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LOCATION, COMMUNICATION, AND CONTROL
WITHIN A VERTICALLY INTEGRATED FIRM

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Location, Communication, and Control Within a Vertically Integrated Firm

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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 firms. In the model that focuses on the relationship among agents within the firms, the owner of the firm makes two decisions: who will have the formal authority (the owner or the controller) and where the manufacturing plant will be located (near or far from the owner). The results show that those two decisions are interdependent. More than that, for certain parameters, the corporation goes from the second best to the first best only if it changes the decision about both aspects; changing just either the delegation scheme or location may drive it to an inferior outcome. In these cases, a flexible managerial structure turns out to be a necessary condition for firms to benefit from locational advantages. The positive correlation between the decentralization of decision-making and geographic decentralization predicted by the model is supported by empirical research. Finally the recent headquarter location decision by the Boeing company is used to illustrate the results obtained.

1. Introduction

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 since each country is seen as a single point.

In a seminal paper, Helpman (1984) constructs a model of monopolistic competition with two countries, two factors, and two sectors – one produces homogeneous goods and the other produces differentiated goods. He assumes that the differentiated good is produced by two processes: one uses only unskilled labor (manufacturing plant) and the other uses only skilled labor (headquarter). Moreover, they can be placed in different countries. One of the interesting findings is that, analogous to the results in Heckscher-Ohlin models, the region of factor price

equalization is enlarged. It happens because the world can now be seen as an economy that produces three products: homogeneous goods, parts of differentiated goods with unskilled labor, and parts of differentiated goods with skilled labor. Thus, the specialization can be even more intensive when the headquarters are concentrated in the country with an abundance of skilled labor.¹ In Helpman's model, the firms' decisions are driven by differences in wages. Recent papers have shown evidence that the trade of inputs has substantially increased around the world over the last few decades, a result of the increase of trade within and between firms. Therefore outsourcing and intra-firm trade 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.

Grossman and Helpman (2004), Antras and Helpman (2004), and Antras (2003) among others have used incomplete contracting to model the decision of firms about not only their location but also the ownership structure. Therefore, those papers, with the exception of Helpman (1984), go beyond what we propose here. The present paper takes as given the fact that the whole production process takes place within the boundaries of a single firm. At first sight, this restriction could be seen as a weakness of the model; however what is claimed here is exactly the contrary. Even when the ownership structure is not under discussion (as in the case of Boeing's recent decision), incomplete contracts established among individuals of a given firm remain important in determining the optimal location strategy. Incomplete contracting provides an appropriate framework to model ownership structures. The idea here is to go one step back and, by using the methodology of recent papers, incomplete contracting, address the issue studied by Helpman (1984): how do vertically integrated firms decide their manufacturing plant location? Of course, the aim of this paper is to add one more element (internal organization of firms) to the debate about vertical multinationals, rather than substituting any aspect previously identified. While Helpman's model focuses on differences in factor prices, in this work the variable labeled "locational advantage" will stand for any enhancing feature of a given region (distance from inputs and markets, wages, etc).

The model, drawing on Aghion and Tirole (1997), is based on an information structure among individuals of a firm. The information is essential for them and the spatial aspects, which are the focus here, can introduce inefficiency into the channels of communication. Grossman and Helpman (2004), Antras and Helpman (2004), and Antras (2003) do not take the cost of

¹ See Feenstra (2004) for references on papers that point out other locational advantages besides wage differences.

interaction (those of communication, controlling, or transaction) into account as the theory of firm traditionally has done.² Therefore, this become a secondary objective of the present paper: preparing a framework that, one day enlarged and adopted, can be used to answer questions related not only to location but also to ownership arrangements.

Usually, models for regional economics allow all factors to move across regions³ that, in turn, tend to reduce the locational advantages within a country. This may explain why the literature on regional economics neglects the existence of multi-located firms and the importance that their location decisions might have in boosting the economic development of a given undeveloped regions. Fujita and Krugman (1995) provide exceptions; even though they do not include multi-located firms in their analysis about the economic transition from a mono-centric economy to a multi-centric economy, they suggest the inclusion as an interesting extension of their model. They comment: “(...) suppose that each firm consists of multiple units (e.g. HQs, R&D units, and manufacturing plants) which can be located separately. Then, since different units will follow different agglomeration forces (e.g. availability of business services and convenience of face-to-face communication for HQs), we will be able to develop a richer class of spatial models” (p.524).

In the present model, there is only one firm formed by two units: the headquarters (HQ) and the manufacturing plant. Two individuals work in this firm: the owner (also called as superior or principal throughout the paper) who resides in the HQ, and the controller (subordinate or agent) who manages the production and lives at the manufacturing plant. 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 constant. The manufacturing plant can be located either at the central point near by the HQ or at the peripheral point where the locational advantage for manufacturing plant is the highest one.

The owner and the controller have only one task: they have to decide the best project among n alternatives. This decision process starts after the owner of the firm decides two things: who will have the formal authority (the owner or the controller) and where the manufacturing plant will be placed (near or far from the corporation's headquarters). The definition of formal

² Even though Coase (1937) argues that “there is a cost of using the price mechanism” (p.390) and within a firm they are greatly reduced, he says also that the cost of negotiating contracts is still present in the firm. The analysis of transaction cost is the central part of his arguments. Regarding the needs of examining the relationship within the firm, see Simon (1991).

³ See Fujita et al. (1999) and Fujita and Thisse (2002)

authority will be better understood in the next section where the decision-making mechanism is explained in more detail, but for now it can be understood as the right to have the final decision about which project will be chosen. 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 or and costs). The delegation of power increases the incentive of the controller; however the owner has less control over the outcome.

The results will reveal that the 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 can experience the worst outcome.

In discussion and conclusion, the Boeing company's recent headquarter location decision is analyzed and it is claimed that it is a good case study where delegation and location decisions work complementarily. Moreover, the findings of recent empirical works, especially those present in Arita and McCann (2002), are compared to the predictions of the model exposed in the next sections.

In section 2, the model by Aghion and Tirole is presented. Thereafter, some adaptations and spatial aspects are introduced to adjust the model to the purpose of the paper. Section 3 introduces the model itself. In Section 4, an illustration is provided that anticipates the general results that are presented in Section 5. Discussion and conclusions are shown in section 6.

2. The Basic Model and New Developments

Formal and real authority- Following Aghion and Tirole (1997), the model analyzes the interaction between a superior (principal) and a subordinate (agent) under a particular circumstance: they have n possible projects in hand and must decide which one will be

undertaken. Both agent and principal will invest some effort to learn about the project. Each one can learn either everything or nothing about it. The probability of understanding everything regarding the project is the amount of effort, which varies between zero and one. The principal can delegate the decision to the agent, thus transferring, the *formal* authority to the agent. Otherwise, the principal keeps the formal authority with her.⁴ Here, it is important to understand in more detail what *formal* authority and *real* authority mean in this model.

The decision process can be seen as a game with (at most) four periods. In the first period, as mentioned above, the principal makes two decisions: who will have the formal authority and where the manufacturing plant will be placed. In the second period, each one decides her own level of effort to be made in order to learn about the projects 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 player *X* has the formal authority. If player *X* has learnt everything in period 2, she chooses the project and the decision is made (in this case, there will not be the fourth period). Otherwise, player *X* gives player *Y* the *real* authority, i.e., the right to choose the project. Thus, in the last period, player *Y* will not choose any project only if he or she has not learnt anything in period 2. In this case, the outcome will be zero for both players. Otherwise if player *Y* knows everything about the projects, player *X* will rubber-stamp player *Y*'s decision.

Note that, in this model, both players tell the other the truth when they learn nothing. It happens because the authors assume that there is a project with a very negative expected payoff; this will make the expected outcome of choosing a project without knowing anything about it negative.

Finally, there is some divergence between the interests of the principal and the agent. If the principal chooses the project, her payoff is *B*, but when the agent makes the final decision, the principal's expected payoff will be a fraction of *B*. The reverse is true: the agent's expected payoff is lower for the case in which the principal decides.

The original model can be represented by the next four equations. Equations (1) and (2) represent, respectively, the utility of the principal and the agent under no delegation, i.e., when

⁴ A contract defines who owns the formal authority. The residual rights – whose definition can be found in Grossman and Hart (1986) – are determined via allocation of formal authority. The formal authority can be seen as the assets in the relationship. The party that has the formal authority can decide under unexpected circumstances. Regarding the relationship between ownership of assets and incentives, Hart and Moore (1990) provide a very didactic example on page 1122.

the formal authority belongs to the principal. Equations (3) and (4) present the utilities under delegation. Interpreting equation (1) will assist in making all the other equations clear.

E and e represent the principal and agent's efforts, respectively. The payoff of the principal is B when the best project is chosen according to her preferences and αB when the agent chooses the project. $g(E)$ measures the cost of effort made to understand the project and it is a convex function. The marginal cost is zero when effort is zero and it is infinite when the effort is one.

$$u_p = EB + (1-E)e\alpha B - g_p(E) \quad (1)$$

$$u_a = E\beta b + (1-E)eb - g_a(e) \quad (2)$$

$$u_p^d = e\alpha B + (1-e)EB - g_p(E) \quad (3)$$

$$u_a^d = eb + (1-e)E\beta b - g_a(e) \quad (4)$$

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

Adaptations and spatial aspects – As mentioned in the introduction, the owner and the subordinate form the firm. We can think of the subordinate as the controller of a manufacturing plant. The controller and the plant are always located in the same place, whereas the owner is in the HQ, i.e., at the central point. Additionally, given the decisions regarding delegation and location, the owner chooses the level of effort for the task of learning about the project. The story takes place in a world with a central point where the owner of the firm is located encircled by infinite points. The distance between any peripheral point and the central one is the same. Each point might represent a particular city.

In Aghion and Tirole's (1997) model, the agent decides the effort based not only on the formal authority arrangement, but also on the effort expended by the principal. The model that will be presented here does not take the second aspect into account. The assumption behind this simplification is that the controller does not know how much effort the owner is carrying out. Thus, the utility function of the agent will not be considered in this model. Nonetheless, although the agent's maximization problem is not presented explicitly, it is assumed that she

responds to the formal authority scheme defined. Instead of determining the amount of effort of the agents by solving their maximization problems, it will be exogenously determined for each formal authority scheme. Appendix A provides some arguments to justify this simplification.

A distinction between the present model and the one constructed by Aghion and Tirole (1997) is that, now, the principal is the owner of the firm and the analyses will be focused on her utility function. Thus, the utility function of the principal is composed by the monetary return of the projects and the cost of effort carried out by her.

As mentioned, the choice of placing the manufacturing plant far away from the owner brings advantages and disadvantages to the firm. We assume that the central point is the best location for the owner, but this may not necessarily be the case for the manufacturing plant. 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.

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. Jones and Kierzkowski (2003) point out that some profound productivity improvements in service links have been witnessed in the last decades. Moreover, they say 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).

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. The owner learns from that information and, therefore, any problem of efficiency of communication will hurt her understanding. Moreover, the only effort involved in this communication is the owner's. The controller does not need any communication to learn about and evaluate the projects since the project is related to the manufacturing plant controlled by him *in loco*. 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 project because the source of information is always close to him.⁵ 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.⁶ We can normalize this index, assuming that the “appropriateness” of locating the plant in the city of the owner is zero.

As noted earlier, there is no special reason to believe that the city of the owner presents more competitive advantages than any other in terms of those elements analyzed here. Thus, one should expect to have some cities with positive and others with negative indices. 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. This is the basic trade-off for the owner in terms of location choice. Showing how this trade-off interacts with the delegation decision is the main propose of the next section and the core of the present paper.

3 The Model

Depending on owner’s decision about the formal authority, her utility function can be represented as follows:⁷

⁵ Although the owner needs information that comes from the manufacturing plant, there is no correlation between the learning processes of the owner and the controller. We can justify this fact by assuming that, first, both need objective information to learn but they interpret it by themselves, separately. Second, the owner can communicate to any worker and, thus, the controller cannot limit the owner’s knowledge.

⁶ Note that the (des)advantage in terms of internal communication is not taken into account here. This aspect will be treated separately following what was said in the paragraph above. The criterion of the rank takes in consideration the “traditional” reasons for vertical multinational.

⁷ w does not depend on E since it can be seen as, for example, the difference in controllers’ wages.

$$u_n = E_n B + (1 - E_n) e_n \alpha B + \sigma \ln(1 - t E_n) + w \quad (5)$$

$$u_d = e_d \alpha B + (1 - e_d) E_d B + \sigma \ln(1 - t E_d) + w \quad (6)$$

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. Otherwise, t is equal to one and there is no loss of efficiency. w represents the gain of having chosen the best city to place the manufacturing plant without considering the effects of the loss of effort. Therefore, w will be positive if owner and controller are in different places and zero otherwise. In Equations (5) and (6), σ has a positive value and can be seen as a sort of fixed cost of the learning process. It is included in the utility function so that the results can be algebraically simpler.

From (5) and (6), we derive the level of effort carried out by the owner under both formal authority schemes:

$$E_n = \frac{B(1 - e_n \alpha) - t\sigma}{B(1 - e_n \alpha)t} \quad (7)$$

$$E_d = \frac{B(1 - e_d) - t\sigma}{B(1 - e_d)t} \quad (8)$$

where $t = 1$ if the manufacturing plant and owner are located at the same city and $t > 1$ otherwise.

The next step is to check which arrangement will be chosen by the owner. There are four alternatives: 1) no delegation and single location (ns); 2) no delegation and multi-location (nm); 3) delegation and single location (ds); and 4) delegation and multi-location (dm). First, we will compare the first two. Plugging (7) into (5) yields:

$$u_{ns} = e_n \alpha B + B(1 - e_n \alpha) - \sigma + \sigma \ln \left[\frac{\sigma}{B(1 - e_n \alpha)} \right] \quad (9)$$

$$u_{nm} = e_n \alpha B + \frac{B(1 - e_n \alpha)}{t} - \sigma + \sigma \ln \left[\frac{t\sigma}{B(1 - e_n \alpha)} \right] + w \quad (10)$$

Therefore, the condition that the owner prefers (ns) to (nm), whenever the efforts are positive,⁸ is:

$$u_{ns} - u_{nm} = \frac{(t-1)}{t} B(1 - e_n \alpha) + \sigma \ln(1/t) - w > 0 \quad (11)$$

From (7), it is possible to see that:⁹

⁸ If t is high enough, the effort of the owner of a multi-located firm is going to be zero. As a consequence, the decision turns out to be independent on t .

$$tE_{nm} = \frac{B(1-e_n\alpha) - t\sigma}{B(1-e_n\alpha)} \quad (12)$$

$$E_{ns} = \frac{B(1-e_n\alpha) - \sigma}{B(1-e_n\alpha)} \quad (13)$$

Equations (12) and (13) yield to:

$$E_{ns} > tE_{nm} \quad (14)$$

Therefore, because of the imperfect communication in (nm) , the owner carries out less effort than she does under perfect communication. Thus, the probability of learning about the project is smaller in (nm) for two reasons: the communication is imperfect and, as a consequence of that, she carries out less effort.

Now, we can analyze the condition described in (11). The first term is positive and represents the greater probability of learning under (ns) than under (nm) . The second term, the difference in cost, is negative, since t is greater than one. The reason was already mentioned; the real effort under (ns) is greater than under (nm) . Finally, w is positive and, given the sign, the gain of choosing the best place to locate the manufacturing plant favors alternative (nm) .

It is worth examining closely how the condition (11) responds to variations in t and α . The analysis about α is straightforward. A high α means that the interest of the controller is similar to the owner's interest. Therefore, as α increases, the incentive of the owner to make an effort decreases in both cases – single and multi-location. Thus, the difference in terms of efficiency of communication becomes less important, favoring the multi-located firm.

The effect of t on the condition (11) should be computed taking into account the restriction that does not allow the effort of owner to be negative. The partial derivative shown in (15) is true when the condition (15') is satisfied. Otherwise, the effort of the owner is zero and an increase in t does not affect the firm's outcome.

$$\frac{\partial(u_{ns} - u_{nm})}{\partial t} = -\frac{\partial u_{nm}}{\partial t} = \frac{B(1-e_n\alpha) - t\sigma}{t^2} > 0 \quad (15)$$

if

$$B(1-e_n\alpha) > t\sigma \quad (15')$$

and

⁹ Note first that under “no delegation and multi-location” (equation 12), tE_{nm} is the real effort made by the owner. Moreover, under “no delegation and single location” (equation 13), $t=1$.

$$\frac{\partial(u_{ns} - u_{nm})}{\partial t} = 0 \quad (16)$$

otherwise.

As should be expected, a larger t favors the single-located firm.¹⁰ Again, if the inefficiency of communication is already high enough, the effort of the owner of the multi-located firm is going to be zero. As a result, the increase in t will not have any effect on the locational decision. The intuition is that when the inefficiency of communication is high enough, in a multi-located firm the real authority always belongs to the controller who analyzes the project *in loco*. Since there is no communication between the controller and the owner, the value of t does not matter.

The comparison above does not take into consideration the possibility of delegating formal authority. Now, the idea is the reverse. On the one hand, this assumption will be relaxed, allowing firms to decide their internal structure and, on the other hand, the possibility of locating the manufacturing plant in a different city from the owner's is eliminated. In other words, the idea is to compare the situation (ns) where there is no delegation and a single-located firm and (ds) where there is delegation and a single-located firm.

This new comparison is similar to the one in Aghion and Tirole's (1997) model since the spatial aspect is not taken into account in either case. Nonetheless, in their paper, the cost function is different and, more importantly, they assume that the effort of the controller depends not only on the formal authority scheme, as is the case here, but also on the effort of the owner. They do not show explicitly the solution of the problem and these two differences mentioned make the model algebraically solvable.

Using Equation (8), considering $t = 1$ and $w = 0$, effort under (ds) will be:

$$E_{ds} = \frac{B(1 - e_d) - \sigma}{B(1 - e_d)} \quad (17)$$

Plugging (17) in (8):

¹⁰In more details, initially – keeping everything else constant - as the efficiency of the long-distance communication goes down, the expected pay-off of the project for the owner of a multi-located firm reduces, say, in k units. Then, the owner diminishes her effort, which, in turn, has two consequences: (1) another reduction in her expected pay-off of the project and (2) a reduction in the total cost of effort. The second consequence – reduction in total cost – overcompensate the first. Finally, the net result for the owner of a multi-located firm will be negative, but the loss will be less than k .

$$u_{ds} = e_d \alpha B + (1 - e_d) B - \sigma + \sigma \ln \left[\frac{\sigma}{B(1 - e_d)} \right] \quad (18)$$

So, the last step is to check the difference in terms of utility between the two arrangements, using to that end equations (9) and (18). The comparison yields the condition for the owner to prefer (*ns*) to (*ds*):

$$u_{ns} - u_{ds} = (1 - \alpha) B e_d + \sigma \ln \left(\frac{1 - e_d}{1 - e_n \alpha} \right) > 0 \quad (19)$$

Then, it follows:

$$\frac{\partial (u_{ns} - u_{ds})}{\partial \alpha} = -e_d B + \frac{\sigma e_n}{1 - e_n \alpha} < 0 \quad (20)$$

$$\frac{\partial (u_{ns} - u_{ds})}{\partial e_d} = -\frac{\partial u_{ds}}{\partial e_d} = (1 - \alpha) B - \frac{\sigma}{1 - e_d} \quad (21)$$

As could be expected, equation (20) indicates that when α increases, the interest of the controller is more similar to the owner's and the delegation of formal authority is more likely to be implemented.¹¹

Equation (21) has an ambiguous result. The increase of effort of the controller has two effects: (1) the owner has less control over the decision; and (2) the owner makes less effort and that, in turn, saves costs. We can see that equation (21) may be positive for high e_d and negative for low e_d .¹² Basically, the intuition is that the response of the owner to the changes in e_d takes into account the absolute value of e_d , since they are under delegation. Then, the higher the e_d the less relevant the owner's effort. As a consequence, for large e_d , any increase in e_d generates a strong owner's reaction, a large reduction of effort, which saves costs.

4. Introducing the Results: an Illustration

Following the sequence presented above, imagine a world where the internal structure of the firm is given. In other words, the owner cannot delegate formal authority. The only decision will be about location. Then, the inverse will be explored: the owner can decide about delegation, but there is no possibility of placing the manufacturing plant in any other city. Finally, the third step

¹¹ The proof that the derivative is always negative can be found in Appendix B.

¹² It is clear that if $(1 - \alpha)B < \sigma$, the increase of e_d always favors the situation with delegation of formal authority.

is to allow her to make a decision about both aspects. The parameters are chosen in order to provide the main result of the paper. It might mean a loss of generality, but it will not be claimed here that the location decision is always determined by internal structure; rather, as seen in the introduction, the argument indicates that the internal structure *may* be an important source of dispersion of a given firm.

Assume the following values for the parameters:

$$\sigma = 0.5;$$

$$B = 4;$$

$$w = 0.8;$$

$$e_n = 0.4;$$

$$e_d = 0.6;$$

$$\alpha = 0.75;$$

$$t = 1.8$$

B is equal to 4 in order to guarantee a positive effort. Therefore, w shows that placing the manufacturing plant in another city yields for the firm a gain of 20% of the maximum obtained by it. The effort of the controller ranges from 0.4 to 0.6 when the formal authority is transferred to him. The choice of the controller provides 75% of the total to the owner. The efficiency of communication within a multi-located firm has a loss of around 45% if it is compared to the face-to-face communication, that is, about 45% of the owner's effort are "wasted" through long-distance communication.

In this world, the formal authority is given to the owner. The decision is about whether or not to place the manufacturing plant in another city. As will be revealed below, the parameters favor the single-located alternative.

$$u_{ns} = 2.64 > u_{nm} = 2.49 \tag{22}$$

Since we have several parameters, there are multiple ways to interpret this result. The result shown in (22) might happen because either t is high or w and α are low.

Now compare the two single-located options: with and without delegation of formal authority.

$$u_{ns} = 2.64 > u_{ds} = 2.32 \tag{23}$$

Again, the ns alternative presents better results.

Therefore, at first sight, we could conclude that, given those parameters, single-located and no delegation are more desirable than, respectively, multi-location and delegation. However, if we allow the owner to decide about both aspects, the results are different as shown in (24):

$$u_{ns} = 2.64 < u_{dm} = 2.7 \quad (24)$$

Hence, given these parameters, the best alternative is to place the manufacturing plant far from the owner as long as the owner is allowed to delegate the formal authority to the controller. Otherwise, she will locate the plant close to her.

Table 1: Utilities of the four arrangements for different values of t

T	<i>Non delegation single</i>	<i>Non delegation multi</i>	<i>Delegation single</i>	<i>Delegation multi</i>
3	2.639	2.121	2.318	2.601
2.9	2.639	2.136	2.318	2.603
2.8	2.639	2.153	2.318	2.605
2.7	2.639	2.172	2.318	2.608
2.6	2.639	2.193	2.318	2.612
2.5	2.639	2.217	2.318	2.617
2.4	2.639	2.243	2.318	2.623
2.3	2.639	2.272	2.318	2.631
2.2	2.639	2.306	2.318	2.640
2.1	2.639	2.343	2.318	2.651
2	2.639	2.385	2.318	2.665
1.9	2.639	2.433	2.318	2.681
1.8	2.639	2.488	2.318	2.701
1.7	2.639	2.551	2.318	2.725
1.6	2.639	2.624	2.318	2.753
1.5	2.639	2.708	2.318	2.788
1.4	2.639	2.807	2.318	2.830
1.3	2.639	2.924	2.318	2.880
1.2	2.639	3.063	2.318	2.943
1.1	2.639	3.232	2.318	3.021
1	2.639	3.439	2.318	3.118

Assuming that t is the only parameter that significantly changes over time, table 1 shows the best option for different levels of communication efficiency; it also helps with the understanding of the intuition behind the results of the illustration. Note that single-located firms have constant utility because the value of t does not matter. In addition, for $t = 1$, the difference between utilities under the same delegation scheme is w since there is no inefficiency of communication.

The key point of table 1 is that $u_{dm} > u_{nm}$ for large t . This happens because when the formal authority belongs to the owner, she carries out more effort than under delegation – as revealed in equations (7) and (8) – and, thus, the loss of efficiency has more impact on u_{nm} . Note that under no delegation and for t between 2.2 and 2.5, the gain w of moving the plant to the other city does not offset the loss of efficiency in communication, but the possibility of delegating formal authority combined with the gain w does offset.

5. Results

In this section, the main result will be presented and it will be seen that the interaction between formal authority and location of manufacturing plants always moves in a unique direction as communication costs change, i.e., the possibility of delegating power is never a reason to have a single-located firm. This property does not depend on the parameters. Finally, there is a discussion about the range of the parameters that provides us the special transaction: from non-delegation and single-located to delegation and multi-located arrangement.

Graphically, we can see how each type responds to variations of t . Note first that:

$$\frac{\partial u_{nm}}{\partial t} = -\frac{B(1-e_n\alpha)}{t^2} + \frac{\sigma^2}{t} \quad (25)$$

$$\frac{\partial u_{dm}}{\partial t} = -\frac{B(1-e_d)}{t^2} + \frac{\sigma^2}{t} \quad (26)$$

It easy to check that (25) and (26) will never be positive because the condition for having positive effort is:

$$B(1-e_n\alpha) > t\sigma \quad (25')$$

$$B(1-e_d) > t\sigma \quad (26')$$

Otherwise, (25) and (26) will be zero.

Since σ is less than one, the derivatives will be negative for any positive value of effort and zero otherwise. Note that (25) is greater than (26) in absolute value (25 is more negative than 26). This result happens because under no delegation, the effort is bigger than under delegation and, consequently, a decreasing t has a stronger impact on the no delegation arrangement. Thus, the example presented before can be illustrated in figure 1, where any

development in communication decreases t , therefore, the tendency over time is to go through the graph from the right to the left.

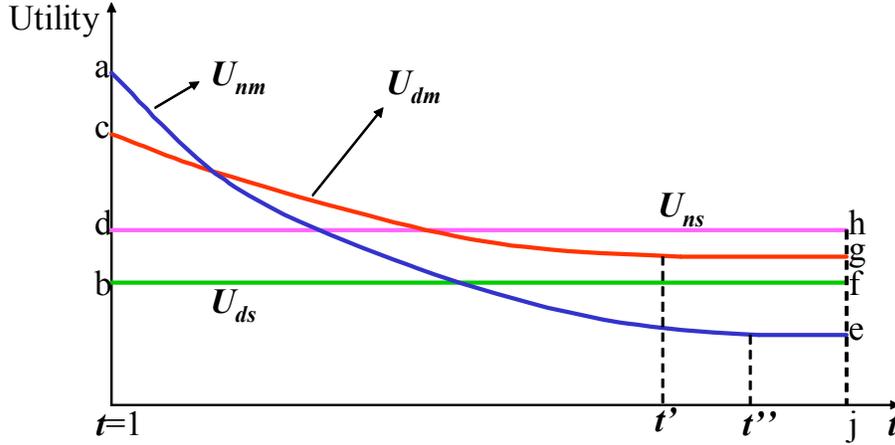


Figure 1: From ns to dm

The horizontal axis shows the value of t . When t is equal to one there is no inefficiency of communication. For $t > t'$, E_{dm} is zero and for $t > t''$, E_{nm} is zero. Note also that:

$$\overline{da} = \overline{bc} = w \quad (27)$$

$$\overline{jg} = B\alpha e_d + w \quad (28)$$

$$\overline{je} = B\alpha e_n + w \quad (29)$$

$$\overline{eg} = B\alpha(e_d - e_n) \quad (30)$$

First, (27) reveals that when there is no inefficiency in communication, multi-located firms are always better off than single-located ones for obvious reasons. It is possible to see in (30) that when t is high enough, delegation is always better than no delegation since the owner's effort is zero in both cases. In that case, the best the owner can do is to provide incentives to the controller to work as much as possible.

Additionally, it can be seen in figure 2 why the reverse never happens. In other words, figure 2 shows that the possibility of delegation never makes the owner of a multi-located firm change to a single-located one. In other words, the transition never goes from (nm) to (ds) .

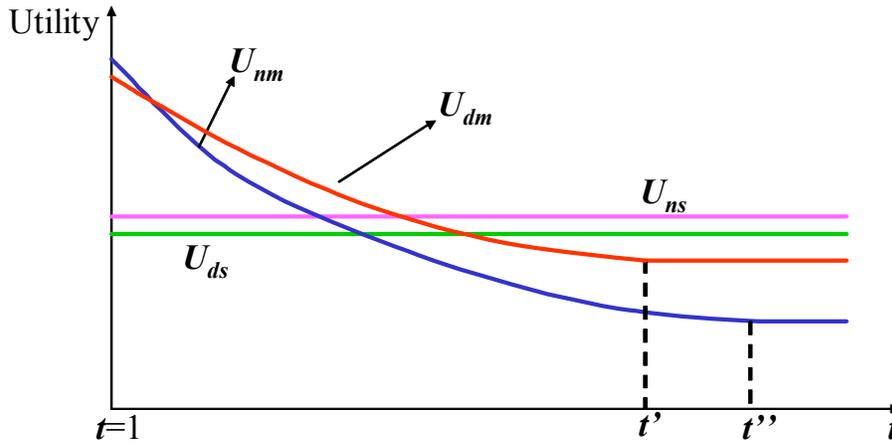


Figure 2: The impossibility of going from ds to nm

As can be seen from figure 2, if $U_{nm} > U_{dm}$ for any t , implies that $u_{ns} > u_{ds}$ for all t since (27) and u_{ns} and u_{ds} are not functions of t . Therefore, if no delegation and multi-located firm is the best option for any t , then, there are no values of t that make delegation and single-located firm the best alternative.

6. Discussion and Conclusion

Puga and Trefler (2003) analyze carefully, from the perspective of their model, the change in the organizational structure of the Boeing Company announced in March 2001. 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, they conclude that the control of innovation was given to the unit heads as they were promoted to chief executive officers. It is worth noting that, in contrast to the model presented here, their model aims to link the delegation of control over the production process with knowledge

creation. They are not concerned about locational advantages.¹³ Nonetheless, the model presented here differs from the one proposed by Puga and Trefler (2003), even though both models are based on Aghion and Tirole (1997).¹⁴

In their model, Boeing's decision to relocate part of the firm is seen as a way to guarantee the delegation of power to the business units. In contrast, it is claimed that in the present model, drawing on the comments of the president and vice-president of the company to support the argument, that the delegation and the location decisions are interconnected aspects and their net effects are taken jointly by the company as the present model predicts.

Puga and Trefler (2003) note that "the simultaneous announcement of these two decisions [relocation and promotion] and the explanation given by Boeing's Chairman at the news conference made it clear that the relocation of Boeing's corporate headquarters (...) was not just about locating more centrally within the United States; it was mainly a commitment to delegating control over incremental knowledge creation" (p.23). In order to show that their interpretation is correct, Puga and Trefler recommend reading the recording of Boeing's news conference of 21 March 2001 in www.boeing.com/news/. The recording reveals the Chairman's concerns about having a creative and innovative company. It is worth saying that the investors of the company formed the audience at that time. He comments:

"Yesterday, we took another step down this path of transformation. First, we announced that we will operate from a new World Corporate Center. Second, we named the heads of our three largest business units as CEOs of those core units. These moves, like the ones before, are aimed at only one thing; i.e., to create value".

On 18 September 2002, one year after Boeing's corporate managers had moved to Chicago, the Executive Vice President of the company Laurette Koellner analyzes the future of

¹³ As in Munroe et al. (1999), "Locational advantages are realized by locating production according to access to particular markets or by taking advantage of regional wage differentials" (p.17).

¹⁴ Other recent working paper based on Aghion and Tirole (1997) has been done by Acemoglu et al. (2005). They construct a very sophisticated continuous-time model to analyze the relationship between technology and decentralization. Geographic aspects with different costs of learning are not addressed. Besides, Marian and Verdier (2002) also use Aghion and Tirole (1997) to discuss market power in a general equilibrium approach.

Boeing in a talk entitled “Boeing: Yesterday, Today and Tomorrow”. About the new location, she says:

*“Here at World Headquarters we also have the office of ethics and business conduct, the law department, communications, finance, international relations, and the **office of technology**. (...) In May of 2001, when we announced the selection of Chicago as the site of our new Boeing World Headquarters we marked an important milestone in the transformation of the company. **Boeing is working toward long-term growth and value creation.** (...) We chose Chicago in part because after the mergers of 1996 and 1997, **Chicago became a location central to Boeing operating units as well as close to the financial community. It provided easier access to our customers all over the world, and it provided a diverse professional talent base in a business friendly environment** (...) it was separate from existing operations, so that leadership would not be identified with any one business unit. This was part of a strategy in which the **business unit CEOs – based in St. Louis and Washington State - are responsible in an autonomous way to manage their business, while allowing Boeing World Headquarters to concentrate on strategy and the development of people**”.*

Puga and Trefler point out that “our aim is not to explain the specific choice of Chicago” (p.23). However, as is evident from the speech above, there was a clear reason for moving to Chicago, to where the office of technology was moved as well. Therefore, it is difficult to figure out which reason was dominant: the necessity of being closer to the financial community with easier access to their customers or the necessity of giving autonomy to the unit heads. It seems to be clear that there were two advantages of moving to Chicago and Puga and Trefler’s model incorporates just one of them. Indeed, it may be an oversimplification to see the decision of moving the HQ to Chicago only as “a commitment to delegating control over incremental knowledge creation” (p.23) in the business units located in Seattle.

Therefore, what we can derive from this story is that: (1) the geographic separation between unit heads and managers generates more autonomy for the former and that, in turn,

provides greater incentives to them to achieve greater productivity and value for the company; and (2) it was important to locate the HQ close to the financial community (locational advantage). Both conclusions fit well in the present model's assumptions.¹⁵ The fact that both decision were made jointly, increasing at the same time the autonomy of unit heads and the geographic decentralization, fits well in the model's predictions.

There are some studies that, instead of examining a specific case, have empirically investigated the headquarter-subsidary relations in some industries (see, for example, Mudambi 2002). Of particular importance for the propose here 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." Therefore, it may be seen that there is more delegation in the American structure than in the Japanese corporations.¹⁶ With this assumption, the model proposed here would expect 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 present paper claims that the internal organization of firms is an important aspect to define location even when the ownership structure is not taken in consideration. It has been shown that the introduction of communication inefficiency between owners and controllers offsets a small gain of placing the manufacturing plant far from the headquarters. Therefore, the owner will decide to move the plant only if the gain is greater than a minimum value. On the other hand, the possibility of delegating the decision to the controller reduces, for a range of the

¹⁵ Moreover, even though the financial community does not belong to the firm, it is interesting to note that the needs of placing the HQ in Chicago captures the idea of the importance of face-to-face communication incorporated here as well.

¹⁶ If we assumed that the Japanese managers delegate less power than the Americans because of the management culture in Japan, we could introduce, in the model, an additional cost for the Japanese managers to delegate power. By doing so, the model obtains the same result as we see in semiconductor industry: the US firms will be more spatially differentiated and internationally integrated.

parameter set, the minimum gain required. As has been demonstrated, the delegation of formal authority may make multi-located firms much more likely.

From the results, one should expect that (1) plants and departments placed far from the owner have more autonomy than those close to the headquarters not only because of the inefficiency of communication per se but also because the owner carries out less effort as a response to this inefficiency. Moreover, (2) there is a tendency that plants placed in different cities than the owner's have more not only real but *de facto* formal authority. Therefore, the framework incorporates some aspects that should be taken in consideration when multinationals (regional) decide their strategies in terms of location.

The results of the present model call attention to the fact that there is a tendency for units located far from the HQs to have greater autonomy. It could provide an additional reason to believe that for a less developed region that wants to expand its industrial sectors via attraction of manufacturing plants, investment in services (e.g., universities to educate the labor force and services in general to attract highly-educated workers) could prove to be more efficient than investment either in infrastructure or in incentives programs given directly to industrial corporations (e.g. tax abatements). 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.

Appendix A

In Aghion and Tirole (1997), Equations (A1) – (A4) represent the utility functions of the principal and the agent.

$$u_p = EB + (1 - E)e\alpha B - g_p(E) \quad (\text{A1})$$

$$u_a = E\beta b + (1 - E)eb - g_a(e) \quad (\text{A2})$$

$$u_p^d = e\alpha B + (1-e)EB - g_p(E) \quad (\text{A3})$$

$$u_a^d = eb + (1-e)E\beta b - g_a(e) \quad (\text{A4})$$

The authors assume that $g_p(E)$ and $g_a(e)$ are increasing and strictly convex. Then, when the principal has the formal authority, the controller maximization problem is:

$$(1-E)b = g_a'(e) \quad (\text{A5})$$

If the controller has the formal authority:

$$(1-\beta E)b = g_a'(e) \quad (\text{A6})$$

Thus:

$$e_d > e_{nd} \quad (\text{A7})$$

Aghion and Tirole justify the result as follows: “Delegation thus increases the agent’s initiative; because the principal cannot overrule the agent, the agent has more incentives to become informed” (p.12). This interpretation is incorporated in the present model. The difference is that, in equations (A5) and (A6), E would be a constant. It can be understood from the perspective that the agent had an expectation about the effort of the owner under those two delegation schemes. Thus, the expectation of E would be incorporated in e , instead of its actual value.

Note that, in their model, E is lower when the agent has the formal authority; therefore, in this case, not only can the principal not overrule the agent, but also E is low. Both consequences of the delegation increase the agent’s initiative and, consequently, e . In other words, including the effect of the actual effort of the owner on the agent’s effort would only intensify the difference between e_d and e_n .

Hence, assuming that $e_d > e_n$ seems to change neither the idea of the original model nor the main results of the present work.

Appendix B

Equation (21) indicates that:

$$\frac{\partial(u_{ns} - u_{ds})}{\partial\alpha} = -e_d B + \frac{\sigma e_n}{1 - e_n \alpha} < 0 \quad (\text{B1})$$

We have seen that:

$$E_{ds} = \frac{B(1-e_d) - \sigma}{B(1-e_d)} \quad (\text{B2})$$

$$B(1-e_d) > \sigma \quad (\text{B3})$$

Equation (B2) shows us that if the condition (B3) is not satisfied, E_{ds} will be zero. In that case, the second term of (B1) disappears, since it represents the gain in terms of cost from reducing effort. Therefore, when (B3) is not true, (B1) is clearly negative.

Assuming that $B(1-e_d) = \sigma$, it is enough to show that:

$$-e_d B + \frac{B(1-e_d)e_n}{1-e_n\alpha} < 0 \quad (\text{B4})$$

That is the same as:

$$(e_n - e_d) - e_d e_n (1 - \alpha) < 0 \quad (\text{B5})$$

Since:

$$e_d > e_n$$

$$\alpha \leq 1;$$

It is straightforward to show that (B1) holds.

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