New ideas need new space

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Abstract

We develop a setting with weak intellectual property rights, where firms' boundaries, location and knowledge spillovers are endogenous. We have two main results. The first one is that, if communication costs increase with distance, entrepreneurs concerned about information leakage have a benefit from locating away from the industry center: distance is an obstacle to collusive trades between members and non-members. The second result is that we identify a trade-off for the entrepreneur between owning a facility (controlling all its characteristics) and sharing a facility with a *non-member* (an agent not involved in production), therefore losing control over some of its characteristics. We focus on "location" as the relevant characteristic of the facility, but location can be used as a spatial metaphor for other relevant characteritics of the facility. For the entrepreneur, sharing the facility with non-members implies that the latter, as co-owners, know the location (even if they do not have access to it). Knowledge of the location for the co-owners facilitates collusion with employees, what increases leakage. The model yields a benefit for new plants from spatial dispersion (locating at the periphery of the industry), particularly so for new plants of new firms. We relate this result with recent empirical findings on the dynamics of industry location.

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1 Introduction

Recent years have witnesses rapid progress in the understanding of economic activity location (see Glaeser (98) for an overview of recent contributions). Economists have focused mainly on three types of forces to model agglomeration. The first motive to agglomerate is to economize in transportation costs. The second one is the exploitation of knowledge externalities, that flow possibly within an industry (these externalities are often referred to as *MAR* -for Marshall Arrow and Romer- externalities) and between different industries (*Jacob's* externalities). The third line of argument relates to the effects of market structure. The market structure of both goods suppliers and labor suppliers are relevant to explain agglomeration. More competition in the supply of goods encourages innovation and growth. The agglomeration of the labor force allows firms and workers to benefit from *labor pooling:* firms and sectors are hit by different shocks; through agglomeration workers have more options to rapidly find a vacancy upon job destruction.

Particularly salient results of the empirical research on the dynamics of spatial concentration of activity are the importance of competition and the importance of *Jacob's* externalities found by Glaeser et al. (92). More recently, Dumais et al. (97) identify the reduction of transportation costs and labor pooling effects as leading explanations for increased spatial concentration of industries.

Before summarizing the building blocks and main results of the model, we briefly consider one additional issue from the empirical literature relating the benefits of locating plants far away from industrial centers. For our purpose, three contributions interest us here:

1. Exploiting the information on plant ownership at the county level in the Census of Manufacturers, Dumais et al (97) provide a *plant lyfe-cycle* decomposition of concentration patterns. They identify the effect on a measure of concentration that can be attributed separately to plant closures, new plants created by new firms, new plants created by existing firms and plant expansions. There are two results of their study that we want to stress: the first one is that average concentration has remained relatively stable in the US in the period 1972-92. The second one is their finding (see section 5.2. in Dumais et al. (97)) that the effect of location decisions by new plants from new firms (and to a lower extent new plants of existing firms) is to reduce spatial concentration.

At the same time the effect of delocation patterns by closing plants is to increase concentration. Dumais et al. (page 17) summarize these results as follows: *New firms are more likely to start away from current geographic centers of the industry, and growth is faster away from those centers, but the risks appear to be higher in the periphery and closures are also higher there.*

2. Glaeser et al. (95) study employment growth in city industries. Among other findings they report[1] that cities with a large concentration of employment in one industry in 1960 suffered in the average loss of employment in that industry. Glaeser et al. argue that a potential explanation for the decline of the specialized city is that existing capital vintages in the city compete with or act as a barrier for subsequent capital vintages, that migrate to new areas.

3. Audretsch and Feldman (96) study the spatial concentration of industrial innovation as a function of a number of variables including the concentration of production in the industry and stage of the industry life-cycle. They find that innovative activity tends to exhibit a lower propensity to cluster spatially as the geographic concentration of production rises during the mature and declining stages of the industry lyfe-cycle[2].

The previous results are obtained with different data bases and methodologies, but they nevertheless share one common idea: whatever the gains from agglomeration that lead firms to cluster in the first place, it appears that possibly for new plants and for plants where innovation takes place, there is a benefit in having a distance separating them and industrial centers. This benefit is greater for new plants of new firms, relative to new plants of existing firms. This is in spite of the apparently higher risk of locating in the periphery of the industry.

In spite of the progress made in the emergence of empirical facts, theory has lagged behind in producing full-blown models compatible with the empirical evidence. In our view, a satisfactory theory of agglomeration of

[1] see table 4 in their paper

[2] Audretsch and Felman (96), page 269. Audretsch and Feldman summarize this finding with the phrase *new ideas need new space,* that we have borrowed as the title of this paper.

activity should explain simultaneously firms' size and location decisions, and knowledge spillovers across firms. Theory should explain in particular why knowledge externalities cannot be avoided or internalized by large firms (as suggested by the argument behind the so called *MAR* externalities). Moreover, since there is evidence that spatial concentration is relatively stable and that new plants benefit relatively more from distance to industrial centers than existing plants, a satisfactory theory should spell out the costs as well as the benefits of agglomeration.

In this paper we attempt to make a first step in this direction. Our starting point is to consider a regime of weak intellectual property rights (henceforth, WIPR). Having a WIPR regimes has a large number of implications. First of all, in any venture where intellectual property rights matter, there is a cost of involving more agents in the venture: as agents are given access and become informed about the internal developments, a potential for costly leakage and collusive trade with outsiders arises. This principle yields a theory of firm's boundaries. Second, since in general production cannot be organized so as to completely avoid collusion, endogenous spillovers occur in equilibrium. Third, a WIPR regime implies that plant location matters if physical distance increases communications costs (as argued for instance by Audretsch and Stephan (96b)), therefore diminishing incumbents' ability to collude with members of new plants.

In addition, we show that integration (ownership of the relevant physical asset) or control rights over assets has a benefit for the entrepreneur because it allows her to unilaterally determine all the relevant characteristics of the asset. Instead, under shared ownership (and therefore partial control) some characteristics of the asset are determined or co-determined (and therefore known) by non-members: co-owners that are not involved in production. This facilitates collusion between non-members and members, what hurts the entrepreneur. This is so even if decentralization is perfect and contracts assure the owner's commitment not to access the facility. To repeat, there are two types of information the entrepreneur cares to keep secret from non-members: the innovation-related knowledge produced by the team and characteristics related to production, like the location of physical assets used and the identity of members. The first type of secret obtains through private property and decentralization contracts, that warrant the inability of non-members to access the entrepreneurs' facility and to directly learn about the innovation. The second type of secret (on location) requires the absence of contact or relationship with non-members. It requires that the entrepreneur creates or buys the new facility, as opposed to sharing the facility with an existing firm.

Environments subject to weak intellectual property rights protection have received increased interest in the last years (see Rodriguez-Palenzuela 99a [3] for references to the literature and to case studies). Employee turnover across firms is the conventional channel used in the literature to motivate diffusion of knowledge across firms. Yet there is also evidence that communication between employees and between employees and clients is an important source of information leakage in firms (for case-study evidence in this respect see von-Hippel (88) and Piore (97)). The evidence from litigation cases in this respect is that it is difficult, for plaintiffs suing employees that allegedly enjoyed rents from communication with outsiders, to win lawsuits for misappropriation. In particular, the court tends to protect employees when they have an interest in, or are the main source of, innovation related knowledge[4]. For legal practitioners' view on the court's ability to avoid information leakage from firms see for instance Dorr and Munch (95) and Lee and Davidson (93).

An additional piece of evidence relating leakage and loss of monopoly rents from unintended diffusion of innovation without employee turnover is provided by *The Economist* in the context of Italian industrial clusters[5]. *The Economist* reports that firms involved in industrial design that control the manufacturing process (for instance, *pasta* and spectacles producers own facilities to make the machines that manufacture final goods) have a greater ability to avoid the emergence of competitors (particularly from South-East Asia). These firms retain market power because they control machine production and they control the right to sell machines to third parties. On the other hand, firms that buy the machines from other companies (and that therefore control the sale of machines to a lower extent) face a more rapid erosion of market power, due to more rapid imitation. This second case applies to gold jewelry and tiles producers.

The rest of the paper is organized as follows. Section 2 is the model. Sec-

[3] Our model extends Rodriguez-Palenzuela (99a) in several respects. We introduce here location decisions and the decision to own or share a physical asset by the innovating entrepreneur. We generalize previous research by endogenizing the presence of arbitrarily many potential entrants and we consider general incentive schemes with a no-burnt money condition.

[4] See for instance *Structural Dynamics Research Corporation* vs *Engineering Mechanics Research Corporation* quoted in Choate et al. (87).

[5] See *The Economist*, January 2^{nd} 1999, pages 57-58.

tion 3 describes the trade-off between saving fixed costs (collaboration) and ownership (entry). In section 4 the basic model is considered in a more general setting where collaboration is interpreted as the introduction of specialist management in the firm. We find that even if technologies are not convex, there are increasing returns to the specialist management skill. Section 5 closes with a discussion.

2 Model

There is initially one entrepreneur $i = 1$, with an innovation project. Executing the project requires sequential stages of research and development.

RESEARCH

Conducting research requires that the entrepreneur chooses a locations l_o in the set $\mathbb{N} = \{0, 1, 2, ..\}$. Research also requires the access to a physical asset and the formation of a researchers' team at location l_o. N is the number of members (including the entrepreneur) in the team, denoted by the set $\{N\}_{x=1}^{N}$. Increasing the size of the team N reduces research costs $C(N)$ ($C' < 0$), but has a marginal cost of w.

The outcome of the research stage is *knowledge*: an idea or a prototype that must be developed in order to become a marketable product. The idea is known necessarily by all members of the team.

DEVELOPMENT AND FINAL MARKET

We assume for simplicity that development is a costless process. Any firm that has had access to the knowledge produced at the research stage is able to develop the product and enter the market. The payoffs at the final market are $\pi_o(n)$ for the initial firm started by the entrepreneur $i = 1$ and $\pi_c(n)$ for all other firms, where n is the total number of competitors to the initial firm. We assume $\pi_o(n) \geq \pi_c(n)$ and $\pi'_o < 0$, $\pi'_c < 0$: competition reduces profits. Moreover, we assume that total industry profits decrease with the number of firms. For all $n, n' : n' > n \geq 0$,

$$\pi_o(n') + n'\pi_c(n') < \pi_o(n) + n\pi_c(n)$$

Collusion

A member x of the initial team (located at l_o), transmitting the knowledge produced at the research team to a non-member[6] y located at l_y, implies an expected loss of $t(d)$, with $t' > 0$ and where d is the distance between l_x and l_y. We assume $d = 1$ if $l_x \neq l_y$ and $d = 0$ otherwise[7]. In addition, for an established firm to make an offer to the members, the established firm needs to know the location l_o. We assume that except for the previous assumptions, there are no restrictions to collusive agreements. At the collusive stage any agent z that knows l_o can make an offer to an arbitrary set of agents $\mathcal{C}$, specifying transfers between z and $c \in \mathcal{C}$ and communication between members of $\mathcal{C}$.

Information

There is a large but finite number of established firms (indexed by y) each of them located at $l_y \in \mathbb{N}$. Established firm y has previously sunk the cost F of the asset located in l_y. The asset is necessary for the research stage and can be costlessly used by the entrepreneur.

We assume that all variables in the model are common knowledge except the entrepreneur's location, l_o. If the entrepreneur has no links with an established firm[8], the latter does not learn l_o, unless $l_o = l_y$ or unless l_o is revealed to firm y. If the entrepreneur uses the asset of firm y then at least one agent in y learns l_o.

Although we assume *perfect decentralization* (it is contractually possible to avoid y having access to the entrepreneur's team and directly learning about the project), we take the view that sharing assets implies that the entrepreneur discloses some information different to the knowledge produced in the research stage. We focus on the firm's location l_o as the relevant piece of information revealed to an established firm upon collaboration. Location can be interpreted more generally as a spatial metaphor of certain attributes of the entrepreneur's project that, once revealed to an existing firm, facilitate collusive trade between members and the established firm.

[6] Allowing the entrepreneur to legally sell information to other firms would not alter the model as long as there is a cost t of transmitting the knowledge. If legal transmission of knowledge costs less than t then contractual sales would occur, at a price determined by the collusive price. The results would be almost identical to our results.

[7] By assuming $t' > 0$ we are saying that collusive communication costs increase with distance.

[8] We assume on the other hand that all members and stake-holders in the entrepreneur's firm know l_o.

TIMING

The exact timing of decisions is as follows:

$t = 1$: Entrepreneur $i = 1$ forms team $\{N\}$, chooses location l_o, and an incentive schedule $\{b_z\}_{z=1}^{N+R}$ where R is the number of non-members that hold stake in the firm and b_z is the proportion[9] of equity held by individual z, that is possibly a non-member. Research takes place.

$t = 2$: Agents make collusive agreements. Development takes place.

$t = 3$: The final market meets.

Finally, we assume that agents face no liquidity constraints, so that all collusion rents to be realized can be captured by the entrepreneur as of $t = 1$. At this initial stage the objective of the entrepreneur is to maximize the joint surplus of the team $\{N\}$.

3 Scale vs Collusion

In this context the efficient allocation for the entrepreneur's team when communication between members and outsiders (n) can be avoided contractually is given by:

Result 1: *At the first best for the entrepreneur, the entrepreneur uses the asset of an established firm and satisfies*:

$$\begin{aligned} n^* &= 0 \\ C(N^*-1) - C(N^*) &\geq w > C(N^*) - C(N^*+1) \end{aligned}$$

Location and incentive schemes are not defined in the first best. Surplus W^* at the first best is: $W^* = \pi_o(0) - C(N^*) - wN^*$.

We now consider the case where intellectual property rights are weakly protected. There are two cases to be explored: *ownership*, where the entrepreneur introduces and owns a new asset and chooses unilaterally a location l_o, and *collaboration*, where the entrepreneur agrees with a established firm y to use an existing asset previously introduced by y at a given location l_y. Our main result is that the entrepreneur faces a trade-off when collaborating with an established firm: the cost of introducing the asset is saved, but the

[9] In the Appendix we show that such linear scheme is optimal.

established firm y becomes informed about the entrepreneur's locus of activities l_o. The established firm knowing l_o raises the possibility of collusion between y and the members of the firm. By *ownership*, the entrepreneur compromises economies of scale in order to reduce collusion and leakage.

To see this trade-off precisely we derive the equilibrium under ownership and collaboration respectively.

3.1 Ownership: full control over location

Under ownership the entrepreneur chooses the location l_o of the new asset that she introduces. The entrepreneur chooses at random one location in the (infinite) set of empty locations, giving equal probability to each location. This implies that as of $t = 2$ the established firms do not know the locus of the new firm and therefore the former cannot make offers to the members. But this does not preclude members to individually make offers to established firms.

In equilibrium under ownership, the optimal incentive scheme is linear and satisfies the following two-wage property:

Proposition 1 *Given the size of the team N, the optimal incentive scheme $\{b_z\}_{z=1}^{N+R}$, satisfies a two wage property*[10]*:*

$$b_z = \tfrac{1}{N-n(N)} : \text{ for } z \in \{n(N)+1, .., N\}$$
$$b_z = 0 : \text{ for } z \notin \{n(N)+1, .., N\}$$

and the number of entrants $n(N)$ is given by[11]*:*

$$n(N) = \{\min n \in \{0, ..., N\} : \Phi(n, N) \leq 0\}$$

where:

$$\Phi(n, N) \equiv \pi_c(n+1) - t(1) + \frac{\Delta\pi_o(n+1)}{N-n}$$

and $\Delta\pi_o(n) \equiv \pi_o(n) - \pi_o(n-1)$.

Proof: In the Appendix.

[10] Recall that $r = 1, .., R$ are non-members that hold firms' equity. The optimal scheme gives no stake to non-members.

[11] $n(N)$ always exists since $\Phi(0, N) > 0$ and $\Phi_n < 0$.

The interpretation of this result is as follows: under the optimal scheme a number $N - n(N)$ of employees split the firm's equity (the other $n(N)$ employees hold zero equity and therefore communicate with an existing firm). It is never optimal to give equity to non-members (in particular it is not optimal to make a third party residual claimant if n is positive). Both results (the linearity of the scheme and the absence of third parties) follow from agents ability to make offers to other agents for side transfers and communication with new entrants. In particular, non-linearities are not optimal because they give rise to arbitrage opportunities in collusive markets.

The term $\Phi(n, N)$ is the net gain from trade for a member when exactly n members are trading: the benefit of communication is the term $\pi_c(n+1)$ and the total cost of communication is the direct cost $t(1)$ plus the opportunity cost of reducing the value of his shares:

$$\text{opportunity cost } = b\left(\pi_o(n) - \pi_o(n+1)\right)$$

The result states that in an equilibrium where $n(N)$ members communicate with outsiders, an equity-endowed member (that holds a fraction $\frac{1}{N-n}$ of shares) has no gains of trade (equivalently, $\Phi(n, N) \leq 0$) when making offers to an established firm. $n(N)$ is the smallest number[12] of trades that can be sustained when there are N members in the firm under the optimal scheme, that is the 2-wage scheme of proposition 1.

Under entry, the entrepreneur solves:

$$\max_{\{N, l_o\}} \left\{ n(N)\, \pi_c(n(N)) + \pi_o(n(N)) - C(N) - wN - F \right\} \tag{1}$$

The entrepreneur that enters as a new firm, by increasing N [13], faces a trade-off between efficient research (smaller C) and more dilution and competition (higher n). It is clear that under entry the entrepreneur chooses an empty location l_o so as to avoid incumbents learning l_o.

[12] The intuition is simple: spliting equity among all members generally would not avoid leakage. Once a member colludes it is optimal to give him zero equity and save those shares to increase the number of non-colluding members.

[13] The entrepreneur chooses N smaller than in the first best N^*, but this result follows from the additive cost specification and is generalized in following sections.

3.2 Collaboration: loss of control over location

Collaboration establishes a link between the entrepreneur and one existing firm[14]. It implies in particular that location l_o is given to the entrepreneur, since the asset has been previously located at l_o by the established firm. This is so even if decentralization is perfect and members of the established firm cannot access the entrepreneur's team, or directly learn about the new knowledge produced. But collaboration gives the established firm sufficient information (i.e., the location) about the new firm to become a potential competitor, through the threat of collusive trade with members. The possibility of collusive trade forces the entrepreneur to make the established firm an additional equity-holder of the entrepreneur's firm, or otherwise let him enter as a competitor. This makes the problem of incentive dilution more severe: it implies in particular that the entrepreneur faces more competition for any given team size N.

In addition, the collaborator makes offers possibly to all members of the firm, that compete among them. Members suffer a negative externality from other members accepting offers. In equilibrium members accept offers that compensate them only for the direct communication cost t [15], and not for the opportunity cost $b(\Delta\pi(n+1))$ in the entry case: under collaboration (and members' competition) the alternative of not accepting the offer $q = t$ by the collaborator is having other member accept such offer. The relevant net surplus from collusive trade between the asset owner and members, Φ^p, is now:

$$\Phi^p(n, b^p) = \pi_c(n+1) - t(0) + b_p \Delta\pi_o(n+1)$$

where b_p is the fraction of equity held by the collaborator. The relevant net surplus from trade between members and other established firms is:

$$\Phi^x(n, b_x) = \pi_c(n+1) - t(1) + b_x \Delta\pi_o(n+1)$$

The relevant program is:

[14] We assume that collaboration between the entrepreneur and one established firm does not reveal the location of the installed facility to other firms. We assume this mainly for realism, but it does not play an important role in the analysis.

[15] The distance between the owner and the members is zero since they are in the same location. The distance between members and other incumbents is 1 since the entrepreneur prefers to choose an incumbent y that is alone in l_y. The result nevertheless does not hinge on this specific details.

Proposition 2 *Under collaboration, the entrepreneur solves:*

$$\max_N \left\{ \widetilde{n}(N)\, \pi_c(\widetilde{n}(N)) + \pi_o(\widetilde{n}(N)) - C(N) - wN \right\} \tag{2}$$

where:

$$n(N) < n(N+1) = \widetilde{n}(N) = \min\left\{ n : \Phi^x(n, b_x, d=1) \leq 0 \right\}$$

Proof: In the Appendix.

Comparing propositions 1 and 2, it is clear that under collaboration the entrepreneur faces more competition for any given team size N, what reduces profits. This is since $\frac{dn}{dN} > 0$ (see the Appendix). The obvious benefit of collaboration is that the fixed cost F is saved.

By inspection of both programs, factors that favor entry over collaboration are a small fixed cost F and soft competition:

Result 4:
4.1) If firms profits decrease fast enough with the number of firms (π_o and π_c are sufficiently concave) then collaboration is superior to entry.
4.2) Under both entry and collaboration, if communication costs $t(d)$ depend positively on the distance, defined as $d = |l_o - l_y|$, between the entrepreneur's firm and existing firms, the entrepreneur chooses l_o so as to maximize such distance:

$$l_o = \max_{l, l_y} |l - l_y|$$

A proof is not required.

Both statements in Result 4 are intuitive: if competition is *tough* and profits decrease rapidly with the number of firms in the market, the collusion stake is smaller and the entry constraint less severe. This makes collaboration less harmful relatively to entry.

4 Specialization vs Collusion

The previous section illustrates well one benefit of integration (or ownership): the absence of contact with established firms facilitates the retention of knowledge in the entrepreneur's firm. Integration creates an informational void between members and non-members, that plays the role of an additional friction in the collusive trade for knowledge. Yet the cost of integration (the duplication of the fixed cost F) is far from being a robust result. In particular, it can be argued that a benefit of collaboration is to alter the strategic interaction between the initial firm and entrants: collaboration possibly makes the initial team more robust to competition and more efficient at setting up entry barriers.

In this section we modify our model precisely in this direction. We ignore ownership of physical assets and we introduce an additional type of skill, that we label marketing ability, λ. The cases of *entry* and *collaboration* are substituted by *centralization* and *specialization*. Under centralization the entrepreneur engages in two activities: managing the research team the marketing effort. In the second case a second manager is introduced that specializes in providing the marketing skill λ.

To keep things simple we introduce the marketing skill λ purely as an entry barrier: we assume that $\pi_o(n)$ does not depend on λ but only $\pi_c(n, \lambda)$ does. In particular: $\frac{\partial \pi_c}{\partial \lambda} < 0$. If a marketing specialist is introduced, increasing the skill λ has a cost $G(\lambda)$, with $G' > 0, G'' > 0$.

In this modified setting a basic trade-off prevails: under centralization the entrepreneur is not specialized and is not able to provide effort for a marketing skill. Yet keeping a small number of managers reduces the dilution problem. Under specialization a second individual is introduced that is able to develop the marketing skill. Having a marginal agent informed aggravates the dilution problem, since the marketing manager becomes necessarily informed.

In addition of extending the previous results, the bottomline of the modified model is that increasing returns to the marketing skill emerge. This is even if the investment cost G is strictly convex. The reason is that introducing the new manager has a fixed cost independently of the skill level λ : having one more manager informed to start with, requires giving equity to the manager, therefore decreasing the members' shares and increasing leakage.

It is clear that the direct effect of the marketing skill λ is to make the leakage constraint less severe ($\frac{\partial n(\lambda,N)}{\partial \lambda} < 0$ as shown in the Appendix). In particular, if λ reaches a level $\overline{\lambda}$ such that $\pi_c\left(\overline{\lambda}, n\right) = 0$ the equilibrium size of the team reaches the first best level: $N\left(\overline{\lambda}\right) = N^*$.

The payoffs to the entrepreneur under centralization and specialization can be written compactly as follows. Define $f(\lambda)$ and $R(\lambda, N)$ respectively as:

$$f(\lambda) = \begin{cases} 1 \text{ if } \lambda > 0 \\ 0 \text{ if } \lambda = 0 \end{cases}$$

$$R(\lambda, N) = \pi_o(n(\lambda, N + f(\lambda))) + n(\lambda, N + f(\lambda))\, \pi_c(\lambda, n(\lambda, N + f(\lambda)))$$

We can write the payoffs under centralization and specialization, W^{cent} and W^{sp}, as:

$$\begin{aligned} W^{cent} &= \max_N W(0, N) = R(0, N) - C(N) - wN \\ W^{sp} &= \max_{\lambda > 0, N} W(\lambda, N) = R(\lambda, N) - G(\lambda) - C(N) - wN \end{aligned}$$

the effect of the non-disclosure constraint for the specialist manager is to introduce a fixed cost in the acquisition of the management skill to the firm. The fixed cost results because for the specialist that introduces a marginal skill $\lambda = \varepsilon$ becomes informed and alters the leakage condition from a lower level:

$$n(\varepsilon, N + f(\varepsilon)) = n(\varepsilon, N + 1) \simeq n(0, N + 1) > n(0, N + f(0)) = n(0, N)$$

Rewrite W^{sp} as:

$$W(\lambda, N) = \pi_o(n(\lambda, N)) + n(\lambda, N)\, \pi_c(\lambda, n(\lambda, N)) - TC(\lambda, N)$$

where TC is the total cost when introducing the management skill. TC is given by:

$$\begin{aligned} TC(\lambda, N) &= H(\lambda, N) + G(\lambda) + C(N) + wN \\ H(\lambda, N) &= R(\lambda, N) - R(0, N) \end{aligned}$$

We have:

Proposition 3 *The average total cost $\frac{TC(\lambda,N)}{\lambda}$ as a function of the marketing skill λ is U-shaped for a given team size N, even if the cost G of producing λ is strictly convex.*

A proof is not required. The bottomline is that imperfect intellectual property rights together with human capital and knowledge indivisibilities imply increasing returns to the management skill. Two type equilibria emerge: small firms (in terms of team size N) without a marketing specialist, and large firms that engage in marketing specialization.

5 Discussion

The factors that affect firm location dynamics are being identified through recent empirical contributions. The theoretical debate used to frame empirical studies has often been kept at an intuitive level: full-blown models where firms' boundaries, location and knowledge spillovers are determined have not been developed. Moreover, the theoretical arguments are used only to explain the benefits of spatial agglomeration. Since there is evidence that the benefits of agglomeration change with plants' life cycle (new plants benefit relatively less from agglomeration than existing plants -Dumais et al. (97)), theoretical arguments are needed to explain also the benefits of spatial dispersion.

We derive a rationale for the benefits of distance to industry centers by new plants that is based on the contractual inability to protect intellectual property rights. The entrepreneur concerned about leakage keeps secret from non-members the knowledge developed in her plant. Through private property and decentralization contracts she denies access to non-members, even if non-members own the facility. If distance increases communication costs, the entrepreneur makes collusion between employees and members more costly by not locating at the center of the industry.

Moreover, we identify a benefit for the entrepreneur from owning the facility (integration). Non-members are able to indirectly access the firm's sensible information through collusive offers to members, as long as they know the location of the facility. Ownership of the facility by the entrepreneur gives her full control to unilaterally determine all its characteristics, as opposed to shared ownership together with a non-member (a co-owner that is not directly involved in the research team). Through this no-relationship with non-members principle, the team keeps the location secret from non-members and achieves improved protection of sensible knowledge generated in the firm.

The bottomline is that there is a benefit for new plants to locate at a distance from the industry center, even if locating in the periphery has a cost on other grounds (the duplication cost F in our model). The benefit to new plants from distance is greater for new firms than for existing firms, since the former benefits additionally from the benefit of location.

Our result on the costs of collaboration (sharing an asset) can be reinterpreted in terms of the costs of hiring specialist management when we generalize our framework in section 4. Specialist management increases efficiency but makes the dilution and leakage problems more severe. As a result, we find increasing returns to the specialist management skill.

Although we see our contribution as only a first step towards a theory of spatial agglomeration and dispersion, we regard more generally the no-intellectual property rights approach to firm location as potentially very fruitful.

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Appendix

Proof of Proposition 1:

We prove the optimallity of the 2-wage scheme of proposition 1 by contradiction. We say that an incentive scheme implements n given N, when in equilibrium at $t = 2$ only n members communicate with an entrant.

A general scheme gives $\omega_z(\pi_o)$ to agent z, that can either be a member ($z \in \{N\}$) or a non-member with stake ($z \in \{R\}$). From the assumption that money cannot be destroyed and since z includes all stake-holders, ω_z satisfies: $\sum_z \omega_z(\pi_o) = \pi_o$.

Define $s(n) \equiv \pi_c(n) - t(1)$ and call $\overline{n}$ the entry level implemented by the 2-wage scheme in proposition 1. $\overline{n}$ satisfies:

$$s(\overline{n}+1) \leq \frac{1}{N-\overline{n}}\pi_o(\overline{n}) - \frac{1}{N-\overline{n}}\pi_o(\overline{n}+1)$$

and from the definition of $\overline{n}$, $\forall n \in \{1, .., \overline{n}-1\}$:

$$s(n+1) > \left(\frac{1}{N-n}\right)\pi_o(n) - \left(\frac{1}{N-n}\right)\pi_o(n+1)$$

so in particular for $n' = \overline{n} - 1$:

$$(N+1-\overline{n})\, s(\overline{n}) > \pi_o(\overline{n}-1) - \pi_o(\overline{n}) \tag{3}$$

If a general scheme ω_z implements $n' = \overline{n} - 1$ (it is straightforward to show the contradiction for any n lower than n') then it satisfies, for all members in $x \in I = \{n'+1, ..., N\}$ that they do not want to trade with non-members:

$$s(n'+1) \leq \omega_x(\pi_o(n')) - \omega_x(\pi_o(n'+1)) \tag{4}$$

so that:

$$(N-\overline{n}+1)\, s(\overline{n}) \leq \sum_{x\in I}\omega_x(\pi_o(\overline{n}-1)) - \sum_{x\in I}\omega_x(\pi_o(\overline{n})) \tag{5}$$

Moreover, since there are no restrictions to collusive agreements, for $\{\omega_z\}_{z=1}^{N+R}$ to implement n' it must be that for any subset $\mathcal{C} \subset \{N\} \cup \{R\}$ of members and/or stake holders, the joint surplus of the members in $\mathcal{C}$ when trading with a non-member is not greater than when no trading:

$$\begin{aligned} \forall \mathcal{C} &\subset \{N\} \cup \{R\} \ \wedge \ \mathcal{C} \cap \{N-n'\} \neq \emptyset \\ s\left(n'+1\right) &\leq \sum_{z\in\mathcal{C}} \left\{\omega_z\left(\pi_o\left(n'\right)\right) - \omega_z\left(\pi_o\left(n'+1\right)\right)\right\} \end{aligned} \tag{6}$$

So in particular for $x \in I$:

$$s\left(n'+1\right) \leq \omega_x\left(\pi_o\left(n'\right)\right) - \omega_x\left(\pi_o\left(n'+1\right)\right) + \sum_{z\notin\mathcal{I}} \left\{\omega_z\left(\pi_o\left(n'\right)\right) - \omega_z\left(\pi_o\left(n'+1\right)\right)\right\}$$

From (4) it is clear that:

$$\begin{aligned} s\left(n'+1\right) &\leq \omega_x\left(\pi_o\left(n'\right)\right) - \omega_x\left(\pi_o\left(n'+1\right)\right) \\ &\quad + \frac{1}{N-n'}\left[\sum_{z\notin\mathcal{I}} \left\{\omega_z\left(\pi_o\left(n'\right)\right) - \omega_z\left(\pi_o\left(n'+1\right)\right)\right\}\right] \end{aligned} \tag{7}$$

Adding (7) for all $x \in I$:

$$\begin{aligned} \left(N-n'\right) s\left(n'+1\right) &\leq \sum_{x\in\mathcal{I}} \left\{\omega_x\left(\pi_o\left(n'\right)\right) - \omega_x\left(\pi_o\left(n'+1\right)\right)\right\} \\ &\quad + \sum_{z\notin\mathcal{I}} \left\{\omega_z\left(\pi_o\left(n'\right)\right) - \omega_z\left(\pi_o\left(n'+1\right)\right)\right\} \\ &= \sum_{z\in\{N\}\cup\{R\}} \omega_z\left(\pi_o\left(n'\right)\right) - \sum_{z\in\{N\}\cup\{R\}} \omega_z\left(\pi_o\left(n'+1\right)\right) \\ &= \pi_o\left(n'\right) - \pi_o\left(n'+1\right) \end{aligned}$$

For $n' = \overline{n} - 1$ we have:

$$\left(N - \overline{n} + 1\right) s\left(\overline{n}\right) \leq \pi_o\left(\overline{n} - 1\right) - \pi_o\left(\overline{n}\right)$$

that contradicts (3).

■

Proof of Proposition 2:

We restrict ourselves here to linear 2-wage schemes as in proposition 1. The proof of the optimallity of such scheme in the case of collaboration is the same as in proposition 1. The key point is that the owner of the asset p has a lower cost of communication but poses the same threat that the other agents, since p's non-disclosure constraint is:

$$\pi_c(\widetilde{n}+1) - t(1) + b_p \Delta\pi_o(\widetilde{n}+1) \leq 0$$

Therefore p is the first agent not-to be given equity. For the rest of agents:

$$\begin{aligned} \pi_c(\widetilde{n}+1) - t(1) + b_x \Delta\pi_o(\widetilde{n}+1) &= 0 \text{for } x \in \{\widetilde{n}+1, .., N-1\} \\ \pi_c(\widetilde{n}+1) - t(1) + b_N \Delta\pi_o(\widetilde{n}+1) &\leq 0 \text{for } x = N \\ (N+1-\widetilde{n}(N))\, b_x + b_N &= 1 \end{aligned}$$

This implies that the budget constraint satisfies: $b_x = \frac{1}{N+1-\widetilde{n}}$. The program can be rewritten as:

$$\begin{aligned} \widetilde{n}(N) &= \min \widetilde{n} \in \{1, .., N+1\} \\ st &: \pi_c(\widetilde{n}+1) - t(1) + \left(\frac{1}{N+1-\widetilde{n}}\right) \Delta\pi_o(\widetilde{n}+1) \leq 0 \end{aligned}$$

It is clear that $\widetilde{n}(N) = n(N+1) > n(N)$ where $n(N)$ is as defined in proposition 1. ■

Specialization vs Collusion:

In this case the relevant program is:

$$\begin{aligned} \min n &\in \{1, .., N\} \\ st &: \pi_c(\lambda, n+1) - t(1) + \left(\frac{1}{N+1-n}\right) \Delta\pi_o(n+1) \leq 0 \end{aligned}$$

Since $\frac{\partial \pi_c}{\partial \lambda} < 0$, it is clear that λ relaxes the non-disclosure constraint and $n(\lambda, N) \leq n(\lambda', N)$ for $\lambda' < \lambda$. Since $\Delta\pi_o(n+1) < 0$, if $\pi_c\left(\overline{\lambda}, n+1\right) = 0$ the constraint is satisfied for any team size N and in particular for N^* in Result 1.

■

This implies in particular that for any member and for any stake holder z:

$$\omega_z\left(\pi_o\left(n'\right)\right)-\omega_z\left(\pi_o\left(n'+1\right)\right)\geq 0 \tag{8}$$

From (3) and (5):

$$\sum_{z\in I}\omega_z\left(\pi_o\left(\overline{n}-1\right)\right)-\sum_{z\in I}\omega_z\left(\pi_o\left(\overline{n}\right)\right)>\pi_o\left(\overline{n}-1\right)-\pi_o\left(\overline{n}\right) \tag{9}$$

Since $\sum_{z\in I}\omega_z\left(\pi_o\left(\overline{n}-1\right)\right)\leq\pi_o\left(\overline{n}-1\right)$, we have:

$$\sum_{z\in I}\omega_z\left(\pi_o\left(\overline{n}\right)\right)<\pi_o\left(\overline{n}\right)=\sum_{z\in I}\omega_z\left(\pi_o\left(\overline{n}\right)\right)+\sum_{z\notin I}\omega_z\left(\pi_o\left(\overline{n}\right)\right) \tag{10}$$

Combining (**??**), (6), (10) and (8) we have:

$$\begin{aligned}
\pi_o\left(\overline{n}-1\right)-\pi_o\left(\overline{n}\right) &< \sum_{z\in I}\omega_z\left(\pi_o\left(\overline{n}-1\right)\right)-\sum_{z\in I}\omega_z\left(\pi_o\left(\overline{n}\right)\right)\\
&= \sum_{z\in I}\omega_z\left(\pi_o\left(\overline{n}-1\right)\right)-\pi_o\left(\overline{n}\right)+\sum_{z\notin I}\omega_z\left(\pi_o\left(\overline{n}\right)\right)\\
&\leq \sum_{z\in I}\omega_z\left(\pi_o\left(\overline{n}-1\right)\right)-\pi_o\left(\overline{n}\right)+\sum_{z\notin I}\omega_z\left(\pi_o\left(\overline{n}-1\right)\right)\\
&= \pi_o\left(\overline{n}-1\right)-\pi_o\left(\overline{n}\right)
\end{aligned}$$

that is a contradiction.

■