The Role of Human Capital Investments in the Location Decision of Firms*

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Abstract

We explore the role of human capital investments in the location decisions of firms. We show that whether human capital investments act as a force for or against concentration depends on who is undertaking them and whether they are industry- or firm-specific. We also discuss the empirical predictions of our theoretical analysis.

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1 INTRODUCTION

In this paper we explore the role of human capital investments in the location decisions of firms. We argue that the location of firms influences the extent of labor market imperfections which in turn affect the incentives to invest in workers' human capital. We show that the optimal location of firms depends on who is undertaking the investments and whether they are industry or firm-specific. Thus, even a simple model that focuses exclusively on human capital investments can provide rich predictions about the spatial concentration of firms.

As an illustrative example, consider the accordion industry which is almost entirely concentrated in Castelfidardo, a small city near Ancona, Italy (see Tappi, 2002).[1] If one asked locals why this industry is concentrated there, they would probably reply that is due to the great skill of the local workforce in producing accordions. But this would just lead to the next question, namely why all these skillful accordion workers are concentrated in Castelfidardo. One potential answer, and the one we focus on here, is that workers who settle down in this medieval town when they are young have very strong incentives to invest in skills that are specific to the accordion industry. In particular, these workers do not have to worry about being held up by their employers after they have invested in their accordion making skills since they can always threaten to work for another local manufacturer. Since they do not worry about being held up when they are old, they have strong incentives to invest in their own skills when they are young.

[1]There are of course many other examples of industries that are very spatially concentrated such as the carpet industry in Dalton, Georgia (USA) and the Swiss watch-making industry in Geneva and in the northwestern mountains of the Jura. Moreover, this is by no means a recent phenomenon. Marshall (1920) reported almost a century ago that the British cutlery manufacturing industry was concentrated in Sheffield and Duranton and Overman (2004) show that this is still the case today. We review the recent empirical literature on the agglomeration of industries below.

The idea that co-location of firms can mitigate the potential hold-up problem between workers and firms and can thus induce more efficient (industry-specific) human capital investments by the workers is not novel and was recently analyzed by Rotemberg and Saloner (2000).[2] The main empirical prediction of their paper is that firms that use the same type of labor locate close to each other to protect the workers' human capital investments. Thus, using the terminology introduced by Duranton and Puga (2003), they predict 'functional' concentration, i.e. concentration of firms using similar skills, rather than 'sectoral' concentration, i.e. concentration of firms producing similar goods. Dumais, Ellison, and Glaeser (1997) test this prediction and find evidence that "plants do seem to locate near other industries when they share the same type of labor. This effect is quite large and suggests that labor market pooling is a dominant force in explaining the agglomeration of industry" (Dumais et al., 1997, 28-31).[3] A number of other papers have since confirmed the importance of labor market pooling in explaining the spatial concentration of firms (see, for instance, Rosenthal and Strange (2001), Rigby and Essletzbichler (2002), and Rosenthal and Strange (2004) for a survey). All these papers take it for granted that spatial concentration of firms mitigates the hold-up problem.

We agree with the authors of these papers that labor market considerations can play an important role in determining the location of firms. However, we want to caution against the view that spatial concentration by firms unambiguously improves the incentives to invest in the workers' human capital. We show below that human capital investments can act as a force for or against spatial concentration and that their net effect on the location of firms depends on their characteristics. In contrast to the existing literature, therefore, the forces for

[2]See also Almazan et al. (2003) and Combes and Duranton (2003).

[3]We are deliberately referring to the working paper and not to the published paper (Dumais, Ellison, and Glaeser (2002)) since the latter omits the material on the sources of agglomeration economies.

and against agglomeration in our model are of the same nature. We hope that taking into account the circumstances under which labor market considerations act as a force *against* spatial concentration will further clarify the empirical evidence about their importance in explaining the spatial concentration of firms.

We focus on two cases in which concerns about human capital investments can act as a force against spatial concentration. First, this will be the case if the firms, rather than the workers, make the human capital investments. For instance, if the accordion manufacturers had to invest in the workers human capital it might be optimal for them to locate away from their competitors so as to protect *their* investments. Second, it may be advantageous for firms to locate away from their competitors if workers can make firm-specific investments. Suppose, for instance, that a particular accordion manufacturer uses some production techniques that are industry-specific – that is they are also used by other firms in the industry – and others that are specific to the manufacturer. Suppose further that a worker can decide how much to invest into learning each production technique. If a worker can work for other local manufacturers in the future, he has an incentive to invest too much into the industry-specific skills relative to the firm-specific skills so as to improve his future bargaining position. To avoid this investment inefficiency a firm may then want to limit the ability of a worker to join a competitor in the future and it may be able to do so by locating away from its competitors.

A number of recent papers have investigated the agglomeration patterns of industries and show that they vary greatly in the degree to which they are spatially concentrated (Ellison and Glaeser (1997), Maurel and Sedillot (1999), and Devereux et al. (2004)). Using employment data, all these papers use a version of the 'dartboard' approach put forth by Ellison and Glaeser (1997) and find that between 75% and 95% of industries are 'localized,' that is they differ significantly from a 'dartboard' random location, and only 15% are

'dispersed.' Using exhaustive data on UK plants and treating space as continuous Duranton and Overman (2004) find that 52% of industries are localized whereas 24% of them are dispersed.

There is no shortage of theories that identify economic forces which may contribute to the differences in agglomeration patterns across industries. In particular, in recent years the 'New Economic Geography (NEG)' literature has focused on the interaction of increasing returns to scale at the firm level, imperfect competition and transportation costs as an explanation for agglomeration patterns (Krugman, 1991, Fujita et al., 1999, Baldwin et al., 2003). Assuming that plant size captures the extent of internal scale economies, this literature suggests that localization should be driven mostly by relatively large plants. However, using Italian data, Lafourcade and Mion (2004) show that in some industries small plants show a pattern of localization. Similarly, Duranton and Overman (2004) stress the importance of small firms in driving the agglomeration patterns of some industries. Since, in contrast to NEG models, the mechanism we stress in this paper does not rely of the size of plant - if anything, it is reinforced by plants being small since they are less likely to have monopsony power - it is a candidate to fill the gap left open by these models. It should be very clear though that we view our model as complementing, rather than substituting, existing theories of agglomeration, including the NEG models.

At the heart of our theory lies the hold-up problem which has received widespread attention in the literature on organizational economics (see in particular Williamson (1985) and Hart (1995)). The standard situation that is considered in this literature is one in which a buyer and/or a seller of a good can make relationship investments ex ante and then bargain over the price of the good ex post. If contracts are incomplete, in the sense that the parties cannot contract ex ante over the price of the good, and investments are non-contractible, the agents are likely to under- or over-invest into the relationship. Starting from this observation

the literature has identified a variety of contractual and non-contractual means that allow the agents to mitigate these investment inefficiencies (see Hart (1995)).

This paper is also related to the large literature in labor economics on the incentives of firms and workers to make human capital investments. In a seminal contribution Becker (1964) showed that firms do not invest in workers' general skills if labor markets work perfectly. This theoretical prediction contrasts with the empirical observation that firms sometimes do invest in workers' general skills (see, for instance, Acemoglu and Pischke (1999a)). A number of papers have reconciled the theory with the empirical evidence by showing that, under certain conditions, firms have an incentive to invest in workers' general skills as long as labor markets work imperfectly (see Acemoglu and Pischke (1999b) and the references therein). In this paper we argue that if it is costly for workers to change locations, then the extent of labor market imperfections, and thus the incentive to invest in workers' skills, depends crucially on the location of firms. We then analyze the optimal location decisions of firms taking into account the effect that location has on the labor market and thus on investment incentives.

2 THE MODEL

There are two entrepreneurs, $k = 1, 2$, and a continuum of workers indexed by l, $l \in [0,2]$. Hence, workers are on the 'long side' of the (labor) market and entrepreneurs are on the 'short side.' Each worker is endowed with one unit of labor and each entrepreneur is endowed with one unit of capital. Denote the set of workers employed by entrepreneur k by L_k. The entrepreneurs also have access to a production technology $R(i, L, K)$, where K denotes capital and i the skill of employed workers L. We assume constant returns to scale in L and K. For simplicity, we also assume that there is only one entrepreneur per firm, i.e. $K = 1$, so that we

can describe the technology by $R(i, L)$ for short. We denote the derivative of $R(\cdot)$ with respect to j by $R_j(\cdot)$, i.e. $R_j(\cdot) \equiv \partial R(\cdot)/\partial j$ for $j = i,\ L$.

For convenience, we assume that $R(\cdot)$ is multiplicatively separable in i and L.[4] This, together with the assumption that returns to scale in L and K are constant, implies that we can write $R_L(i, L)$ as $R_L(i, L) = \alpha(L)R(i, L)$ where $\alpha(L) \in (0,\ 1)$ for all $L > 0$. Next, we assume that $R(\cdot)$ is increasing and concave in i, hence we write

(1) $\quad R_j(\cdot) > 0,\ R_{jj}(\cdot) < 0, \quad j = i, L$

for all $i,\ L \geq 0,$ and that the Inada conditions in L and i hold, namely

(2) $\quad \lim_{j \to 0} R_j(\cdot) = +\infty, \quad \lim_{j \to +\infty} R_j(\cdot) = 0\ , \quad j = i, L$

for all $i,\ L \geq 0$. For notational convenience we normalize $R(0,1)$ to zero.

To focus attention on labor market reasons for spatial concentration, and to abstract from goods markets considerations, we assume that firms produce identical products, are price takers in the goods markets and that the location of firms and the wages they pay do not affect the price of the goods they produce. We normalize the price of the final goods to one. As a result, $R(\cdot)$ also describes the gross revenue of the entrepreneur.

We now turn to the spatial environment and the timing of the model. There are two ex-ante identical regions. At the beginning of the game (at time $t = 0$) the entrepreneurs and the workers get together and contract over both the location of the agents and over which entrepreneur each worker joins. We assume that while moving to either region is costless for the agents before any contractual commitment is made, it is prohibitively costly for them to change location once they have agreed on and moved to a specific region. We make the assumption that entrepreneurs and workers contract over location both because it applies to

[4]This allows us to avoid the discussion of a number of uninteresting cases.

many situations and because it simplifies the analysis. A model in which locations are first chosen non-cooperatively by the entrepreneurs and then by the workers gives similar results as those described below.[5]

After the agents have moved to the agreed upon location each worker starts to work for the entrepreneur who has hired him (at time $t=1$). At this stage the workers are unproductive and merely acquire the skills necessary to perform their jobs in the future. We consider the following three cases:

- Case 1 (Workers Make Industry-Specific Investments): Each worker decides how much to invest in his human capital. In particular, each worker chooses $i \geq 0$ and bears the sunk cost of investment $c(i)=i$. Both entrepreneurs value the investments equally.
- Case 2 (Entrepreneurs Make Industry-Specific Investments): Each entrepreneur decides how much to invest in the workers' human capital. In particular, each entrepreneur chooses $i \geq 0$ and bears the per worker sunk cost of investment $c(i)=i$. Both entrepreneurs value the investments equally.
- Case 3 (Workers Make Firm-Specific Investments): Each worker decides how much to invest in his firm-specific human capital. In particular, each worker chooses i_1 and i_2 and bears the sunk cost of investment $c(i_1,i_2)=i_1+i_2$. Investment i_1 is only valued by entrepreneur 1 and investment i_2 is only valued by entrepreneur 2. We refer to i_1 as skill 1 and i_2 as skill 2.

After the investments are sunk (at time $t=2$), the entrepreneurs offer wages and the workers decide whether to continue to work for their current employer or to join the other

[5]Derivations are available from the authors upon request. Also, in their discussion of our model Duranton and Puga (2004) depart from the set up described here by allowing firms to choose locations before the workers do. The results they derive are qualitatively the same as those described below.

entrepreneur.[6] When there is only one entrepreneur in each location she makes the workers a take-it-or-leave-it wage offer and when both entrepreneurs are in the same location they Bertrand-compete for the workers. The results that we derive below are not sensitive to these assumed wage-setting games. All that is needed for our results to hold is that spatial concentration reduces the (labor) market power of the entrepreneurs.

To summarize, the structure of the game is as follows: at $t = 0$ the entrepreneurs and the workers contract over the initial employment and their respective location decisions, at $t = 1$ workers start to work for their initial employer and investments take place, and at $t = 2$ firms compete for trained workers, workers decide whether to change jobs, production takes place, and wages are paid.

The set up that we just described includes a number of strong assumptions. The most important one is that investment decisions are observable but not contractible and that the entrepreneurs cannot commit to wage payments before the investments have taken place. We refer to Hart (1995) and Rotemberg and Saloner (2000) for discussions of these assumptions. A second important assumption is that workers are more mobile within than across local labor markets. We believe that this assumption is reasonable since workers make important location specific investments such as buying a house, making friends, and finding schools for their children. For simplicity we take this assumption to the extreme and assume that once workers have chosen where to live, the cost of moving to another region is prohibitive. Finally, the third key assumption that we make is that the location of firms influences how local labor markets work. Specifically, when firms locate in the same region then competition for workers in the local labor market is very intense. When firms instead locate in different regions they essentially protect themselves against this kind of competition and are able to exert some monopsony power over the local labor force. Here we again take the assumption

[6] They are only able to join the other entrepreneur if she is located in the same region.

to the extreme and assume that competition is 'perfect' when firms locate in the same region and that the firms are monopsonists when they do not. The qualitative results that we derive below are not driven by the starkness of our assumptions.

3 ANALYSIS

We solve the game by backward induction for each one of the three cases. In each case we first derive the equilibrium wages and investments under spatial concentration and spatial dispersion and then analyze which geographic configurations the agents choose at the contracting stage.

3.1 Workers Make Industry-Specific Investments (Case 1)

We first consider the 'standard' case in which the workers make industry-specific investments. In this case, the investments are undertaken by the 'long side' of the market.

Spatial concentration

Suppose first that all agents are concentrated in one region and that all workers have chosen the same investment level i_C^*, where the subscript 'C' stands for concentration. The entrepreneurs then Bertrand-compete for the workers and the Nash equilibrium of the wage setting sub-game is given by (w_1^*, w_2^*), where

(3) $$w_1^* = \arg\max_{w_1} R(i_C^*, L_1) - w_1 L_1$$

with

(4) $$L_1 = \begin{cases} 0 & if\ w_1 < w_2^* \\ 1 & if\ w_1 = w_2^* \\ 2 & if\ w_1 > w_2^* \end{cases}$$

and w_2^* is defined symmetrically. The workers get paid their marginal products and each firm hires an equal number ('mass') of workers, i.e. $w_1^* = w_2^* = R_L(i_C^*, 1)$.

At the investment stage $t = 1$ each worker then invests

(5) $i_C^* = \arg\max_i R_L(i,1) - i.$

Given our assumption that $R(\cdot)$ is separable in *i* and *L*, i_C^* is implicitly defined by

(6) $\alpha R_i(i_C^*,1) = 1,$

where $\alpha \equiv \alpha(1).$

Spatial dispersion

Suppose now that there is only one entrepreneur and a unit mass of workers in each region, a situation we refer to as 'dispersion.' At $t = 2$ the entrepreneurs then offer the reservation wage (normalized to zero) to the workers which they just accept. Anticipating a zero wage at $t = 2,$ the workers have no incentive to invest in $t = 1.$ The optimal investment level under dispersion is then given by $i_D^* = 0.$

Subgame perfect equilibrium

At $t = 0$ the entrepreneurs and the workers agree on the location and initial employment decisions that maximize their joint expected surplus. Note first that due to decreasing returns from labor, it is optimal to allocate workers evenly between entrepreneurs. Note second that the optimal location decision in this case is concentration rather than dispersion since

(7) $R(i_C^*,1) - i_C^* > R(i_D^*,1) - i_D^* = 0$

by (1). However, while concentration is optimal it does not achieve first best since first best would require the workers to invest $i_{FB}^*,$ where i_{FB}^* is implicitly defined by

(8) $R_i(i_{FB}^*,1) = 1.$

Since $\alpha < 1$ the workers under-invest relative to first best.[7] The results of Case 1 are summarized in the following proposition.

> *PROPOSITION 1. If the workers make industry-specific human capital investments, it is optimal for the entrepreneurs and the workers to concentrate in one region. However, even under concentration, the workers under-invest relative to first best.*

The intuition for Proposition 1 is straightforward. The entrepreneurs and the workers can both be made better off if the workers invest in their human capital. However, the workers only have an incentive to do so if the entrepreneurs commit themselves to rewarding human capital investments by paying higher wages. In our set up, in which contracts are highly incomplete, the only way in which entrepreneurs can do so is by locating close to their competitors. However, since workers do not internalize the benefit their investment provides to the entrepreneurs, they under-invest even under concentration. Thus, although concentration mitigates the hold-up problem, it does not solve it entirely.

Proposition 1 is closely related to the analysis in Rotemberg and Saloner (2000) and represents the view that spatial concentration may be efficient if human capital investments are important. We now show that this need not always be the case, that is, we show that concentration is not always optimal when human capital investments are important.

3.2 Entrepreneurs Make Industry-Specific Investments (Case 2)

We now turn to the case in which entrepreneurs invest in the workers' general human capital. Thus, investments are now undertaken by the 'short side' of the market.

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[7]Note that a worker is not the full residual claimant on the returns of his investment. This is the case since capital does not adjust in our model (there is exactly one unit of *K* per firm). Hence, there are decreasing returns in labor and the entrepreneur gets the Ricardian surplus. Since the workers do not internalize the benefit of their investments to the entrepreneur they under-invest from a social perspective.

For given symmetric investments i_C^* (when entrepreneurs are concentrated) or i_D^* (when entrepreneurs are dispersed), the entrepreneurs make, and the workers accept, the same wage offers as in Case 1 (note that i_C^* and i_D^* need not be the same as in Case 1). Thus, under concentration the wages are given by

(9) $$w_1^* = w_2^* = R_L(i_C^*, 1)$$

and under dispersion they are equal to the reservation wage of zero. Note that only under concentration does the wage depend on the human capital investments.

Next we turn to the entrepreneurs' human capital investments at $t = 1$.

Spatial concentration

The entrepreneurs choose the investment level that maximizes their profits, which is the value of production net of wage and investment costs. Under concentration, their optimal investment level is then given by

(10) $$i_C^* = \arg\max_i R(i,1) - R_L(i,1) - i.$$

Since, as argued above, $R_L(i,1)$ is equal to $\alpha R(i,1)$, i_C^* is implicitly defined by

(11) $$(1-\alpha) R_i(i_C^*, 1) = 1.$$

Note the similarity with (6). In each case, the private marginal benefit of the investing party – the left-hand side of equations (6) and (11) – is only a share (α and 1-α, respectively) of the social marginal benefit of making the investment. Hence, both the entrepreneurs in the current case and the workers in the previous one under-invest relative to the first-best, which is given in (8). Here, entrepreneurs under-invest because their labor market competitors can poach their workers.

Spatial dispersion

Under dispersion the entrepreneurs' optimal investment level is given by

(12) $i_D^* = \arg\max_i R(i,1) - i.$

The first order condition to this problem is given by $R(i_D^*,1) = 1$, which is equivalent to the first order condition (8) that defines the first best investment level. Thus, when the entrepreneurs make the human capital investments, dispersion 'solves' the hold-up problem and induces first best investments.[8]

Subgame perfect equilibrium

Since the entrepreneurs invest efficiently when dispersed and under-invest when concentrated, it must be that the total surplus generated under dispersion is larger than that generated under concentration, i.e.

(13) $R(i_D^*,1) - i_D^* > R(i_C^*,1) - i_C^*.$

Thus, at the contracting stage $t = 0$ the agents always agree to disperse. The results of Case 2 are summarized in the following proposition.

> *PROPOSITION 2. If the entrepreneurs make industry-specific investments in the workers' human capital, it is optimal for the entrepreneurs and the workers to disperse. Under dispersion the entrepreneurs take the first best investment decisions.*

The intuition for Proposition 2 is again straightforward. The entrepreneurs and the workers can both be made better off if the entrepreneurs invest in the workers' human capital. However, the entrepreneurs only have the right incentive to do so if they do not get 'punished' for investing in the workers human capital by having to pay higher wages. If an entrepreneur is located close to her competitor then she does have to pay a higher wage to a more skilled worker since competition for workers makes wages contingent on i (see (9)). She therefore

[8]In contrast to workers in Case 1, firms are the residual claimants on the return on i and, as such, they face the correct investment incentives from a social point of view.

does get 'punished' for investing in the workers' human capital, which reduces her incentive to do so. If an entrepreneur is not located close to her competitor, in contrast, she will not have to pay a higher wage to a more skilled worker since the worker does not have the option to work for the competitor. In other words, the entrepreneurs are residual claimants on the investment returns. The entrepreneurs' incentives to invest in the workers' human capital are therefore stronger under dispersion than under concentration.

The labor literature that we briefly discussed in the introduction argues that labor market imperfections improve the incentives of firms to invest in workers' general skills since "labor market imperfections […] turn general skills into *de facto* specific skills" (Acemoglu and Pischke, 1999b, F120). In this model firms can turn general skills into de facto specific skills, and thus improve their investment incentives, by locating in different regions.

Note the different implications of Proposition 1 and 2. While Proposition 1 shows that spatial concentration may be efficient if human capital investments are important, Proposition 2 shows that this need not always be the case. In particular, whether concentration or dispersion provides the right investment incentives depends crucially on who is making, and bearing the costs of, the investments. If the workers do so, then concentration is optimal since concentration ensures that the workers get rewarded for human capital investments through higher wages. If the entrepreneurs do so, however, dispersion is optimal since dispersion ensures that the entrepreneurs do not get punished for human capital investments through higher wages.

3.3 Workers Make Firm-Specific Human Capital Investments (Case 3)

The previous two subsections have shown that the role that human capital investments play in the location decisions of firms depends crucially on who is making the investments. We now show that it also depends on whether the investments are industry- or firm-specific.

In particular, we now allow the workers to invest in two different, entrepreneur-specific skills. We denote the skill that is specific to entrepreneur k by i_k and the output of entrepreneur k by $R^k(\cdot), k = 1, 2$. Before solving the game using backward induction, it is useful to consider the first best solution.

First best investment decisions

Due to the decreasing returns from labor, joint surplus is maximized if each entrepreneur employs a unit mass of workers. Suppose then that entrepreneur k employs a unit mass of workers. Recall also that the cost of total skill acquisition now takes the form

(14) $c(i_1, i_2) = i_1 + i_2,$

which generalizes the form of *c(i)* we assumed in Cases 1 and 2. To maximize joint surplus, worker $l \in L_1$ should then invest

(15) $i^*_{1,FB} = \arg\max_{i_1} R^1(i_1, 1)$

into skill 1 and $i^*_{2,FB} = 0$ into skill 2. Worker $l \in L_2$ should do the reverse. Note that $i^*_{1,FB}$ in (15) is equivalent to i^*_{FB} in (8).

The intuition for these results is straightforward. On the one hand, the workers should not invest into skills that they do not use since these investments bear a social cost and do not generate a social return. On the other hand, they should invest into the skills that they do use,

taking into account the return from that investment for themselves and their employers. We now solve the game in the usual manner.

Spatial concentration

Suppose for now that all agents are located in the same region and that the workers invested equally into skill 1 and skill 2, i.e. $i_1 = i_2 = i_C^*$. Then by the same reasoning as in Cases 1 and 2, the entrepreneurs offer wages $w_1^* = w_2^* = R_L^k(i_C^*, 1)$, $k = 1, 2$. The workers accept these wage offers.

At the investment stage $t = 1$ the workers always invest the same amount into skills 1 and 2 to make themselves equally attractive to both entrepreneurs. Thus, under concentration, all workers invest

(16) $$i_C^* = \arg\max_{i_k} R_L^k(i_k, 1) - i_k, \quad k = 1, 2$$

into both skills. To see this, note that if the entrepreneurs Bertrand-compete for the workers, each worker gets paid his marginal product in the job in which he is least productive, i.e. $w_k^* = \min\left\{R_L^\kappa(i_C^*, 1)\right\}_{\kappa=1,2}$. Since the investments are costly, it immediately follows that, in equilibrium, workers never invest more in one skill than in the other. Since we can once again write $R_L^k(i_k, 1) = \alpha R^k(i_k, 1)$, i_C^* is implicitly defined by

(17) $$\alpha R_{i_k}^k(i_C^*, 1) = 1, \quad k = 1, 2.$$

Under concentration workers therefore under-invest in the 'useful' skill and over-invest in the other, 'redundant' skill. It is privately optimal for each worker to invest in the redundant skill since this improves his bargaining position (at time $t = 2$) and thus his future wage. However, since he never uses this skill in equilibrium his investment is socially wasteful. Each worker under-invests in the useful skill since he anticipates that he will not receive the full return from his investment in equilibrium.

Spatial dispersion

Suppose next that the agents are dispersed, that is there are one entrepreneur and a unit mass of workers in each region. At $t = 2$ the workers again receive a zero wage and, anticipating this wage, they do not invest in either skill at $t = 1$. The optimal investment level under dispersion is then given by $i_D^* = 0$ for both skills. Under dispersion the workers therefore under-invest in the useful skill and invest efficiently (namely not at all) in the redundant skill.

Subgame perfect equilibrium

We just saw that, under concentration, the workers invest too little in the useful skill and too much in the redundant skill while, under dispersion, they invest even less in the useful skill but efficiently in the redundant skill. The optimal location decision at $t = 0$ then depends on the relative magnitude of the under-investment and over-investment inefficiencies. In particular, the agents will concentrate if the return from inducing the second best investments in the useful skill outweighs the costs of inducing inefficient over-investment in the redundant skill, i.e. if

(18) $$R^k(i_C^*, 1) - 2i_C^* > R^k(i_D^*, 1) - i_D^* = 0,$$

and they will disperse otherwise. Note that, in spite of the assumed Inada conditions, the left-hand side of (18) can be positive or negative, depending on the exact form of $R(\cdot)$. The following proposition then follows from the above analysis.

> *PROPOSITION 3. If the workers make firm-specific human capital investments the agents concentrate if and only if the return from inducing the second best investments in the useful skill outweighs the costs of inducing inefficient over-investment in the redundant skill, i.e. if and only if (18) holds.*

Our model is too parsimonious to perform very insightful comparative statics. However, it is straightforward to analyze extensions of the model to gain additional insights. For instance, if one allows for the marginal investment cost to be equal to $c > 0$ one can apply the envelope theorem to show that an increase in the investment costs makes dispersion more likely (since it makes the over-investment more costly).

It is also straightforward to analyze the effect of changes in workers' (labor) market power on the likelihood of dispersion. Suppose, for instance, that if the agents are dispersed the workers get to make a take-it-or-leave-it offer with probability $p \in [0,1]$, so that increases in p capture an increase in their market power (so far we assumed $p = 0$). It is straightforward to show that a small increase in p does not affect the inequality (18) while a large increase in the workers' market power does affect (18) and in particular makes dispersion more likely. This is the case since more market power in the dispersed situation induces the workers to invest more in the useful skill but does not induce them to invest more in the redundant skill.

4 CONCLUSION

The purpose of this paper was to analyze the role of human capital investments in the location decisions of firms and to caution against the view that human capital investments always act as a force for spatial concentration. The model we developed is stylized and simple. This allows us to highlight important, basic economic forces and analyze their effect on the location decisions of firms. Also, in spite of its simplicity, the model generates a number of hypotheses that are empirically testable. First, if human capital investments are industry-specific we would expect firms to be less concentrated if they, rather than the workers, are making the investments. Second, we would expect industries to be less concentrated if

workers can make firm-specific investments than if they can only make industry-specific investments.

Straightforward extensions of our model can provide additional testable implications. Suppose, for instance, that workers can make both industry-specific and general-purpose investments. We would then expect industries to be concentrated but located away from other industries. This induces workers to invest in the useful industry-specific skill and not waste effort acquiring general-purpose skills that they do not use. In the case of the accordion industry, this suggests a reason why this industry is not only very concentrated but also located far away from other industries (a typical pattern, for instance, for the Italian 'industrial districts').

The difficulty with actually testing the hypotheses of this model is that location and human capital investments are both endogenous. One possible solution to this problem may be to exploit the exogenous differences across countries with regards to legislation that obliges firms to provide training for their workers. For instance, the model would predict that in countries, such as Germany, in which firms are obliged to provide some general training firms are more dispersed than in countries in which this obligation does not exist.[9]

The model could be extended in a variety of ways. For instance, one could relax our stark assumptions about the labor market by modeling labor market competition more explicitly. Also, it would be interesting to endogenize the specificity of the investments. Finally, one could analyze how the location of firms affects their willingness to pay for worker trainings.[10] We leave these extensions for future research.

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[9] We thank one of the referees for pointing this out to us.

[10] In the German apprenticeship system employers bear most of the cost of providing employees with the opportunity to acquire industry-specific skills (see Acemoglu and Pischke (1999b) and the evidence cited therein). It is an open theoretical and empirical question to what extent the willingness of firms to participate in the system depends on how close they are located to their competitors.

To conclude, we believe that labor market considerations play a potentially important role in the location decisions of firms. We hope that the above analysis sheds more light on these issues and will lead to future empirical research that further evaluates their importance.

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