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Locational and managerial decisions as interdependent choices in the headquarter-manufacturing plant relationship: a theoretical approach

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Abstract The main purpose of the paper is to provide a link between the location decision and the internal organization of vertically integrated firms. The results of the model show that the decisions about location and managerial (de)centralization are interdependent: For certain parameters, firms should change both aspects simultaneously as a response to lower communication costs. The positive correlation between the decentralization of decision-making and geographic decentralization predicted by the model is supported by empirical research.

JEL Classification R12 · F23

1 Introduction

Jones and Kierzkowski (2005) have recently proposed that the idea of fragmentation can serve as an important concept in explaining the geographical location of firms, as a complement to the formalism of the new economic geography. Fragmentation is a process whereby the value chain of production is broken down into a series of separate operations, often assigned to different establishments that may be located in different regions or different countries and linked by a complex bundle of services that

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include transportation.[1] Recent papers have shown evidence that the trade in inputs has substantially increased around the world over the past few decades, a result of the increase of trade within and between firms.[2] Outsourcing and intra-firm trade, a result of fragmentation, seem to have had their relevance expanded in the global economy as a consequence of the fact that the production process has become multi-locational. An additional, complementary approach has been proposed by Yomogida (2007) who considered the welfare implications of fragmentation and outsourcing. According to his model with imperfect competition, the equilibrium outcome may not be socially desirable and government intervention through lump-sum subsidies may or may not be welfare improving.

Vertical integration can be defined as a process in which more than one link of the production chain takes place within the boundaries of a corporation. In the international trade literature, many papers on vertically integrated multinationals consider the production of final goods as a two-phase process; inputs produced in the manufacturing plant are combined with the headquarter services to produce the final good. The production of inputs may or may not be placed near the headquarters. In the international trade terminology, when inputs and final goods are produced in different places we have a vertical multinational. Following this idea, Fujita and Thisse (2006) build an insightful general equilibrium model in which a manufacturing plant uses the headquarter services and unskilled labor to produce differentiated goods. As in the present work, the headquarter and production facility of a firm need not be located in the same region. The authors show that reducing communication costs lead some integrated firms to the spatial fragmentation. However, while they discuss differences in wages between regions and some welfare implications—what is not done here—their work does not investigate the relationship between headquarter and subsidiary in terms of autonomy of decision; rather Fujita and Thisse assume that lower communication costs allow subsidiaries to use more efficiently headquarters' services.

There is an extensive literature that has studied the relationship between headquarters and subsidiaries. Gates and Egelhof (1986) analyze how the degree of centralization varies in response to some characteristics of the company and/or subsidiary. Birkinshaw and Morrison (1995) propose an exploratory study to examine in what ways the subsidiary's structural context varies according to its strategy/role. Even though both articles provide the debate with important contributions, locational decisions are not a central issue in their works.

More recently, Mudambi (2007, 2008) has examined the interaction between location and control decisions in multinational corporations (MNCs), considering also the opposite strategies of vertically integrating or outsourcing part of a value chain. Many production chains present "the smile of value creation", i.e., activities at the left or 'input' end (supported by R&D knowledge) and activities at the right or 'output' end (supported by marketing knowledge) are those that present higher value added, while intermediate activities as manufacturing and standardized services present lower value

[1] See also Jones and Kierzkowski (2003, 1990) and Jones (2000).

[2] See Antras (2003) and Antras and Helpman (2004)

added. The degree of standardization of each operation is crucial for the firms to decide their geographical location strategies.

Studying the migration of part of the footwear and clothing chains from Italy to Romania, Crestanello and Tattara (2010) identify the same phases in terms of value added and relate them to the locational decisions: "the initial phases of value chain (such as design) and the final phases (such as logistics and marketing) are still carried out in Italy" (p. 830). The authors emphasize that the Italian firms have moved to other countries only (intermediate) activities presenting low value added.

The model proposed here seems to respond very well to those findings, as it is discussed in more details along the next sections.

Along the last decades, the dispersal of knowledge-creating activities within MNC has changed the behavior of the subsidiaries in trying to influence the distribution of the firm's resources and investments (Mudanbi and Navarra 2004; Phelps and Fuller 2000). More autonomy of decision and initiative may mean for the operation unit more control over the resources and procedures, which, in turn, may have irreversible consequences in terms of both the future development of that operation unit and its relationship with the headquarters.

According to Mudanbi and Navarra (2004), increasing knowledge intensity of the subsidiaries' operations has allowed their managers to exercise considerable intra-firm bargaining power to pursue their own ends. The authors emphasize that the nature and pattern of knowledge flows are key aspects of this bargaining process between subsidiaries or between a subsidiary and the headquarters, since the same "mixture of competition and cooperation that is found in inter-firm relationships now characterizes intra-firm relationships" (p. 386).

Therefore, subsidiaries should not be seen as passive recipients of the head office mandates; rather the subsidiary strategy must be included in the analysis (Delany 2000). In the present model, even though the controller (subsidiary's manager) chooses the effort level that maximizes his utility, there is no bargaining game between the headquarters and the subsidiary. Nonetheless, in a extension of the results, the controller is allowed to behave subversively,[3] i.e., he may hide information from the headquarters.

Regionally, an interesting example of fragmentation was the change in the organizational structure of the Boeing Company announced in March 2001. Puga and Trefler (2003) analyzed carefully, from the perspective of their insightful model, this change. Briefly, the company "(…) promoted the three existing unit heads to chief executive officers and geographically separated the corporate headquarters from all three business units" (p. 23). Then, the authors conclude that the control of innovation was given to the unit heads as they were promoted to chief executive officers and the decision "(…) was mainly a commitment to delegating control over incremental knowledge creation" (p. 23). They are not concerned about locational advantages and say that "our aim is not to explain the specific choice of Chicago" (p. 23). The fact that both decisions were made jointly, increasing at the same time the autonomy of

[3] Delany (2000) explains that this subversive behavior pointed out by some authors does not intend to undermine the parent; "it is because the subsidiary management team can be made to feel that it is being subversive in straying from strict interpretation if its original mandate" (p. 222). In the present paper, the subversive behavior may hurt the firm's utility.

unit heads and the geographic decentralization, fits well the model's predictions that will be elaborated in this paper.

The aim of this paper is to add one more element—the organizational dimension of firms—to the debate about vertical multinationals through relating it to the location decision-making and the role of communication costs, rather than substituting any aspect previously identified. This work seeks to contribute to the debate by highlighting the importance of management for the map of production. In other works, the theoretical model proposed suggests that some answers about how the economic activity is geographically distributed depend on the internal organization of the firm. In Sect. 2, the model is presented. Thereafter, Sect. 3 provides the results, while discussion and conclusion are found in Sect. 4.

2 The model

In a seminal paper, Helpman (1984) constructed a model of monopolistic competition with two countries, two factors, and two sectors – one produces homogeneous goods and the other produces differentiated goods. While Helpman's model focuses on differences in factor prices, in the present work the variable labeled "locational advantage" will stand for any enhancing feature of a given region (distance from inputs and markets, wage differences, etc).

The present model, drawing on Aghion and Tirole (1997), is based on an information structure among individuals and establishments of a firm. The information is essential for their efficient operation, and the spatial separation of activities that is the focus here can introduce inefficiency into the channels of communication.

The results will reveal that decisions about both the location of the manufacturing plant and the internal delegation scheme are interdependent. More than that, for certain parameters, the existence of multi-located firms (here represented by those firms with headquarters and manufacturing plant geographically separated) can be justified only by the existence of a flexible managerial structure. In other words, under those parameters, the first best is to delegate power to the controller and to place the manufacturing plant far from the owner, whereas the second best is the opposite strategy: no delegation and locational proximity between headquarter and manufacturing plant. Therefore, if the owner intends to drive the firm from the second best to the first best (given a new cost of communication for instance) she has to change both aspects at once; otherwise, the firm will experience an inferior outcome.

In the model, these simultaneous transitions in terms of location and managerial strategy take place as a consequence of lower communication costs.[4] While Coase (1937) pointed out that telephone and telegraph tended both to reduce the cost of organizing spatially and increase the size of the firm, here internet and lower costs

[4] While the insightful article by Earle et al. (2006) that empirically analyzes the relationship and its causality between information technology adoption and organizational forms (specially in terms of ownership structure), in the present model there is no cost for communication technology adoption and the investigation tries to identify ways through which lower communication costs can simultaneously affect internal organization (in terms of management) and locational decisions.

of traditional communication services witnessed in the past decades allow firms with flexible managerial structure to spread their production.

Assume that there is only one firm formed by two units: the headquarters (HQ) and the manufacturing plant (MP). Two individuals work in this firm: the owner who resides in the HQ, and the controller who manages the production and lives at the MP. The HQ is placed at the central point of the world surrounded by infinite peripheral points. The distance between any peripheral point and the central one is the same.

The decision process can be seen as a game with (at most) four periods. In the first period, the owner decides who will have the formal authority and the location of the MP. In the second period, a problem in the MP arises and each one makes a decision about her/his own level of extra-effort that would be required in order to learn about the problem and then, they learn either everything or nothing. Next, after the learning process, the individual who has the formal authority that is defined in period 1 plays in the third period. Assume that the owner (controller) has the formal authority. If she has learnt everything in period 2, she chooses the solution and the decision is made (in this case, there will not be the fourth period). Otherwise, the owner (controller) gives the controller (owner) the *real* authority, i.e., the right to choose the solution. Thus, in the last period, the controller (owner) will not choose any solution only if he or she has not learnt anything in period 2. In this case, the outcome will be zero for both. Otherwise, if the controller (owner) knows everything about the problem, the owner (controller) will rubber-stamp the controller's (owner's) decision.[5]

In Aghion and Tirole (1997), the outcome cannot be contracted ex ante and the relationship is established by an incomplete contract. The formal authority defines the part that has the final decision, which is crucial in the case when both parts learn everything about the project. As the authors state, their approach is based on Grossman and Hart (1986), who propose (and formalize) the concept of residual right: the ownership of the assets guarantees the residual right of control, i.e., the owner of the assets has the power of deciding under unexpected circumstances.[6] In the present paper, when the owner delegates the decision to the controller she gives him the residual right. In this sense, the definition of formal authority (and delegation) might have a much broader meaning. However, instead of defining whether delegating the decision to the controller is the same as giving assets to him—which would drive the model to other questions such as the required investments to own those assets—this work simply considers that the delegation scheme indicates a more or less integrated organization.[7] Nonetheless, the lack of a clear specification about the boundaries of the firm is a limitation of the model.

As noted, the central point is assumed to be the best location for the owner, but this may not necessarily be the case for the manufacturing plant. The choice of placing the

[5] Note that, in this model, both tell the other the truth in the case when they learn nothing. It happens because it is assumed that the expected return of the partner's choice is never lower than a random choice.

[6] "Vertical integration is the purchase of the assets of a supplier (or of a purchaser) for the purpose of acquiring the residual rights of control" (Grossman and Hart 1986, p. 716).

[7] Gereffi et al. (2005) consider five governance types with different degrees of explicit coordination and Grossman and Hart (1986) "do not distinguish between ownership and control and virtually define ownership as the power to exercise control" (p. 693–694).

manufacturing plant far away from the owner brings advantages and disadvantages to the firm. The only sure advantage of having the manufacturing plant close to the owner has to do with the efficiency of communication between the owner and the controller. Therefore, in other words, the disadvantage of placing the plant far from the owner is that communication is less efficient or one could consider this to imply that the cost of implementing an efficient communication system is higher.

There is a crucial aspect of the model that should be understood. The owner is seen as a receptor of information coming from the manufacturing plant (not only from the controller). The owner learns from that information and, therefore, any problem of efficiency of communication between the owner and the manufacturing plant will hurt her understanding. Therefore, even when the controller and the owner are far from each other, the controller does not have any additional cost to learn about the problem because he controls the production process in loco. As a consequence, no effort of the owner means there is no communication between her and the controller. In that case, the controller will have the real authority.

The question, now, could be why should the manufacturing plant be located far away if this does not seem to be desirable for the owner? As we have seen in the first section, some reasons can be advanced to explain why firms implement the multi-locational system. The differences in prices of factors across locations are examples of those reasons. Here, we assume those advantages do exist; however, we do not investigate which ones they are for a particular firm. Instead, in an imaginary process, we take all the possible reasons into account and rank the cities (infinite cities in the continuous case) according to their appropriateness for the placement of the manufacturing plant. We can normalize this index, assuming that the "appropriateness" of locating the plant in the city of the owner is zero. Since the distance between the central point where the owner is located and any other point is the same, the decision turns out to be either keeping the manufacturing plant at the central point where there will be the highest efficiency in communication but at the cost of giving up the chance of choosing the best place for the manufacturing plant, or placing it in the city that presents the highest index at some cost in terms of the efficiency of communication.[8]

Thus, the owner deals with two trade-offs: Placing the manufacturing plant far from the owner entails, on one hand, a high cost of controlling the process of production and, on the other hand, gains in terms of locational advantages (e.g., lower wages and/or costs). The delegation of power increases the incentive of the controller; however, the owner has less control over the outcome. Showing how these trade-offs interact with each other is the main propose of the next section and the core of the present paper.

It is important to stress that the location decision of a firm involves many complex aspects, and the model does not analyze each one separately. To simplify the problem, all economic features of a given location (the qualification of its labor force, its tax system, the distance from the market and inputs, etc) are exogenously determined and

[8] Since there are infinite possible locations for the manufacturing plant, we assume that there is at least one place in which the locational advantage (v) for the manufacturing plant of that particular firm is greater than the location advantage (v) of the place where the headquarter is located. Note that the locational advantage of the city j (v_j) is independent of the location of the headquarter. v_j represents all variables that are specific for location j, such as wage, land price, and local taxes. The fact that the headquarter is (or is not) in j will be relevant only to determine t (internal cost of communication)

summarized in a variable (v). This simplification allows the model to focus on the interdependence between the decisions regarding managerial (de)centralization and spatial fragmentation, also considering the influence of communication costs on these decisions.

Initially the owner chooses one of the following alternatives: no delegation and single-located firm (ns); no delegation and multi-located firm (nm); delegation and single-located firm (ds); and delegation and multi-located firm (dm). Thereafter, the owner and the controller will have to choose solutions for problems that occur in the MP. Most procedures undertaken in the MP are simple and do not create room for divergence of interests. However, from time to time, a problem may occur and, at this moment, the process of seeking a solution starts.

Even though, as in a typical principal-agent problem, they do not perfectly see each other's effort, when the owner decides the delegation scheme she has no idea about what kind of problems they will face and much less possible solutions for them. That is why a menu of incentive compensations cannot be included into the incomplete contract established between the owner and her controller.

Depending on the owner's decision about the formal authority, her utility function can be represented as follows:

$$U_n = E_n B + (1 - E_n) e_n \alpha B + \ln(1 - t E_n) + v \tag{1}$$

$$U_d = e_d \alpha B + (1 - e_d) E_d B + \ln(1 - t E_d) + v \tag{2}$$

If the manufacturing plant is located far from the owner, part of the effort undertaken by the owner is lost in the process and, then, t is greater than one in (1) and (2). Otherwise, t is equal to one and there is no loss of efficiency. v represents the gain of having chosen the best city to place the manufacturing plant, i.e., the locational advantage without considering the effects of the loss of effort. Therefore, v will be positive if owner and controller are in different places and zero otherwise.

e represents both the *extra* effort of the controller, which is used exclusively to find a solution for the problem, and the probability that he learns about it, whereas tE is the *extra* effort of the owner and E is the probability that she learns. They will be coincident for $t = 1$.

The payoff of the owner is B when the best solution is chosen according to her preferences and αB when the controller chooses the solution. Therefore, α measures the divergence between the interests of the owner and the decisions of the controller, from the owner's point of view.[9]

Before determining the best level of effort of each one, it is worth examining in more details the meaning of parameters α and t. The room for the controller to deviate from the owner's interest should be a function of the difficulty of specifying in a contract the expected outcome of the procedures of the controller's tasks. It means

[9] To make both the return of the problem solution and the locational advantage compatible in terms of time period, it is assumed that B represents the return in present value of finding the best solution for all problems that will occur after the location and delegation decisions. Alternatively, Eqs. (1) and (2) could correspond to a single problem and the locational advantage would be related to the amount gained in a period that, on average, the owner expects to face in a new (and single) problem.

that the controller can deviate from the owner's interest as long as the latter cannot clearly evaluate the controller's performance. Following Gereffi et al. (2005)'s nomenclature, low α would mean at least one of the following conditions: high complexity of information involved in the relationship; high difficulty to codify transactions; or low capabilities of the parts to understand the right procedure to undertake the task. It typically happens to those activities at the ends of 'the smile of value creation' proposed by Mudambi (2007, 2008) : planning, design, R&D, marketing, etc.

Gereffi et al. (2005) classify the transactions between the corporation and its suppliers in five levels according to the degree of integration. The three conditions that would determine a high α in our framework will also define the most integrated partnership in their analysis, while the opposite conditions (low α) will define the less integrated relationship. The model here reaches and formalizes parallel conclusions.

Regarding the communication cost (t), it is important to note that the rapid development of information technology has a relevant impact on the operations of a company. Earle et al. (2006) analyze its effects in terms of (des)centralization of decisions, emphasizing that improvements in information technology can, on the one hand, facilitate monitoring (GPS monitoring a remote truck) and, on the other hand, increase the complexity of a subordinate's tasks (a copy maker that uses now a integrated and computational system), which makes problems and procedures less predictable. In this paper, as mentioned above, both cases—remote control to evaluate the controller's performance and the complexity of the procedures—are incorporated in α. Here, communication costs (t) represent only the communication between headquarter and manufacturing plant that facilitates the owner's understanding about the problem to be solved in the manufacturing plant.

Note that in Eq. (1), EB is the probability of identifying the best project multiplied by the payoff that this project yields to the owner. The effect of delegation on the owner's payoff can be seen in Eq. (3). $(1 - e)$ precedes EB, which means that the choice of the owner will be undertaken only if the controller does not learn anything. Otherwise, the controller will choose the solution and this is represented by the first term of the equation.

From (1) and (2), we derive the level of effort carried out by the owner under both formal authority schemes:

$$E_n = \frac{B(1 - e_n\alpha) - t}{B(1 - e_n\alpha)t} \tag{3}$$

$$E_d = \frac{B(1 - e_d) - t}{B(1 - e_d)t} \tag{4}$$

As the actual effort of the owner is tE, Eqs. (3) and (4) show that lower efficiency in communication mean lower effort. When communication is inefficient, the owner carries out less effort than she does under perfect communication. Thus, the probability that the owner learns about the problems when MP and HQ are in different places is smaller for two reasons: the communication is imperfect and, as a consequence of that, she carries out less effort.

Regarding the agent's utility function, it is defined in the same fashion:

$$u_n = E_n \beta b + (1 - E_n) e_n b + \ln(1 - e_n) \tag{5}$$

$$u_d = e_d b + (1 - e_d) E_d \beta b + \ln(1 - e_d) \tag{6}$$

Of course, there is neither locational advantage nor communication costs for the controller. However, here an additional assumption is made. The expected return for the controller is b when he can make the final decision and zero when the owner does it, i.e., parameter β is equal to zero. This assumption will be important to simplify the model's results and it means that the owner's choice is not better than a random choice for the controller, whose expected utility is normalized in zero.

The optimum level of effort will be

$$e_n = 1 - \frac{1}{(1 - E_n) b} \tag{7}$$

$$e_d = 1 - \frac{1}{b} \tag{8}$$

The effort of both the owner and the controller will be defined by Eqs. (3), (4), (7), and (8) as long as they are positive. Otherwise the effort will be zero.

3 Results

The main result of this work can be stated as follows:

Proposition 1 *Let λ be a small number. Then there exist a set of parameters $\{B^*, b^*, v^*, \alpha^*, t^*\}$, where all parameters are non-negative, $\alpha^* \leq 1$, and $t^* \geq 1$, to which the best strategy of firm goes from ns (no delegation and single location) arrangement to dm (delegation and multi-location) arrangement, as communication costs decreases from $t^* + \lambda$ to $t^* - \lambda$.*

The proof of *existence* is straightforward: assume the parameters take on the following values:

$$B = 6;$$
$$b = 2;$$
$$v = 0,5;$$
$$\alpha = 0,75.$$

Then, $t^* = 1{,}314$ satisfies all conditions required to be a solution for proposition (1) as will be seen.

Inserting Eq. (7) in Eq. (4) the owner's effort under delegation can be found:

$$E_d = \frac{B - tb}{tB} > 0 \tag{9}$$

It easy to check that as long as condition (10) is satisfied

$$1 < b < \frac{Bt}{tB - B + t} \tag{10}$$

The controller's effort will be positive under delegation scheme (see Eq. 7) and zero under non-delegation arrangement. Manipulating Eqs. (3) and (7) shows us that the equilibrium will be

$$E_n = \frac{B - t}{tB} \tag{11}$$

$$e_n = 0 \tag{12}$$

Adding condition (13), the owner's effort will be always positive (see Eq. 9).

$$B > tb \tag{13}$$

Considering conditions (10) and (13) as, respectively, assumptions (1) and (2), the derivatives of utility functions with respect to cost communication can be defined for all arrangements:

$$\frac{\partial U_{\text{ns}}}{\partial t} = \frac{\partial U_{\text{ds}}}{\partial t} = 0 \tag{14}$$

$$\frac{\partial U_{\text{dm}}}{\partial t} < 0 \tag{15}$$

$$\frac{\partial U_{\text{nm}}}{\partial t} < 0 \tag{16}$$

Therefore, considering assumptions (1) and (2), a given set of parameters $\{B^*, b^*, v^*, \alpha^*, t^*\}$ will be a solution for *Proposition 1* as long as it satisfies these additional conditions:

$$U_{\text{ns}}(B^*, b^*, v^*, \alpha^*) > U_{\text{ds}}(B^*, b^*, v^*, \alpha^*) \tag{17}$$

$$U_{\text{dm}}(B^*, b^*, v^*, \alpha^*, t^*) > U_{\text{nm}}(B^*, b^*, v^*, \alpha^*, t^*) \tag{18}$$

$$U_{\text{dm}}(B^*, b^*, v^*, \alpha^*, t^*) = U_{\text{ns}}(B^*, b^*, v^*, \alpha^*) \tag{19}$$

Taking those values suggested above, the utilities for different arrangements will be

$$U_{\text{nm}} = 2{,}548$$

$$U_{\text{ns}} = 3{,}208$$

$$U_{\text{ds}} = 3{,}151$$

$$U_{\text{dm}} = 3{,}208$$

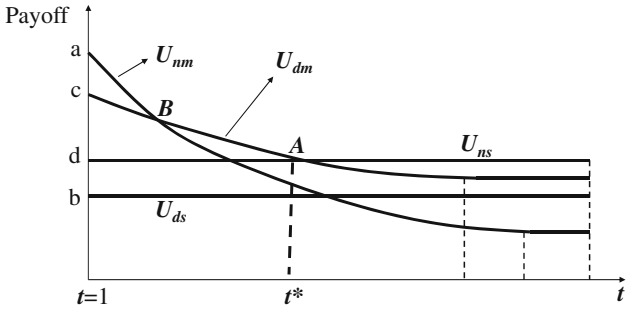

Fig. 1 Pay-off for different arrangements

Figure 1 illustrates this case and shows the pay-off of the owner for different arrangements. These pay-offs are determined by the interaction between the efforts of the owner and the controller as shown in Eqs. (3), (4), (7), and (8). Even though both individuals participate in the game in each case, the owner is the one who decides which arrangement to choose.

The horizontal axis shows the value of t. When t is equal to one there is no inefficiency of communication. It can be seen that transition from ns to dm occurs for $t = t^*$ (point A). It means that when communication costs decline from $(t^* + \lambda)$ to $(t^* - \lambda)$, where$\lambda$is a small number, the firm should change both aspects simultaneously.

Of course, this transaction will not happen whenever either w or α is too low. As $v(\alpha)$ goes to zero, a multi-located firm (delegating power) tends to be undesirable. In contrast, when $v(\alpha)$ is too high, a multi-located firm (delegating power) will be always adopted. Those limits are investigated subsequently. Finally, note also that $\overline{da} = \overline{bc} = v$.

It is possible to investigate the limits of some parameters so that the transition from ns to dm arrangement may happen. Condition (17) establishes an upper limit to α:

$$\alpha < 1 + \ln(1/b)\frac{b}{B(b-1)} \tag{20}$$

If inequality (20) does not hold, the firm will be always better off by choosing the ds strategy, rather than the ns strategy; in other words, if the controller does not deviate too much from the owner's interest, there is no reason to centralize the final decision.

Similarly, condition (18) can be translated into condition (21):

$$v < \frac{B(t^* - 1)}{t^*} + \ln(1/t^*) \tag{21}$$

If it is not satisfied, the pay-off of the nm strategy will be higher than the one defined by the intersection between U_{ns} and U_{dm} curves. In Fig. 1, in case condition (21) does not hold, the U_{nm} curve will cross U_{dm} curve for a value of t greater than t^*. In other words, condition (21) shows that if the locational advantage is too high, the owner fragments the company even for a higher t and never delegates the decision. Therefore, the transaction from nd to dm never happens.

Finally, it is possible to verify the effects of a change of either v or α in t^*. Totally differentiating $f(t^*, i^*) = U_{\text{dm}}(t^*, i^*) - U_{\text{ns}}(t^*, i^*)$, where i is either α or v, the following is obtained:

$$\frac{dt}{dv} = \frac{bt^2}{B - bt} \tag{22}$$

$$\frac{dt}{d\alpha} = \frac{Bt^2(b-1)}{B - bt} \tag{23}$$

The impact of a change in either v or α in t^* is positive; thus one should expect that the production fragmentation of firms and sectors that face higher v and/or higher α will happen sooner.

The efficiency of communication has been considered as an exogenous parameter. However, an additional assumption could allow the controller to select the information sent to the owner whenever the production is spatially fragmented. In the model's framework, it means that the controller can raise t, according to the controller's interests.

The important result coming from this additional assumption is that, once the firm adopts dm strategy, the controller will be able to keep the formal authority forever. The controller can do that by increasing t when necessary so that the next transaction (from dm to nm, represented by point B in Fig. 1) never happens.[10]

As both the controller's utility does not depend on t and the owner's choice is not better than a random choice for the controller ($\beta = 0$), it is straightforward to see that the utility of the controller is, *ceteris paribus*, always higher under delegation than under no delegation (Eqs. 5 and 6).

Therefore, under the additional assumption, the combination of fragmenting the production process and giving more autonomy to the subsidiary has irreversible consequences.[11] In this case, the controller will have more room to act strategically and his power will come not only from the formal authority, but also from the possibility of increasing the informational asymmetry in the learning process, which is crucial for the owner's decision about the delegation scheme.

It is worth saying that, even with this additional assumption, the present framework is far from providing a model that accounts for all aspects of the intra-MNC competition; rather this extension tries to recognize and consider the importance of information flows between operation units and its consequence for the behavior of the subsidiary's managers. New advances in modeling the strategic behavior within MNC are still needed.

[10] Note that the additional assumption does not change the main result of the model: the controller has no interest in avoiding the transition from the ns to dm scheme (Point A in Fig. 1).

[11] Fragmenting the production and delegating the final decision are necessary to obtain this result. Suppose that the firm fragments the production without delegating the final decision to the controller because α is too high. In this case, the controller does not have an incentive to raise t.

4 Discussion and conclusion

The first result of the paper—and most important one—reveals that delegating the decision is often a condition for the firm to benefit from locational advantages through the fragmentation of its production. In the Jones and Kierzkowski framework, the fragmentation process happens especially among countries in which each economy produces only part of the final good thus increasing the international trade of inputs. One of the important extensions of the present model would be to cases in which the MP was further fragmented into a series of components allocated to production in plants that may be extensively geographically separated (e.g., the production value chains for the Airbus 380 and the Boeing 787). The coordination decisions then would involve multiple locations but, equally importantly, there would be further complications from the critical sequencing in the production process.

Moreover, there are some recent empirical studies that, instead of examining a specific case, have empirically investigated the headquarter-subsidiary relations in some industries, considering their implications for the locational decision of the firm.

As mentioned, a high degree of standardization of operations means, in the framework presented, high α, which, in turn, tends to generate spatial fragmentation and the autonomy of the manufacturing plant. This result fits very well in the case studies presented in Constantin et al. (2010). The authors justify the migration of some activities of the woodworking-furniture and footwear industries in Europe saying that, "the high degree of standardization of operations, the specific kind of technologies used, and the way the process is organized, allow for the slicing of the production chain into relatively autonomous operations which do not require spatial contiguity" (p. 830). To the extent of this paper literature review, there is no theoretical model that shows the interdependence of locational and managerial choices, which may change with the communication costs reduction.

Of particular importance for the propose here is the work by Arita and McCann (2002) that analyzes the electronics and semiconductor industry and tries to link the internal structure of the American and Japanese firms with the location of their assembly plants. According to the authors (p. 360), "the Japanese organizational arrangements are constructed within a strict hierarchical system with very little individual autonomy, whereas US firms have a greater degree of decision-making latitude." Under this assumption, which can be understood as an additional cost for Japanese managers to delegate power, the model proposed here would predict that there would be a tendency for the Japanese plants to be located closer to headquarters, whereas American plants would be more aggressive in placing their plants where the locational advantage appears to be higher. Arita and McCann (2002) comment that "(…) the US firms are much more spatially differentiated and internationally integrated than the Japanese firms, in the sense that the activities are distributed more widely according to both location and activity types" (p. 359). Studying the US and Japanese automobile industry, Sheard (1983) found the same results in terms of spatial organization.

The framework incorporates some aspects that should be taken in consideration when multinationals (regional) decide their strategies in terms of location. As a consequence of greater autonomy of units located far from the HQ, less developed regions

that want to expand their industrial sectors via attraction of manufacturing plants should be concerned not only about investment in infrastructure or in incentives programs given directly to industrial corporations (e.g. tax abatements), but also about investment in human capital formation. In the model, a region improving the skills of its labor force would favor the attraction of high value-added activities because high-skilled people have more technical knowledge, which allows them to better specify targets and procedures in the contract, increasing α.

Finally, as mentioned, there are some studies that have empirically identified the positive relation between geographic dispersion and decentralization of decision-making. This relation seems to be quite intuitive. In contrast, the present paper tries to offer a formalization of this phenomenon, incorporating the role of communication costs in this process.

The second conclusion of this work suggests that the rapid development of communication tools, such as the internet, that has occurred in the last decades has provided firms with new alternatives to benefit from more dispersed location decisions. When managers can coordinate the production from anywhere, and firms are not seen as maximizing black-boxes, what happens is that firms can take advantages by placing each establishment and department where they benefit most from relatively immobile resources and markets.

In the model, the fragmentation depends on managerial aspects, but it happens as a consequence of lower communication costs. The creation and use of the Internet is a good example of increasing the efficiency of long-distance communication, even though it is still less efficient than negotiations between departments located side-by-side that facilitate face-to-face communications. Jones and Kierzkowski (2003) point out that some profound productivity improvements in service links have been witnessed in the past decades. Moreover, they note that "the changes in communication costs have probably been the most significant in lowering the service costs required to co-ordinate spatially separated production fragments" (p. 16). Kolko and Neumark (2008) study business establishments in California and establishments anywhere in the United States that are owned by firms headquartered in California and find an increasing geographic dispersion of firms' operations, especially in industries with lower communication costs, an outcome that is predicted by the present model.

As mentioned throughout the text, this second result is not a quite new result: empirical and theoretical works have shown that lower communication costs facilitate the process of fragmentation. However, the model proposed here shows the interdependence between location and managerial decisions and how lower communication costs may lead firms to different combination of those choices. Moreover, comparing activities within a production chain or the activities of different industries, the model formalizes the findings that firms have more freedom in choosing the location of standardized operations, since it is easier to evaluate the outcome of these activities.

Possible extensions, besides the one already mentioned, would be to allow firms to outsource part of its activities. The decision of delegating the final word to the controller could be more broadly defined in order to determine the ownership structures endogenously. Moreover, the extended model could consider the strategic decisions of the firm faced with falling communications costs and a wider variety of feasible locations to do business. This would enable the firm to disaggregate its value chain

to lower costs and/or to re-aggregate its value chain in novel ways to create more differentiation.

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