52	0.59	0.39
integration	0.45	0.43	0.38	0.32	0.23	0.11	0.03	0.22

Table 3: Range of specificity for each governance form

Based on the previous results, Table 3 reports the ranges of specificity values for which each governance form is the most preferred and it shows as this range varies according to the level of heterogeneity. For example, when D = 0.3, Table 2 shows that hybrids is the most convenient governance form if heterogeneity is higher than 0.36 (otherwise market is preferred) and lower than 0.62 (otherwise integration is preferred).

It follows that Table 3, when D = 0.3, defines the range of specificity supporting hybrids as equal to 0.62 – 0.36 = 0.26.[4]

In the last column, the analysis takes into account only coordination costs. Such case is considered the benchmark in order to see how the introduction of heterogeneity modifies the results based exclusively on the TCE approach.

The first row reports the range of specificity for which the market is convenient. Such range does not vary significantly and does not diverge from the benchmark value. Since market is generally substituted by hybrids, its range strictly depends on the trend of the costs connected with hybrids. Being the production costs of hybrids initially decreasing and then increasing in heterogeneity, this explains the initial reduction and then the recover of the range of market.

The second row shows the range of hybrids. It grows almost constantly as heterogeneity increases, showing a significant spread from the benchmark value. This trend is initially due to a gain with respect to the market. Subsequently, as heterogeneity increases, the loss of convenience with respect to the market is more than balanced by the gain with respect to integration.

Finally, the third row shows as the range of integration is constantly decreasing in heterogeneity. In fact, the higher the heterogeneity, the higher the costs the firm has to sustain to integrate the production of the intermediate good. Also in this case, the heterogeneity significantly affects the comparative course of the average total cost. It follows that the benchmark case does not generally well represent the relevance of the integration.

4. Conclusions

This paper proposes an approach that jointly considers insights from TCE tradition and RBV and KBV analyses. Starting from Williamson's 1991 contribution, which individuates the specificity (of material and immaterial assets) as the key element determining the governance choice, we enrich the framework by introducing the relevance of the heterogeneity of cognitive resources. Generally, such extension permits to explain why economic transactions characterized by the same level of specificity are ruled by different institutional arrangements and why in some productive context integration rarely emerge.

Indeed, the results of the paper suggest that an effective choice between market, hybrids and integration does not always exist. Indeed, integration becomes almost irrelevant for high values of heterogeneity. The area of convenience of hybrids start to be significantly wide only for medium values of heterogeneity, becoming the widest for high levels of cognitive distance. Moreover, hybrids emerge mostly as substitutes for integration, where the heterogeneity of competences starts to erode away specialization economies. This effect could not be visible taking into account only coordination costs, where substitutability between the different forms of governance is rigidly linked to the trend of specificity.

The aim of the work was twofold. On one hand, we were willing to study the trend of firm decision as the level of heterogeneity was varying. On the other hand, implicitly, we wanted to investigate if and how taking into account heterogeneity could modify the conclusions drawn by following TCE approach.

[4] If it was assumed that specificity was uniformly distributed the values reported in Table 3 would represent the probability of choosing each governance form.

Concerning the second point, the introduction of heterogeneity tends to deeply modify the conclusions of TCE approach we took as benchmark. Firstly, the introduction of the effects of heterogeneity tends to make the area of convenience of the different institutional alternatives more flexible. This involves the possibility to interpret the presence of different governance choices in contexts characterised by similar levels of specificity.

Secondly, while in Williamson's idea the firm has the possibility to choose among three different alternatives as specificity varies, our results stress the evidence that for some level of heterogeneity, the firm has only two relevant choices. This involves the possibility to interpret the fact that, in some sectors, alliances (supposedly in productive processes characterised by low levels of heterogeneity) or integration (for high levels of heterogeneity) hardly emerge.

Concerning the first point, the results of the numerical simulation of the model allow us to stress some interesting insights. For low levels of heterogeneity, hybrids are rarely a viable alternative. This finding, if joined with the observation of a high degree of substitutability between hybrids and integration, is able to give an interpretation of the emersion of inter-firm collaborations when a strong tendency towards de-integration is observed. This would largely confirm the argument of a complementarity between specialization and collaborations (Powell, 1990; Grandori, 1999; Cecli and Green, 2000). Moreover, this seems to confirm also that those phenomena have to be connected with the evolution of the technological composition of products (which has tended to a progressive increment of heterogeneity).

The role of market, as it derives from the proposed analysis, permits to consider it as an alternative that is always viable and that is alternatively substituted by hybrids or integration according to the given combination of the levels of heterogeneity and specificity.

Therefore, our extension of TCE approach is able to confirm the relevance of the effect of the heterogeneity of cognitive resources on governance choice, where our results are coherent with both theoretical findings and empirical evidences of the literature that studies industrial dynamics within RBV and KBV frameworks. Particularly, far from invalidating the conclusions of TCE, the approach we proposed seems to be tightly complementary to it, where the introduction of heterogeneity of cognitive resources among the determinants of the governance choice allows us to explain phenomena (the increasing relevance of hybrids, the tendency toward specialization though the raise in factor interdependencies, the scarce substitutability between market and collaborations) that would be difficult to be apprehended taking into account only the effect of specificity.

Finally, the model permits to consider policy effects on the structure of the market in which transactions are carried out (by modifying the structure of the mark-ups in the context of the production costs) and on the institutional environment in which each form of governance is built-up (by modifying the structure of the autonomous components of the coordination costs).

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