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Investment in Human Capital in the Development of Clusters:
A Theoretical Approach

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Abstract: The main objective of this work is to analyze the investment in human capital in the development of clusters. The starting point of the analysis is to understand the concept of general and specific training proposed by Gary Becker (1964) in a dynamic perspective, where what begins as specific becomes general as the cluster develops. In the beginning of the process, a cluster is not formed yet and a single firm provides specific training. As the cluster grows and new firms of the same sector come, the training becomes less specific and more general once now other firms can use the skills of those trained workers. Consequently, firms will be less willing to invest in human capital and the suboptimal equilibrium may be overcome only if a third party comes to offer training to all workers.

1. Introduction

The importance of human capital and learning for industrial development, especially in the development of clusters, is well known in the literature. The role of inter-firm alliances and mutual information exchanges for the innovation process is one of the central points of the discussion. In examining innovation dynamics in the London region, Gordon and McCann (2005) found evidence that agglomeration economies enhance the innovation process in a diffuse and flexible manner. They did not find strong links between inter-business connections and innovation and say that “the importance of especially local informal information spillover for successful innovation is very much more limited than has been suggested” (p.523). The distinction between tacit and codifiable knowledge is also an aspect frequently highlighted by the economic geography literature. Lawson and Lorenz (1999), for instance, study how the relation of tacit knowledge to the innovation process can explain regional competitive advantages.

Many articles examine and test the positive effect coming from the interaction of firms (Hudson, 1999; Pinch *et al*, 2003). However, in the model proposed here, the agglomeration of firms can have positive and negative effects, depending upon the stage

of the development of clusters. Identifying different stages of development is also highlighted by research on cluster formation. For example, Yamamura *et al.* (2003) investigate the role of human capital in different stages of development, showing that formal schooling has been more important for later stages, whereas know-how played a major role in the formation of a garment cluster in Japan. Regarding the negative aspect of competition, Shaver and Flyer (2000) find empirical support in the U.S. manufacturing industries for a convincing argument that firms with the best technologies, human capital and training programs have little motivation to geographically cluster since their strength can spill over to competitors. Firms with the weakest characteristics are those that benefit from the agglomeration economies creating, therefore, an adverse selection.

The objective of this paper is to explore the role of investment in human capital in the development of clusters. As will be seen, the geographic proximity of firms with similar production processes can add interesting aspects to the problem. In the next section, a review of the relevant literature will be provided; section 3 introduced the model. The main focus of the paper is provided in section 4 where various concepts of market equilibrium are explored. The process starts with a single firm and the conditions for training to the case where there are a finite number but many firms and to a case with an infinite number of firms. In the latter case, various forms of equilibrium are explored formally and graphically. A third part (university) offering training is then introduced and alternative equilibria explored. The paper concludes with some discussion of the findings and suggestions for further elaboration of the model.

2. Literature Review

In the literature about investment in human capital, one important point is related to the fact that firms investing in training have no guarantee that they will fully benefit from the increase in productivity of their workers since workers may switch jobs after receiving training and, as a consequence, future employers can capture part of the productivity improvement (Becker, 1964; Acemoglu, 1997; Acemoglu and Pischke, 1998; Acemoglu and Pischke, 1999; Shaver and Flyer 2000). For firms, the most desirable scenario is, on one hand, not to spend any money on training and, on the other hand, to be able to attract

workers that have been trained by other firms. This free-rider problem, which will be explored in more detail later, provides important implications for the analysis concerning investment in training and is the central issue of the present work.

Before examining the implications coming from the free-rider problem in terms of both wages and which party (firms or workers) should pay for training, two conditions should be presented so that those implications can be better understood. The first condition is about the nature of the labor market. Hiring workers from other firms requires a certain level of mobility of workers; in a perfectly competitive market, where agents have complete information and labor mobility, the free-rider problem is maximized and firms have to pay the marginal productivity every period. As workers become less mobile for any reason such as the lack of either information or competition among firms, or the existence of enforceable contracts, the opportunistic behavior turns out to be more difficult for firms.

In his analysis, Becker (1964) assumes perfect competition to examine the implications coming from the type of training provided by firms, which is the second condition that allows firms to act opportunistically. Becker defines two types of investment in human capital: general and specific training. According to him, “General training is useful in many firms besides those providing it [...] ‘Perfectly general’ training would be equally useful in many firms and marginal product would rise by the same extent in all of them” (p. 33 and 34). In this case, firms can try to hire trained workers from other firms. Therefore, under conditions of perfect competition, firms do not have any incentive to pay for general training, which raises the marginal productivity of workers in all firms because they cannot collect the return of investment in the subsequent periods since the wage rates paid by any firm are determined by the marginal productivity in other firms. As consequence, trainees have to pay for general training.

In contrast, skills acquired in specific training increase the productivity for the production process of the firm providing it to a greater extent than for any other firm (completely specific training would have no effect on productivity in other firms’ processes). Thus, in the case of specific training, the marginal productivity in any other firm would be lower than in the one providing it and, as result, the latter can pay less than the workers’

marginal productivity after training without running the risk of losing employees. Hence, the return of investment undertaken in the first period is collected in the second period, assuming that the firm and the trained employee stay together after the first period. Therefore, as long as firms and workers share both the training costs in the first period and the return of investment in the second period, there is a disincentive for both firm and employee to terminate the relationship before the end of the second period. From an incomplete contracting perspective, it could be said that once both parties keep some residual right (see Grossman and Hart, 1986), and with employees able to change jobs and firms able to fire employees, the risk of investment should be shared as well.

Note, however, that, using Becker's distinction, there can be no objective definition for general and specific training since it is not possible to identify the type of training by examining only the firm providing it. The crucial aspect that makes it specific or general is the possibility of other firms using the skills obtained by workers in training. Therefore, the characterization must come from an analysis that takes into account the entire group of firms of a market (or a region). In fact, the neighbors of the firm providing training are those that define the type of training.

This consideration has critical implications for the analyses about investment in human capital in any dynamic environment where some sectors grow and others decline. In a dynamic environment, whether training is designated specific or general is dependant not on the training itself, but on changes in the environment. In other words, it happens not necessarily because the training itself has been modified; rather it can change as a consequence of structural changes of the economy. In fact, Reich (1992) noted that an employee entering the labor market in the 1990s could expect to have to undergone retraining 4 or 5 times during the course of his lifetime (in contrast to only modest reinvestment for those entering the labor market fifty years earlier). Thus, inter-temporal allocations (the timing and frequency of investment in re-training) and expectations about the structural changes in the economy that might affect specific labor demands present further complications for the articulation of optimal behavior on the part of both firms and labor.

The main objective of this paper is to analyze the investment in human capital in the development of clusters. While cluster-based development strategy has become very popular, relatively little attention has been paid to the human capital issue and the optimal strategy of cluster members (whose composition will change as the cluster evolves). In the beginning of the process, a cluster is not formed yet and a single firm provides specific training. As the cluster grows and new firms of the same sector enter, the training becomes less specific and more general now that other firms can use the skills of those trained workers. Consequently, firms will be less willing to invest in human capital and the suboptimal equilibrium will be overcome only if a third party enters to offer training to all workers. Given that training activity presents fixed costs, the third party enters in the market only when the number of firms is large enough, i.e., after a threshold the clustered firms begin benefiting from some scale economies. Thus, this model tries to capture the tension between the negative effects from the regional competition among firms, empirically shown in Shaver and Flyer (2000), and the benefits from scale economies; which seems to be both a critical element in the cluster development and widely neglected by the literature.

Whenever one analyzes clusters, the first mission should be to define them, which is not a trivial task as the literature has shown. However, before investigating research that has focused on this definition and specifying how clusters should be seen here according to the purposes of the work, it is worth introducing the insightful model by Acemoglu (1997) that, using the paradigm proposed by Becker (1964), examines training in an imperfect labor market. In contrast to what has been proposed here, Acemoglu (1997) assumes that “human capital is general in the sense that the worker can use his skills with any firm” (p.447). However, because his model deals with a frictional labor market, firms may pay part of the cost of training.¹ Besides, firms can improve the efficiency of their production process by buying a new machine. The productivity comes from the combination of the investment in physical and human capital. In his world, firms need a worker to produce fixed output following a Leontief production function. If separated, they produce nothing. As will be seen, the same idea is used in the present model.

¹ About this, see Acemoglu and Pischke (1998 and 1999).

A fundamental feature of the technology is that, for each pair firm/worker, there is a probability that an adverse match-specific shock occurs at the end of every period. In this case, the output falls to zero for all future periods. Once the adverse shock happens, both parties seek new partners. Every agent finds a partner; however, there is no guarantee that workers who have more training will match with firms with the new machine since the process is random. According to Acemoglu (1997), this imperfect matching is an important difference between frictional and competitive labor markets. Moreover, he assumes that looking for a second partner within the same period is too costly and, consequently, firms and workers find profitable to reach an agreement in the first matching.

Note, therefore, that when a high-tech firm hires a well-trained worker, both can maximize their return. Nonetheless, the adverse match-specific shock can occur at the end of the period and they will have to start a random search for a new partner. Thus, agents maximize their outcomes given the matching, but there is no rational motivation for workers (firms) to switch (replace) jobs (their employees). In the model to be presented in the next section, workers will change their firms for higher wages, whereas firms with no trained workers will try to replace them with trained workers.

In the determination of wages, Acemoglu's model follows a bargaining rule where the gross surplus of partnership is shared by both parties. They jointly maximize the total surplus, since they can write a long-term contract and utility is perfectly transferable, by choosing the optimal level of training (the author explains the main result of the article assuming no investment in physical capital).

However, as noted earlier, if the adverse shock occurs at the end of the first period, they will terminate the relationship. In this case, the outcome of the worker will not be affected (again: assuming constant and equal technology across firms) because the worker will share the same surplus with her future employer, whereas the outcome for the firm in the second period depends on the distribution function of training among workers.

Here resides the key point of his model. There is a positive probability (adverse shock) that firms will not benefit from the level of training provided for its employee in the first period; a future employer will capture it. Consequently, and the main conclusion of the

article, is that the investment in general skills will be suboptimally low once “part of the productivity gains from general training will be captured by future employers” (p.445). This opportunistic behavior is identified in the present model as well. The possibility of attracting a trained worker in the beginning of the second period from other firms (or, looking at those that provide training, the possibility of losing a trained worker) creates a disincentive for firms to invest in human capital. In the present model, as the ratio between firms that provide training and those that do not provide decreases, not only the incentive to provide training declines but also the expected outcome. Even though Acemoglu’s work offers many interesting insights about how to model the problem, it is worth emphasizing that the environment is distinct: while he analyzes the investment in human capital in an imperfect labor market, the purpose here is to study the implications of the development of clusters for training, which can generate a dialectic mechanism where development creates unsatisfactory conditions for strengthening the cluster.

In his article about clusters and networks, Steiner (2002) begins his analysis saying that “Clusters have the discreet charm of being obscure objects of desire” (p.208). According to Feser and Bergman (2000), many cities and states have proposed developing cluster-based strategies during the 1990s. Despite this appealing aspect of clusters, both studies agree that cluster issues are worthy of a careful analysis about their assumptions and presumed benefits since “the logic behind such initiatives [developing cluster-based strategies] is often poorly specified or simply not recognized as relevant” (Feser and Bergman, 2000; p. 2). Following the same track, Martin and Sunley (2003) emphasize the lack of precise concepts regarding clusters in their analysis and suggest cautious and circumspect use of the notion, especially within a policy context. They close the abstract of the paper saying that “the cluster concept should carry a public policy health warning” (p.5).

One can find in the economic literature different definitions and reasons for the existence of clusters. According to Steiner (2002), clusters might be interpreted “as a system of production which is more than just a territorial concentration of specific firms working in the same sector, but one which involves complex organizations with tight trans-sectorial relationship (...) They are an essential element of the debate on the ‘new economic geography’, which emphasizes economies of scale and scope, the importance of transport

costs, and hence of the advantages of proximity” (p.208). Fujita *et al.* (1999) opens a chapter about industrial clustering citing Silicon Valley and proposing models that enable “us to study the forces for agglomeration within each industry as well as within the manufacturing sector as a whole. It allows us to move from the question ‘Where will manufacturing concentrate (if it does)?’ to the question ‘What manufacturing will be concentrated where?’” (p. 283). Fujita and Thisse (2002) explain the industrial agglomeration forces by dividing the Marshallian externalities into two types: (1) the localization economies that occur as consequence of the proximity of firms producing similar goods and (2) the urbanization economies, “which are defined by all the advantages associated with the overall level of activity prevailing in a particular area” (p.267).

The spillover effects of knowledge and, consequently, innovations are repeatedly utilized as advantages shared by clustered firms. Silicon Valley and all kinds of high-tech clusters are often cited by the literature to emphasize the role played by innovations. Despite the emphasis on the importance of firms’ interaction, other local advantages are also pointed out such as specialization of the labor force and proximity to inputs to justify the existence of low-tech clusters. Therefore, what can be gleaned from the definitions is that the cluster formation theory always tries to understand *why a given location is desirable for a specific manufacturing complex*.

The Competitive Advantage of Nations published by Porter (1990) and his subsequent work have become very influential in the course of the last two decades. Porter’s theory claims that the competitive advantage of an industry can be defined by evaluating the presence of five forces related to suppliers, customers, rivalry, the existence of substitute goods, and barriers to entry into the market. His analysis stresses the importance of the economic location of the industry, arguing that the competitive advantages coming from those five forces are heavily localized. However, in Porter’s view, the geographic proximity should not be seen as a criterion for determining the existence of clusters; rather the boundaries are defined by the linkages and spillover effects among firms. Thus, the geographic aspect is a consequence of the fact that those forces are often localized, instead of being a necessary condition for the determination of clusters (Feser and Sweeney, 2000; Martin and Sunley, 2003). Regarding whether or not the geographic

aspect should be included in the definition, Feser and Bergman (2000) claim that the appropriateness of any definition depends on the policy objective involved.

Martin and Sunley (2003) point out that there is a “lack of clear boundaries, both industrial and geographical” (p.10) in Porter’s definition. According to them, the level of industrial aggregation, how strong the linkages among firms have to be, and how economically specialized the local concentration has to be are some of the questions for which Porter’s theory has no answer. In the authors’ point of view, Porter’s ideas are “deliberately vague and sufficiently indeterminate as to admit a very wide spectrum” (p.9) of conditions and features. “Rather than being a model or theory to be rigorously tested and evaluated, the cluster idea has instead become accepted largely on faith as a valid and meaningful ‘way of thinking’ about the national economy” (p.9). In their conclusion, Martin and Sunley (2003) say that the “cluster literature is a patchy constellation of ideas, some of which are clearly important [...] and some of which are either banal or misleading” (p.28).

As have been shown, the definition of cluster is somewhat controversial. For the purposes of this work, clusters are here defined as a group of firms that present two characteristics: (1) the production processes are similar enough so that the skills acquired in training provided by one firm can be useful for other firms of the group and (2) firms are located near enough such that workers have mobility among them. Thus, the geographical and industrial boundaries are determined according to these two requirements. The important point for this work is not a precise definition for clusters; rather the key aspect is about the implications that the agglomeration of firms producing related goods can generate in terms of investment in human capital. What is investigated here is the fact that whenever there are a group of firms using similar production processes, the investment in human capital may be discouraged as a response to the presence of opportunistic behavior among firms.

3. The Model

The model construction follows the framework proposed by Becker (1964), incorporating assumptions and conclusions from Acemoglu (1997) and Acemoglu and Pischke (1998,

1999). Initially, the scenario is designed. Following Acemoglu's (1997) model, firms adopt a Leontief production function and are formed by the owner providing the physical capital which is essential for production, and one worker. Firms and workers are risk neutral. According to Acemoglu (1997) and Acemoglu and Pischke (1998, 1999), in an imperfect labor market, firms pay part of the training, even when the skills might be captured by other firms. In this model, as will be seen, the labor market is imperfect because firms and trained workers do not have perfect matching once agents do not have full information.

However, the model departs from Acemoglu (1997), in that training will be either more specific or more general depending only on the number of the firms belonging to the same cluster and not on the specificities of the training itself. Therefore, there is only one 'type' of training, which is useful for all firms of a cluster and firms decide whether or not they should invest in human capital. The variable 'training' is discrete, i.e., firms do not decide the amount of training; rather they choose between 'training' and 'no training'.

The growth of the cluster happens according to following process: the number of firms increases when, randomly, a new firm migrates from another region bringing its worker; and the number of firm decreases when a firm of the cluster dies. In the later case, the worker of the firm that died leaves the region. Thus, the flows of workers and firms are coincident and the numbers of firms and workers are always the same. Therefore, there is no unemployment.

Nonetheless, as will be seen, whether or not firms pay wages equal to the marginal product will be irrelevant. The developing process explained above assures a constant ratio of firms to workers so that the outcome of the bargaining processes between workers and firms does not vary over time. It is assumed that firms pay W_1 and W_2 for a non-trained worker in a two-period contract. Moreover, the firms of the cluster analyzed here sell their products to a large market and that the cluster size does not affect prices. These simplifications are convenient to allow the model to emphasize the central question: what happens to the investment in human capital as the cluster grows.

Note that (1) training is useful exclusively for firms belonging to the same cluster and (2) new firms come from outside of the region. Hence, there is no interaction between the

cluster and the rest of the economy and, as consequence, its development can be analyzed separately. Thus, the analysis starts with a single firm with only one decision to be made: it may or may not provide training to its employee. By assumption, training is entirely depreciated in one period. In other words, training provided in period j is fully consumed in period $j+1$. Today's decision does not depend on the decision made in the past because there is no knowledge accumulation over time and firms decide by looking at the current period and period immediately following. In fact, as will be seen after the model presentation, two additional assumptions will be necessary to guarantee that firms deal with two-period maximization, instead of solving a Bellman-equation problem.

At the beginning of the first period, firms and workers make an incomplete contract that determines the wages for both periods and whether or not the worker will receive training in the first one, but the contract does not prevent her from quitting the job or the firm from firing the employee. It is similar to what Acemoglu (1997) proposes; a relationship defined in a long-term contract that can be terminated in case of an adverse shock. Here, at the end of the first period, workers may find a new partner that might pay higher wages and, in this case, they undertake a bargaining process and proceed to an agreement. There is no search cost.

Besides firms and workers, there is a third party in this model (which will be called 'university' from now on). It is assumed that there are many universities outside the market waiting for profitable conditions to get into it. Thus, one of them gets into the market as soon as the number of the cluster's firms is large enough to make the training activity profitable and, as a result of the competition among them, the university always charges its average costs. However, the university will be introduced in the last part of the model analysis.

In Becker (1964), when firms provide training in the competitive equilibrium, the present value of return exactly equal costs:

$$MP'_0 + \sum_{t=1}^{n-1} \frac{MP_t - W_t}{(1+i)^t} = W_0 + C \quad (1)$$

In equation (1), the first terms on the right and left sides represent, respectively, the marginal productivity of trainees and the wage elsewhere of trainees. The second term on the left shows the present value of the return from training and C is the cost of training.

Assuming that firms pay for all costs and $MP'_o = W_0$, the return exactly equals the costs of training. If some productivity is foregone as part of the training program, $MP'_o < W_0$, and the return will be greater than costs. If only workers pay for training, the return is zero and $MP'_o - C = W_0$ (this is the case of general training). As discussed in the previous section, when firms provide specific training, in order to provide an incentive to both parties to stay together in the future, firms and workers should pay part of the costs.

In the imperfect market analyzed here, firms face the following utility functions when they, respectively, provide (tr) and do not provide (ntr) training:

$$U(tr) = P_1 - (W_1 - k) - C + \frac{(1-l)(P_t - W_t) + l(P_2 - W_2)}{1+r} \quad (2)$$

$$U(ntr) = P_1 - W_1 + \frac{(1-g)(P_2 - W_2) + g(P_t - W_g)}{1+r} \quad (3)$$

In equation (2), the first three terms represent, respectively, the productivity of the worker in the first period, the wage of the trainee, $(W_1 - k)$, and the total cost of training. It is important to highlight two assumptions: (1) k is the amount paid by the worker for training, which corresponds to the decrease in productivity caused by training (2) the total cost of training (C) incorporates both the money spent by the firm to pay training and k . Since firms pay part of the costs:

$$C > k \quad (4)$$

Despite the fact that workers trained in period j are more productive in period $j+1$, the decrease in productivity caused by training is the same in absolute terms (k) for trained and non-trained workers. This outcome implies that workers trained in period j spend fewer hours to get trained in period $j+1$ than those that do not receive training in period j . l is the probability of losing the trained worker to any other firm. Thus, the second term shows the outcome when the firm and the worker agree to stay together in the second

period. P_{tr} and W_{tr} stand for, respectively, productivity and the wage of a trained worker. To simplify analysis, profit without training can be normalized to zero, i.e., $W_1 = P_1$ and $W_2 = P_2$.

In equation (3), W_g , is the wage paid by a firm that hires a trained worker from another firm and g is the probability of attracting a trained worker from another firm. To attract the trained workers in the end of the first period, firms have to pay more than the worker would receive if she stayed with the original employer. However, firms cannot pay more than the productivity of trained workers.

$$W_{tr} < W_g < P_{tr} \quad (5)$$

Therefore, firms and workers can split the surplus $P_{tr} - W_{tr}$. By assumption, the surplus of the partnership is equally shared:

$$W_g = W_{tr} + \frac{P_{tr} - W_{tr}}{2} \quad (6)$$

The key point of the model resides in the determination of the variables l and g . Assume that $n = x + z$, where x and z are, respectively, the number of firms that provide and that do not provide training, and n is the total number of firm in this market. If firm j provides training, l represents the probability that its employee finds a new partner at the end of the first period. If firm j does not offer training, g is the probability that firm j hires a trained worker in the end of the first period to replace its non-trained worker. Note that the probability of finding a new partner is a function of z and x , but the outcome of the bargaining process does not depend on them. Workers have time to negotiate with just one firm. Then, l can be defined as a function of x and z , such that:

$$0 \leq l(x, z) \leq 1 \quad (7)$$

$$l(x, 0) = 0 \quad (8)$$

$$l(x, z) > 0 \text{ for } z > 0 \quad (9)$$

$$\frac{\partial l(x, z)}{\partial x} < 0 \text{ for } l(x, z) > 0 \quad (10)$$

$$\frac{\partial l(x, z)}{\partial x} = 0 \text{ for } z = 0 \quad (11)$$

$$\frac{\partial l(x, z)}{\partial z} > 0 \quad (12)$$

Recall that l represents the probability that the trained worker finds a new partner and quits her original job. Hence, property (7) is straightforward. Properties (8) and (9) say that if all firms provide training, the probability of losing a trained worker is zero and positive otherwise. Property (10) means that more firms providing training reduces the chance that a particular firm loses its trained worker. The opposite happens if the number of firms that do not provide training increases as shown in (12). When z goes to infinity, $l(x, z)$ goes to one.

Following the same idea, g can be defined as a function of x and z , such that:

$$0 \leq g(x, z) \leq 1 \quad (7')$$

$$g(0, z) = 0 \quad (8')$$

$$g(x, z) > 0 \text{ for } x > 0 \quad (9')$$

$$\frac{\partial g(x, z)}{\partial z} < 0 \text{ for } g(x, z) > 0 \quad (10')$$

$$\frac{\partial g(x, z)}{\partial z} = 0 \text{ for } z = 0 \quad (11')$$

$$\frac{\partial g(x, z)}{\partial x} > 0 \quad (12')$$

When x goes to infinity, $g(x, z)$ goes to one.

To make the model more realistic, an additional assumption captures the effects of the agglomeration of those firms belonging to the cluster. Given the size of the city, it is assumed that:

$$l(z, x) < l(\delta z, \delta x) \text{ for any } \delta > 1 \quad (13)$$

$$g(z, x) < g(\delta z, \delta x) \text{ for any } \delta > 1 \quad (13')$$

4. Market Equilibrium

One firm: the basic condition for training- Initially, it is assumed that there is only one firm in the market. In this case, the firm has no uncertainty about the future; it will have a trained worker in the second period as long as it provides training in the first period and it will certainly have a non-trained worker otherwise. Therefore, there is no room for opportunistic behavior and, consequently, the market with only one firm is the most encouraging situation for training. If training is not worth it in this case, it will never be worth it.

The first task is to find the condition in which training would be desirable. Note that, with one firm in the market, l and g are equal to zero. Using equations (2) and (3), training is desirable as long as:

$$P_1 - (W_1 - k) - C + \frac{(P_{tr} - W_{tr})}{1+r} > P_1 - W_1 + \frac{(P_2 - W_2)}{1+r} \quad (14)$$

which implies (assuming $W_2 = P_2$):

$$W_{tr} < P_{tr} - (C - k)(1+r) \quad (15)$$

and

$$(C - k) < \frac{(P_{tr} - W_{tr})}{(1+r)} \quad (16)$$

Equation (15) shows the maximum wage the firm can pay in the second period so that training is still advantageous. The left side of equation (16) is the amount the firm spends on training, which has to be less than the return on training, in present value. As noted, if this condition does not hold, training will never be worth the investment in any circumstance. Therefore, condition (16) is a key assumption of the model.

Many (finite) firms: wages and fixed points- Workers agree to pay for training as long as their expected gains in present values do not change. Besides, there is no reason for firms to pay their employees more than the workers would earn without training. Thus, W_t can be determined as follows:

$$W_1 + \frac{W_2}{(1+r)} = W_1 - k + \frac{(1-l(z,x))W_{tr} + l(z,x)\left(\frac{P_{tr} - W_{tr}}{2} + W_{tr}\right)}{(1+r)} \quad (17)$$

$$W_{tr} = \frac{2k(1+r) + 2W_2 - l(z,x)P_{tr}}{2-l(z,x)} \quad (18)$$

Note that the last term of the right side of equation (17) shows that the worker takes into consideration the probability of finding another firm with which she can bargain.

In case there is only one firm in the market, l is zero and W_t will be:

$$W_{tr} = k(1+r) + W_2 \quad (19)$$

The next step is to see what happens to the wage of the second period when the number of those firms that do not provide training increases:

$$\frac{\partial W_{tr}}{\partial z} = \frac{\partial W_{tr}}{\partial l} \frac{\partial l}{\partial z} = \frac{2W_2 + 2k(r+1) - 2P_{tr}}{(2-l)^2} \frac{\partial l(z,x)}{\partial z} \quad (20)$$

It is known that $\frac{\partial l(x,z)}{\partial z} > 0$ and $(2-l)^2 \geq 0$. Then the derivative in (20) is negative as long as:

$$W_2 + k(r+1) - P_t < 0 \quad (21)$$

Using Equation (19), condition (21) becomes:

$$P_{tr} > W_{tr} (l=0) \quad (22)$$

Since the assumption (4) notes that firms pay at least part of the total training costs, firms have to obtain a return in the second period and, consequently, condition (22) holds. As a result:

$$\frac{\partial W_{tr}}{\partial z} < 0 \quad (23)$$

Therefore, as the number of firms that do not invest in human capital increases, the trained worker turns out to have a larger range of firms interested in her knowledge. Consequently, *training becomes more general and the worker accepts a contract that*

determines a lower wage for the second period once she incorporates into her expectation the probability of benefiting from a new partner at the end of the first period.

Whenever firms decide to provide training in period t , they sign a new contract to define both the wage for the period $t+1$ and the amount (k) workers will pay for training in period t . Note that if firms provide training in period $t-1$ the decision in period t does not change. In this case, W_1 is replaced by W_{tr} in the *both* utility functions (17) and (18) and everything else remains the same.

In Becker's framework, when training is general, firms do not pay for it and wages in the second period correspond to the marginal productivity. In contrast, firms pay less than the marginal productivity when they provide specific training in the first period. Here, the more general the training, the lower are the wages in the second period. What seems to be a contradiction, in fact, is a coincident result. In the present model, workers and firms write a two-period contract and the present value of payments is what really matters. Therefore, lower wages in the second period, everything else being constant, means that the worker is paying more for training.

A relevant aspect to be highlighted here is the fact that the probability (l) of finding a new partner for the second period affects the wages established by contract (W_{tr}); however, the reverse is not true. Increasing the wage of the second period does not affect the worker's chance of meeting another firm with which to bargain. As long as W_{tr} is lower than the worker's productivity (P_{tr}), l is a function only of x and z .

The graphic analysis starts by assuming that the number of firms ($n = x + z$) in the market is finite and greater than one. In figure 1, while n is fixed, x (number of firms providing training) varies.

The derivative $\frac{\partial U(t)}{\partial x}$ defines the slope of the curve "training", which can be computed as following:

$$\frac{\partial U(tr)}{\partial x(x, z)} = \frac{\partial U(tr)}{\partial l(x, z)} \frac{\partial l(x, z)}{\partial x} \quad (24)$$

Since W_{tr} is a function of l , from (2) and (18), the expected utility is defined as:

$$U(tr) = P_1 - (W_1 - k) - C + \frac{(1-l(z,x))(P_r - \frac{2k(1+r) + 2W_2 - l(z,x)P_r}{2-l(z,x)}) + l(z,x)(P_2 - W_2)}{1+r} \quad (25)$$

then:

$$\frac{\partial U(tr)}{\partial x} = \frac{-P_r + \frac{2k(1+r) + 2W_2 - l(z,x)P_r}{2-l(z,x)} - \frac{(1-l(z,x))[2k(1+r) + 2W_2 - 2P_r]}{(2-l(z,x))^2}}{1+r} \frac{\partial l(z,x)}{\partial x} \quad (26)$$

since $\frac{\partial l}{\partial x} < 0$, then $\frac{\partial U(tr)}{\partial x} > 0$ if and only if:

$$-P_r + \frac{2k(1+r) + 2W_2 - l(z,x)P_r}{2-l(z,x)} - \frac{(1-l(z,x))[2k(1+r) + 2W_2 - 2P_r]}{(2-l(z,x))^2} < 0 \quad (27)$$

which leads to the following condition:

$$P_r > k(1+r) + W_2 = W_r(l=0) \quad (28)$$

The right side of (28) is exactly the wage of the trained worker when there is only one firm in the market. Since this is the best scenario for firms providing training, condition (28) holds by assumption. Therefore, ‘training’ curve is increasing in x .

As result, $\frac{\partial U(tr)}{\partial x}$ is positive and *training provided by one firm generates a positive externality to all other firms providing training.*

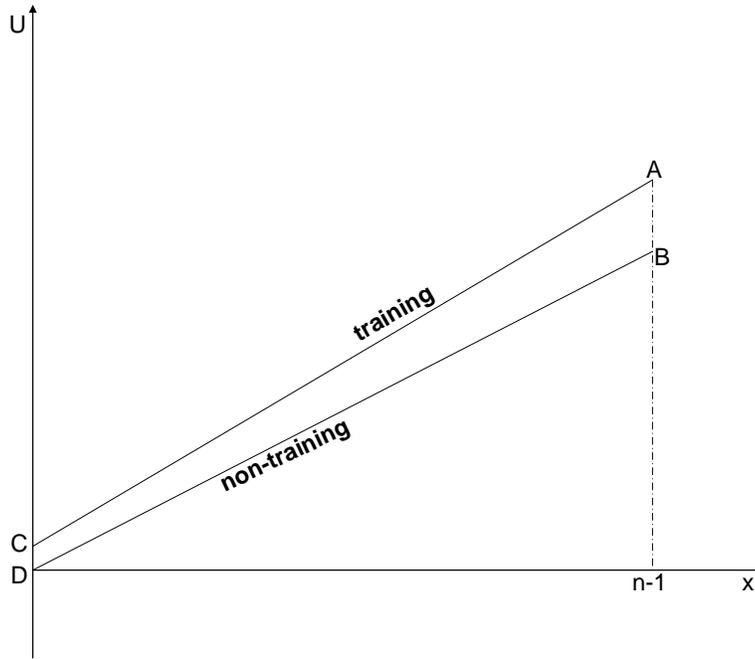


Figure 1: Expected utility of firm j according to the decision about training

Note that there are two effects on firm j coming from the training provided by firm, say, h . First, as firm h provides training, the chance of the worker of firm j meeting a new partner (which does not provide training) in period two is reduced. On one hand, W_{tr} increases, which is harmful for firm j . On the other hand, the probability that firm j loses its employee in the end of first period diminishes. The positive slope of curve ‘training’ shows that the second effect over compensates the first one.

Regarding the slope of the ‘non-training’ curve, it is not possible to assure a positive slope unless the functions $l(x,z)$ and $g(x,z)$ were specified. It happens because the derivative involves both $l(x,z)$ and $g(x,z)$ as equation (29) shows. Workers take $l(x,z)$ into account to define their wages, whereas $g(x,z)$ is the probability that firm j can attract a trained worker for the second period.

$$\frac{\partial U(W_{tr}(l(z,x)), g(z,x))}{\partial x} = \frac{\partial U(W_{tr})}{\partial W_{tr}(l)} \frac{\partial W(l)}{\partial l(z,x)} \frac{\partial l(z,x)}{\partial x} + \frac{\partial U(g,l)}{\partial g(y)} \frac{\partial g(z,x)}{\partial x} \quad (29)$$

and:

$$\frac{\partial U(W_{tr}(l(z, x)), g(z, x))}{\partial x} = -g(z, x)W'_{tr}(l)l'_x(z, x) + (P_{tr} - W_{tr}(l))g'_x(z, x) \quad (30)$$

From (30), it can be shown that the condition for the expected utility to be an increasing function of x is:

$$(P_{tr} - W_{tr}(l)) > g(z, x)W'_{tr}(l) \frac{l'_x(z, x)}{g'_x(z, x)} \quad (31)$$

Even though it is not possible to determine the slope of the ‘non-training’ curve, it seems to be reasonable to assume that it is positive because, as will be seen, it is easy to show that the expected utility at point D is always higher than at point B regardless of the number of firms (n). Concerning the shape of the curve, note that a straight line satisfies all the economic assumptions listed above (7-13 and 7'-13'). For expositional purposes, the curves ‘training’ and ‘non-training’ will be considered as straight lines as shown in figure 1.²

Note that, in figure 1, training is always desirable and the only Nash equilibrium is all firms choosing ‘training’ (point A). This outcome may change when n increases. To explore this outcome, it is important first to analyze what happens to points A , B , C , and D as the number of firms in the cluster increases. Point A shows the expected utility of firm j when it provides training together with all other firms. In other words, $l = 0$ at point A , i.e., the probability that the employee is attracted by any other firm is zero. Recall that in figure 1 n is constant. However, when every firm provides training, l will always be zero and the expected utility is the same regardless of the number of firms (n) in the market. Thus point A does not move as n increases (see equation 11).

² In fact, the assumption about the shape of the curves does not need to be so restricted. To get the same results as those shown in this model, the only necessary assumption about the shape of curves is that they cross each other no more than one time. However, even if they do cross more than one time, the tendency of incentive for training remains the same.

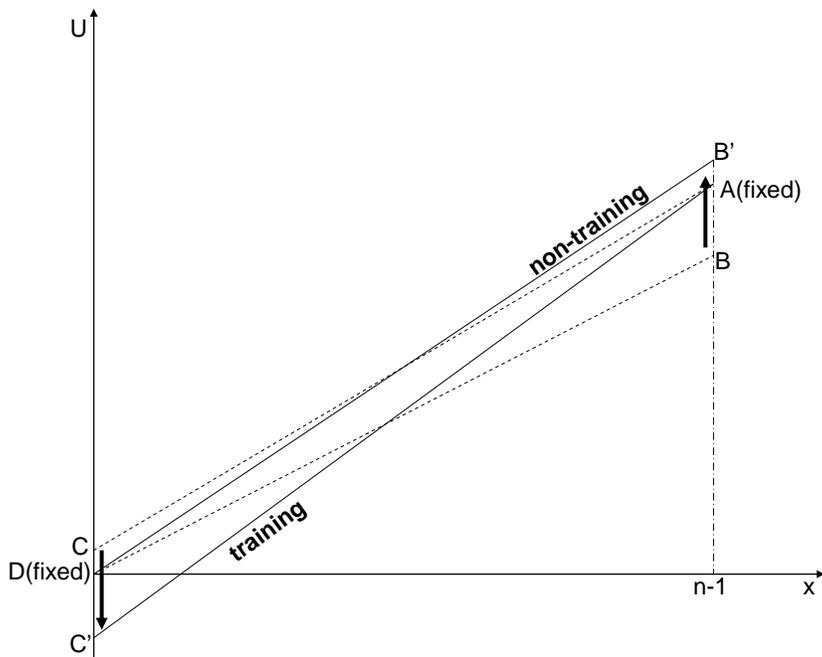


Figure 2: Changes in expected utility of firm j when n increases

The same thing can be said about point D ; in this case, no one provides training and there is no trained worker in the market, i.e., $g = 0$, regardless of n . Point D , as point A , does not move as n varies (see equation 11'). Point C represents the situation where firm j is the only one providing training. Therefore, l is greater than zero and it goes up as n increases because more firms will try to contract firm j 's worker and, consequently, the expected utility (point C) decreases, as shown in figure 2. The reverse happens to point B : Once all firms are providing training ($z = n-1$) except firm j , the probability that firm j finds a trained worker for the second period increases as z increases, which, in turn, increases firm j 's expected utility.

Even though the limits of this process have to be understood and covered in the next section, figures 1 and 2 show the main result of this chapter: *as the number of firms in the cluster increases, training becomes 'more general' and, as result, the Nash Equilibrium has the tendency to go from 'everybody training' to 'nobody non-training'*.

Infinite firms: limits and Nash Equilibrium – The question here is how far points B and C can move. First, however, the expected utilities in points D and A will be determined. At point D , firms provide no training ($g(x) = 0$), including firm j . The reverse occurs at point A ; all firms are providing training ($l(x) = 0$). Thus, the expected utilities are:

$$U_D(ntr) = P_1 - W_1 + \frac{P_2 - W_2}{(r+1)} = 0 \quad (32)$$

$$U_A(tr) = P_1 - (W_1 - k) - C + \frac{P_{tr} - W_{tr}}{(r+1)} = k - C + \frac{P_{tr} - W_{tr}}{(r+1)} \quad (33)$$

In (32), by normalization, the utility of firms that neither invest in human capital nor hire a trained worker for the second period is zero. Equation (33) shows the case where firms invest in human capital and keep their workers in the second period. As long as the return from training is greater than the amount spent on it, the utility is positive.

Points C and B are functions of n . As in this case, n is infinite, l and g are equal to 1, respectively, at points C and B .

$$U_B(ntr) = P_1 - W_1 + \frac{P_{tr} - (W_{tr} + \frac{P_{tr} - W_{tr}}{2})}{(r+1)} = \frac{P_{tr} - W_{tr}}{2(r+1)} \quad (34)$$

$$U_C(tr) = P_1 - (W_1 - k) - C + \frac{P_2 - W_2}{(r+1)} = k - C < 0 \quad (35)$$

When firm j does not provide training and can surely hire a trained worker for the second period they obtain what is described in (34). Note that the utility is half of the return of training. This difference comes from the bargaining process and represents the cost of not having established a contract with the worker in the first period and having taken her from other firm.

Finally, in (35) firm j invests in human capital and cannot keep its worker for the next period. Therefore, despite the training provided, firm j obtains no return of investment. It happens whenever firm j is the only one to provide training among an infinite number

of firms. Since C is the total cost of training and k is the amount paid by the worker, the total utility is always negative.

The first conclusion from this analysis is that when there are many firms in the market and they do not provide training, point C is below point D , i.e., *training is no longer desirable for firm j* .

The minimum number of firms in the market (n) that makes firm j not provide training can be determined from condition (36). Note that, now, l is a function of x and z where $x = 1$ (firm j) and $z = n-1$.

$$U_c(tr) = P_1 - (W_1 - k) - C + \frac{(1-l(z,x))(P_{tr} - W_{tr}) + l(z,x)(P_2 - W_2)}{1+r} \leq 0 \quad (36)$$

It can be shown that:

$$l(z,x) \geq 1 - \frac{(C-k)(1+r)}{(P_{tr} - W_{tr})} \quad (37)$$

Therefore, if the amount spent by firm j , $(C-k)(r+1)$, equals the return, any positive value of $l(z,x)$ results in firm j not providing training. If the numerator is zero, firm j does not pay for training costs, but training is always desirable. Finally, when the left side is equal to the right side in equation (37), points D and C are coincident.

Examining the other side of figure 2, with infinite firms in the market, point B will be higher than A as long as:

$$k - C + \frac{P_{tr} - W_{tr}}{(1+r)} < \frac{1}{2} \left(\frac{P_{tr} - W_{tr}}{(r+1)} \right) \quad (38)$$

which leads to:

$$\frac{1}{2} (P_{tr} - W_{tr}) < (C-k)(1+r) \quad (39)$$

When there are infinite firms providing training, firm j will have a trained worker in the second period regardless of its decision in the first period. However, if firm j does not provide training, it will have to pay an additional amount in the second period in the bargaining process to take the worker from her original firm. Training will be desirable

only if its costs are smaller than the additional amount paid by the firm to take a worker from another firm.

Letting n be finite and greater than one, point B (where $x = n-1$) will be higher than A as long as:

$$k - C + \frac{P_{tr} - W_{tr}}{(1+r)} < g(z=1, x=n-1) \frac{1}{2} \left(\frac{P_{tr} - W_{tr}}{(r+1)} \right) \quad (40)$$

$$g(z=1, x=n-1) > 2 - \frac{2(C-k)(r+1)}{P_{tr} - W_{tr}} \quad (41)$$

The same result is obtained if training costs are less than half of the return of firms providing training; training is always desirable.

Comparing inequality (41) with inequality (37):

$$l(z=n-1, x=1) > 1 - \frac{(C-k)(r+1)}{P_{tr} - W_{tr}} > \frac{g(z=1, x=n-1)}{2} \quad (42)$$

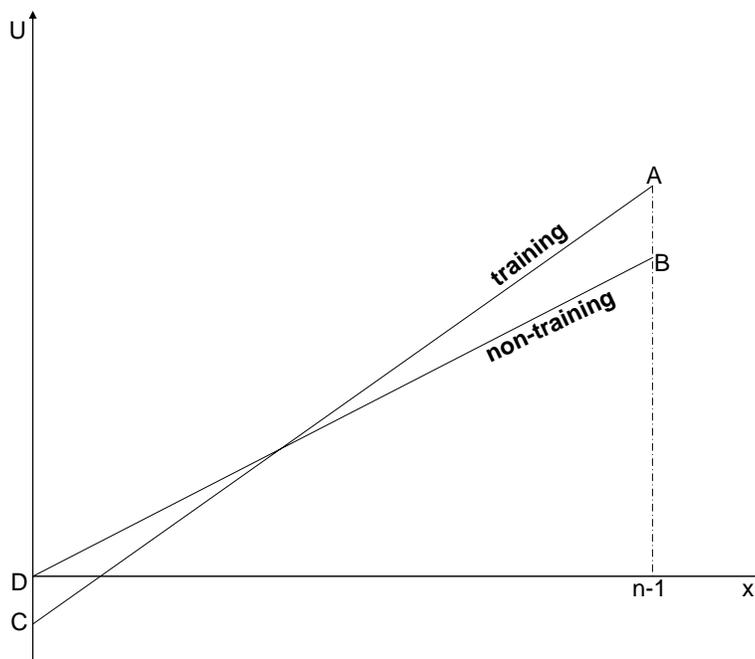


Figure 3: The second stage with two Nash Equilibria.

In this framework proposed, there are four possible cases. The first situation is characterized by figure 1, where there is only one Nash Equilibrium; all firms invest in human capital (point *A*). The second one is represented by figure 2; when n is large enough, firms decide not to provide training (point *D*).

The third and fourth cases are in figure 3 and 4 respectively. In figure 3, there are two Nash Equilibria: points *A* (all firms provide) and *D* (no firm provides). That will be the case as long as the condition (42) is satisfied. The first inequality in (42) assures that point *C* is below point *D* and the second one implies that point *A* is still above point *B*. If both inequalities are satisfied, the ‘training’ curve crosses the ‘non-training’ curve from below.

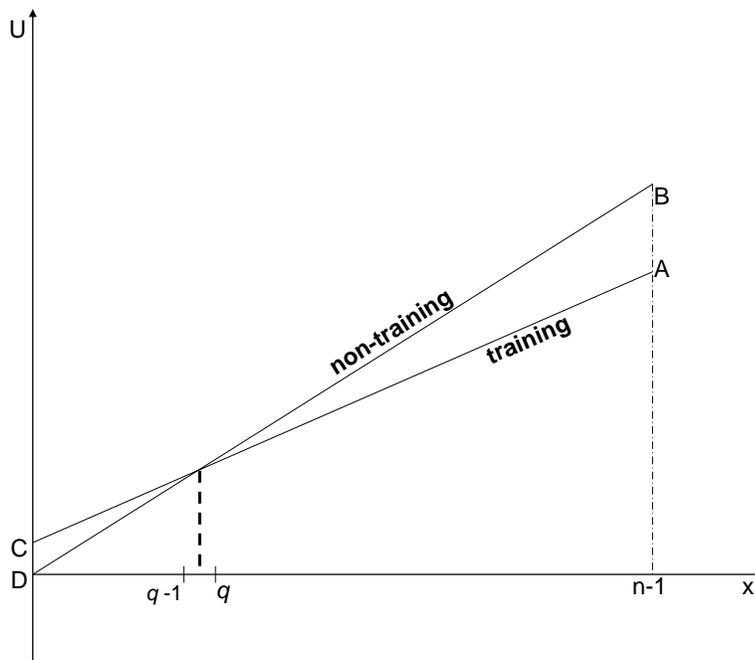


Figure 4: The second stage with only one Nash Equilibrium

If the condition (42) is not satisfied and condition (43) holds, the equilibrium turns out to be determined by figure 4, where the only Nash Equilibrium is point Q with q firms investing in human capital.

$$l(z = n - 1, x = 1) < 1 - \frac{(C - k)(r + 1)}{P_{tr} - W_{tr}} < \frac{g(z = 1, x = n - 1)}{2} \quad (43)$$

Summarizing the results, it can be said that:

Assumption 1: With only one firm in the market, training is desirable;

Assumption 2: Firms pay part of training;

Then: \exists a positive y such that, for $n < y$, there is only one equilibrium in which all firms choose ‘training’ and, for $n \geq y$, in at least one equilibrium some firms do not provide training.

Based on what has been presented, as a cluster develops, it faces one of those three sequences of equilibria described in figure 5. In all cases, for small n (first stage), all firms choose ‘training.’ If assumption (42) is valid, the second stage will be the one represented by cases 1 and 2. Otherwise, there will be a unique equilibrium as in case 3. Since firms pay part of training, in case 3 for n big enough, firms do not invest in human capital. Notice that, in case 2, it is assumed that inequality (39) does not hold and, then, the second case does not have the third stage.³

³ Notice that as n increases, the intersection point goes up in northeast direction in cases #1 and 2, whereas it goes down in southwest direction in case #3. This is a direct result of the assumption about the agglomeration of firms belonging to the cluster. To see this aspect, assume that $x = z$ over time. When the number of firms of cluster increases, keeping $z = x$, matching between firms and workers becomes more likely, which is advantageous for firms that do not provide training and harmful for firms that provide training.

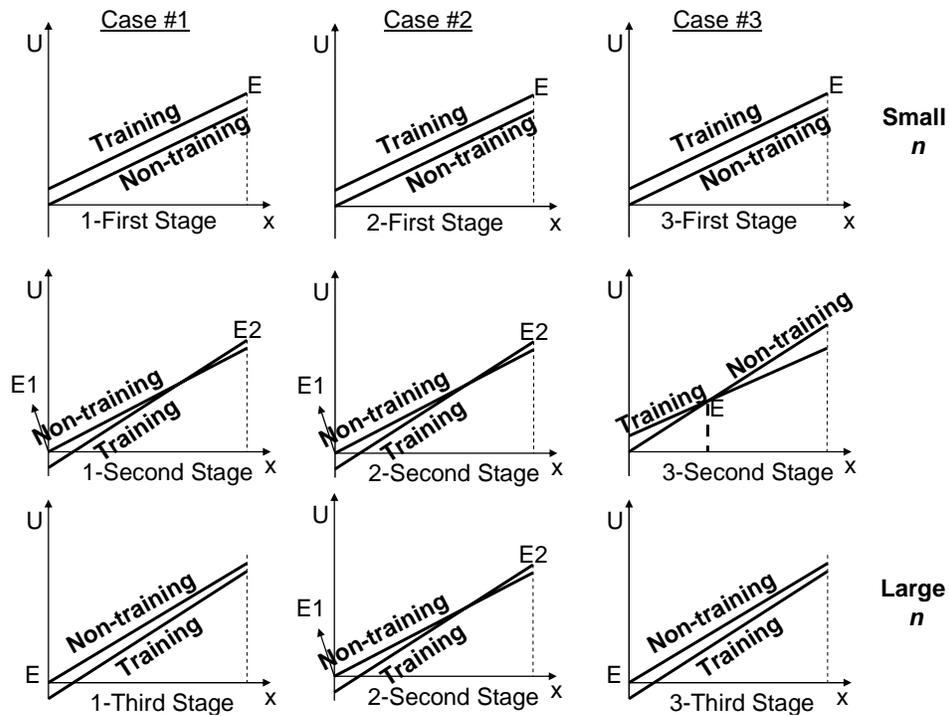


Figure 5: Stages of the development of clusters

The main conclusion of this discussion is that firms have less incentive to invest in human capital as the number of firms belonging to the cluster increases as shown in figure 6.

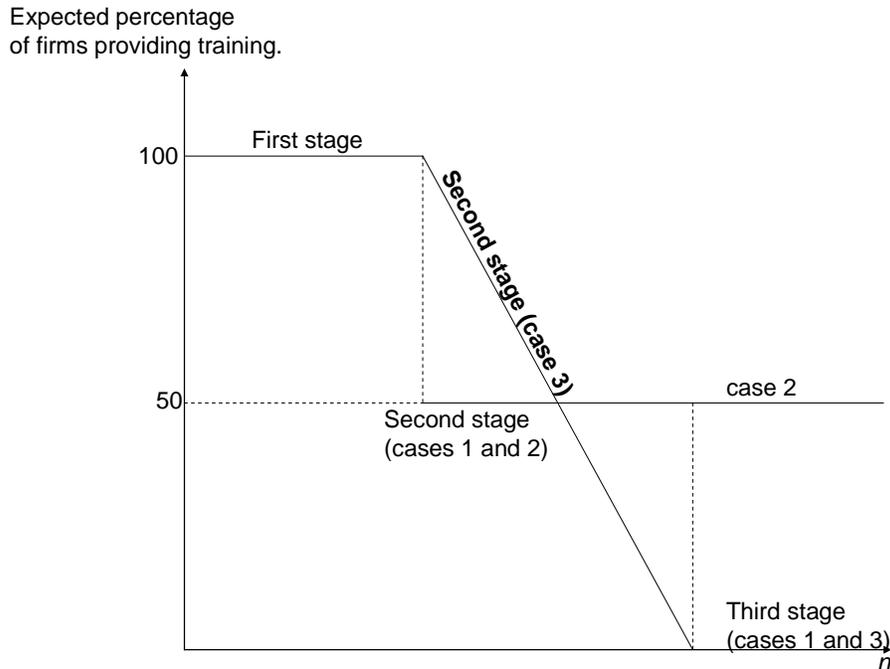


Figure 6: Expected percentage of firms providing training (case #2 has only first and second stages)

University- In this section, the third party (University) is introduced into the model. The idea is very straightforward: making the additional assumption that those training activities present fixed costs, the third party comes into the market as soon as demand is big enough and, then, training becomes cheaper and thus shifts the ‘training’ curve up in the figures already presented. As a result, training turns out to be more likely.

In general, the literature combining education and economics has been related to four main topics. First, the economic education literature has explored the learning process and its aspects such as outcome from instruction, courses and programs, and methods and materials.⁴ Secondly, many articles have examined the social and private returns of education and, based on the framework proposed by Becker (1967), have tried to estimate them.⁵ Thirdly, policy analyses about the outcomes of different education systems form

⁴ see Marlin and Duden (1993) for a detailed literature review

⁵ See Card (2001) for an analyses and review about difficulties in schooling return measurement

the third topic that the literature has been concerned about.⁶ The fourth area of study is related to the local spillover effects coming from Universities and private corporations that invest in R&D.⁷

It seems there is an absence of research modeling the education-service suppliers. Even though this section does not require a complete “theory of firm” for the education sector, it is important to construct a cost structure for educational institutions. The first assumption made here says that there are ‘general’ fixed costs to implement a new University. Moreover, once the university is in operation, starting a new course requires some specific fixed costs, which are, by assumption, constant across courses. Those specific fixed costs represent the needs of new classrooms, laboratories, etc. However, the ‘general’ fixed costs are justified by the fact that the university can benefit from some economies of scope once the new course can use both management services of the central administration and professors from other departments.

Thus, the total cost is defined as follows:

$$T_u = F_g + \beta F_s + \beta n M g \quad (45)$$

Where β is the number of courses offered, Mg is the marginal costs, and n is the number of students in each course. As noted in the introduction, it is assumed there are many Universities in the regional market; thus forcing the first comer to charge its average cost. Thus, tuitions (and fees) are going to be:

$$E = \frac{F_g}{\beta n} + \frac{F_s}{n} + M g \quad (46)$$

There is just one course useful for the cluster. In contrast, the other courses are more general; they are useful for all sectors, except for workers of the cluster. These assumptions are made to address the following question: how large does the city and the cluster have to be so that the University can start a course focused on the cluster’s needs? Thus, given n , β is a measure of the size of the city, whereas n will indicate the smallest cluster that can benefit from education provided by an institution.

⁶ Miyagiwa (1991), Fraja (2002), and Glomm and Ravikumar (1992)

⁷ See Jaffe (1989) and Acs et al. (1992, 1994)

In order not to overload workers, which would require the introduction of leisure into the model, it is assumed that they leave the job earlier to obtain training. Thus k is still what is discounted from their wages (W_l) and firms pay for tuition.

Finally, in a market with a single firm ($n = 1$), it is always cheaper for the firm to offer training itself than paying the specific fixed costs of the University, even in a metropolitan area where β is very high. It happens because firms can benefit from some economies of scope: machines, human resources and infrastructure are already there. It means that:

$$C - k < F_g + Mg = E(n=1, high\beta) \quad (47)$$

The University will start course only if:

$$C - k > \frac{F_g}{n\beta} + \frac{F_s}{n} + Mg \quad (48)$$

Which is the same as:

$$n > \frac{F_g + \beta F_s}{\beta(C - k - Mg)} \quad (49)$$

When the number of firms willing to provide training is high enough (x^*), the University starts offering the course. Then, as x increases, the costs of education decline. Note that when n goes up x^* moves to the right as shown in figure 7.

To focus on the main modification caused by the introduction of university in this model, it is important to reconsider figure 5, where the three cases and their stages are shown. In the first stage for all cases, when n is too small, the University does not enter the market and there are no changes in the results. Even if n is big enough so that the University can start the course in the first stage, the only change is the slope of part of the ‘training’ curve, as shown in figure 7, and firms benefit from lower education costs, but the number of trained workers remains the same (all workers).

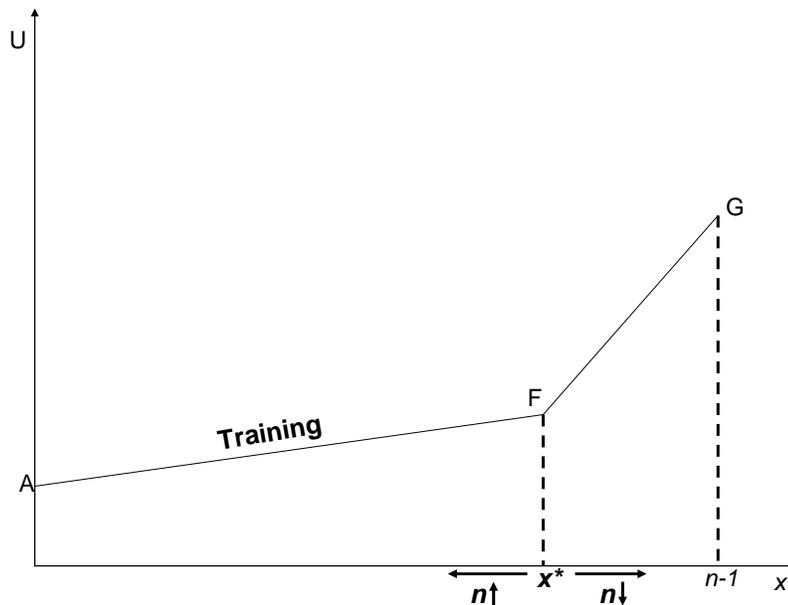


Figure 7: ‘Training’ curve when the University is considered in the model

A similar analysis can be used to interpret the second stage in cases #1 and #2; with the University in the market, there will be still two Nash Equilibria. In the second stage of case #3, the University may or may not introduce a new equilibrium, depending on the decrease in costs. However, the original equilibrium remains valid. While the University does not strongly impact the outcomes of the first two stages, it may considerably change the outcomes of third stage.

First, note that there is no third stage in case #2 because training is so profitable that, as seen before, inequality (50) holds:

$$\frac{(P_{tr} - W_{tr})}{2(1+r)} > (C - k) \quad (50)$$

The cost of taking the trained worker out of her original firm is higher than the amount firms pay for training. In other words, training costs are less than half of its return. Therefore, for case #2, the University only reduces the cost of training, but there are still two Nash Equilibria: (1) all firms provide training and (2) no firm provides training.

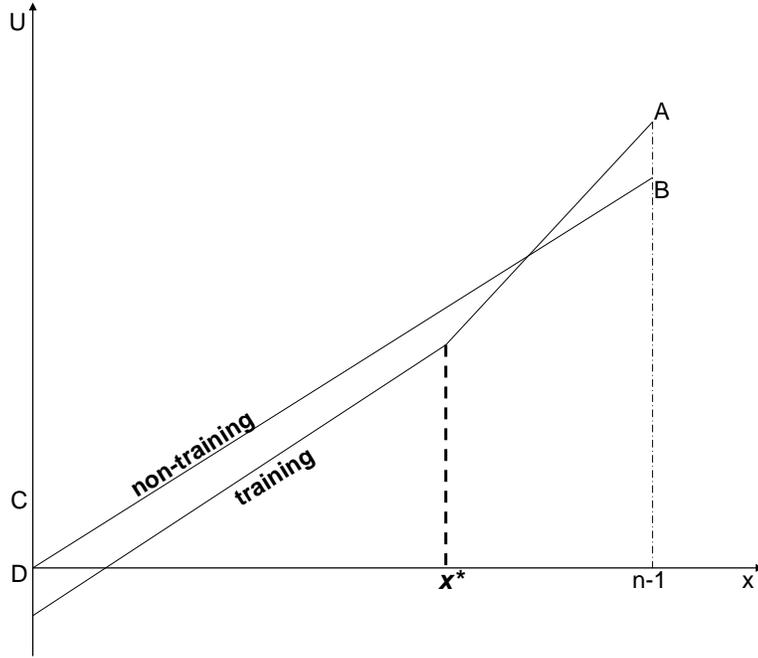


Figure 8: Third stage when inequality (51) holds

In contrast, for the third stage (cases #1 and #3), inequality (50) does not hold and there is a unique equilibrium; no firm provides training. However, when the University enters the market, there will be two Nash Equilibria as long as:

$$Mg < \frac{(P_{tr} - W_{tr})}{2(1+r)} - \frac{F_g}{\beta n} - \frac{F_s}{n} \quad (51)$$

Therefore, as long as $Mg < \frac{(P_{tr} - W_{tr})}{2(1+r)}$, there is n^* such that there will be two Nash

Equilibria for any $n \geq n^*$, where n^* is:

$$n^* = \frac{2(F_g + \beta F_s)(1+r)}{\beta[(2 - g(z=1, x=n-1))(P_{tr} - W_{tr}) - 2(Mg)(1+r)]} \quad (52)$$

This outcome seems to be the most important change caused by the introduction of the University into the model; for developed clusters, instead of having one (bad)

equilibrium; there are two equilibria and one of them is all firms investing in human capital (see figure 8).

However, there is a second fundamental positive effect that cannot be seen graphically; the University strongly facilitates an agreement among firms to prevent the cluster from the bad equilibrium, driving the cluster to a good equilibrium. Before the University comes, any agreement among firm in favor of training was not possible because training was provided inside each establishment and, therefore, training could not be verified by other firms. With the university, not only do training costs and learning process become homogenous across firms and workers, but also any betrayal can be easily verified.

Therefore, for a sector in which the return of training is less than twice its costs, the University tends to move the equilibrium from one where all firms choose ‘non-training’ to another where all firms choose ‘training’ at very low costs. Assuming that firms with trained workers have more chance of surviving, it is clear that the University may be essential for the cluster development.

In figure 9, it is assumed that the University comes to the market at the moment in which the third stage starts. Comparing figure 9 with 6, the University does not change the percentage of firms providing training in the case #2 with no agreement. Even in this case, the expected utility is increasing in n as a consequence of decreasing training costs. For cases #1 and #3, with or without agreement, it is easy to envisage a sort of U-shape curve.

Given the ‘general’ fixed cost, the distance between n^{**} and n^* depends on β (the city size), as shown below:

$$n^* = \frac{2(1+r)}{[(2-2l(z,x)-g(z,x))(P_r - W_r) - 2(Mg)(1+r)]} \left(\frac{F_g}{\beta} + F_s \right) \quad (53)$$

Thus, in a hypothetical small city, where there are only firms of the cluster, β is one and they have to afford both specific and general costs.

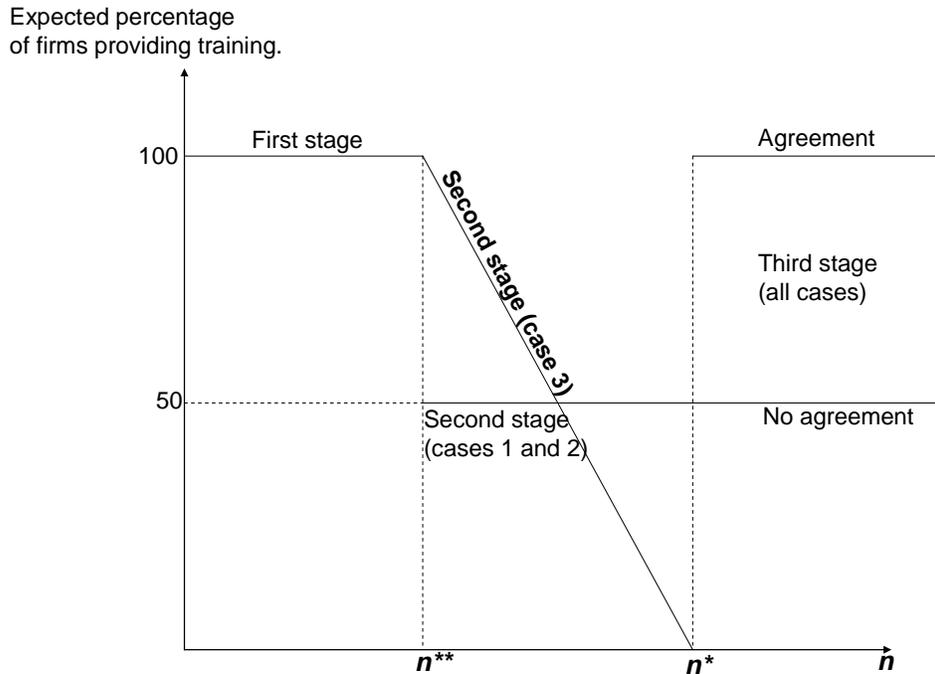


Figure 9: Increasing in the percentage of firms providing training

5. Discussion and Conclusion

Given their criticism about the vagueness of the concept and definition of cluster, especially those proposed by Porter, Martin and Sunley (2003) state that “clusters, it seems, have become a world-wide fad, a sort of academic and policy fashion item” (p.6). Specifically about Porter’s ideas and the popularity of them, the authors finish their article saying that “fashionable ideas tend to share one thing in common: they all eventually become unfashionable”.

What has given clusters “the discreet charm of being obscure objects of desire” (Steiner, 2002, already cited in the introduction)? It seems that clusters have had the charm of being an object of desire especially because the understanding about them has proved to be obscure. Porter’s ideas will not become unfashionable unless the literature can offer better definitions and explanations about how clusters work. However, under this obscure scenario, looking for a more precise definition and discussing whether one is better does not provide useful contributions to the debate. As long as the literature is not

able to answer some fundamental questions, any definition is both acceptable and useless and, consequently, rhetoric defines the level of popularity.

In trying to answer the fundamental question, it seems that the literature has overestimated the importance of interaction among firms and neglected the negative effects from competition within a delimited area. The overestimation of knowledge spillover highlights an additional problem. As the task of modeling learning and innovation has not been fully accomplished, models on clusters become very straightforward and somewhat tautological: assuming the existence of spillover of knowledge leading firms to agglomerate to benefit from it.

Surely, the negative effects of competition should not be used to explain the success of clusters? However, the permanent tension between the benefits of scale economies and the negative effects coming from the spatial competition is essentially what differentiates clusters from an isolated firm. In this context, the relevance of this work can be summarized as follows: A theoretical model is constructed to capture the tension between those two forces and identify the consequences of them for knowledge diffusion by examining the investment in human capital.

The starting point of the work is to understand the concept of general and specific training proposed by Becker in a dynamic perspective, where what begins as specific becomes general as the cluster develops. As soon as training turns out to be useful for more than one firm, competition generates a disincentive for firms to invest in human capital. After a threshold, the returns to scale allow the University to come into the market, which, in turn, allows firms to invest again in training.

Note that whatever is advantageous for more than one firm, human capital, suppliers, market, is the object of dispute among them; however, the competition can be especially harmful if some ex-ante investment is required and its return is excluded. In this sense, the role of the University is to separate the bulk of investment from returns. Now, different agents undertake different tasks and there is a significant reduction in both inter-temporal dependence and risk. The University invests today and derived the return today, whereas firms pay much less for training today, because of scale economies, to benefit tomorrow.

As happens in all models, the results presented here are based on the assumptions and some of them should be seen as limitations of the model. Some of them are discussed below. A critical feature of this model is the probability functions of finding a new partner in the labor market. On one hand, the fact that functions $l(z,x)$ and $g(x,z)$ are not specified makes the model more general and avoids algebraically complicated results. On the other hand, the proofs and analyses of the results require caution. The lack of specification leads the model to alternative scenarios, each one satisfying different conditions related to the behavior of the curves – ‘training’ and ‘non-training’.

The relationship between workers and firms is defined by a contract that establishes wages for each period and how much workers will pay for training. While wages paid in the second period vary according to the level of competition, the amount paid by workers for training is fixed. Even though there is no justification for this distinction, the assumption tries to capture the idea that workers are not always able to pay the total training costs, once they face some credit constraint. Whenever training requires firms’ investment, the same results are obtained. The labor market, though essential for the results, is not well described. Non-trained workers receive fixed wages regardless of the size (or importance) of the cluster relative to the regional economy.

Moreover, the assumption that imposes some fixed costs on training activity recalls the tautology about the effects of knowledge spillover, since this assumption is supported by neither empirical results nor the theoretical model; rather some arguments are provided in order to justify the simple cost structure used for training suppliers. Other strong assumptions are: (1) there is no direct interaction between the cluster and the rest of the economy; and (2) the market where firms sell their products is large enough so that the size of the cluster does not affect price. Further, in this model, no attention is directed to the possibility of interaction between the firms (for example, they may be linked in a value chain); in this case, the incentives for training become more complicated as the presence of less skilled workers producing components early in the chain may compromise the overall quality and competitiveness of the final product.

Finally, the equilibrium could be determined in a different fashion. Instead of the probability of agreement between the worker and the new firm, searching could be costly

and, once the worker decided to pay for it, she would find a new partner. The cost of search would be a function of z and x . Because of the cost of searching, there would be room for firms to propose a contract with W_t high enough so that the worker would decide not to search for new partner. Therefore, in equilibrium, workers would not move to another firm after the first period. As training became more general, with more firms not providing training, the cost of searching would decrease and firms would have to offer higher W_{tr} in the first-period contract. However, similar to what happens in the framework proposed in this work, the results would depend on the specification of the search function.

From this framework, three alternative policies already experimented by several countries emerge: (1) increasing credit for workers to pay for general training, (2) making contracts enforceable, and (3) subsidizing Universities (not firms) to locate their entries where there are clusters in the second stage.

References

- Acemoglu, Daron. (1997) "Training and Innovation in an Imperfect Labor Market," *Review of Economic Studies*, 64, 445-464
- Acemoglu, Daron; Jorn-Steffen Pischke. (1998) "Why Do Firms Train? Theory and Evidence," *Quarterly Journal of Economics*, 113, 79-119.
- Acemoglu, Daron; Jorn-Steffen Pischke (1999). "Beyond Becker: Training in Imperfect Labor Market," *Economic Journal*, 109: 112-142.
- Acs, Zolten, David Audretsch and Maryann Feldman. (1994) "R&D Spillovers and Recipient Firm Size," *Review of Economics and Statistics*. 76, 336-340.
- Acs, Zolten, David Audretsch and Maryann Feldman. (1992) "Real Effects of Academic research: Comment," *American Economic Review*, 82, 363-367.
- Becker, Gary. (1964) *Human Capital*. Chicago, The University of Chicago Press.
- Becker, Gary (1967). *Human Capital and the Personal Distribution of Income*. Ann Arbor Michigan, University of Michigan Press.
- Card, David (2001). "Estimating the return to schooling: progress in some persistent econometric problems," *Econometrica* 69, 1127-1160.
- Feser, Edward; and Edward Bergman. (2000) "National Industry Cluster Templates: A Frame for Applied Regional Cluster Analysis". *Regional Studies*, 34, 1-19.
- Feser, Edward; and Stuart Sweeney. (2000) "A Test for the Coincident Economic and Spatial Clustering of Business Enterprises," *Journal of Geographical Systems*, 2, 349-373.

- Franja, Gianni (2001). "The design of optimal education policies," *The Review of Economic Studies*, 69, 437-466.
- Fujita, Masahisa, Paul Krugman, and Anthony Venables. (1999). *The Spatial Economy*. Cambridge, MIT Press.
- Fujita, Masahisa and Jacques-Francois Thisse. (2002) *Economics of Agglomeration: Cities, Industrial Location, and Regional Growth*. Cambridge, Cambridge University Press.
- Glomm, Gerhard and B. Ravikumar (1992). "Public versus private investment in human capital: endogenous growth and income inequality," *The Journal of Political Economy*, 100, 818-834.
- Gordon, Ian and Phillip McCann (2005). "Innovation, agglomeration, and regional development," *Journal of Economic Geography*, 5, 523-543.
- Grossman, Sanford; Oliver Hart. (1986) "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration". *The Journal of Political Economy*, 94, 691-719.
- Jaffe, Adam (1989). "Real Effects of Academic Research," *American Economic Review*. 79, 957-970.
- Lawson, Clive and Edward Lorenz (1999). "Collective learning, tacit knowledge and regional innovative capacity," *Regional Studies*, 33(4), 305-317.
- Marlin, James and Garey Durden (1993). "An analysis of contributions and contributors in economic education research," *The Journal of Economic Education*, 24, 171-186.
- Martin, Ron and Peter Sunley (2003). "Deconstructing clusters: chaotic concept or policy panacea?" *Journal of Economic Geography*, 3, 5-35.
- Miyagiwa, Kaz (1991) "Scale economies in education and the brain drain problem," *International Economic Review*, 32, 743-759.
- Pinch, Steven; Nick Henry, Mark Jenkins, and Stephen Tallman. (2003). "From 'industrial districts' to 'knowledge clusters': a model of knowledge dissemination and competitive advantage in industrial agglomerations," *Journal of Economic Geography*, 3, 373-388.
- Porter, Michael. (1990) *The Competitive Advantage of Nations*. New York, Free Press.
- Reich, Robert (1992) *The Work of Nations*, New York, Random House
- Shaver, J. and Fredrick Flyer. (2000). "Agglomeration economies, firm heterogeneity, and foreign direct investment in the United States," *Strategic Management Journal*, 21, 1175-1193.
- Steiner, Michael. (2002) "Clusters and Networks: Institutional Settings and Strategic Perspectives." In Philip McCann (ed.) *Industrial Location Economics* Northampton, Massachusetts, Elgar, pp. 207-221.
- Yamamura, Eiji.; Tetsushi Sonobe, and Keijiro Otsuka (2003). "Human capital, cluster formation, and international relocation: the case of the garment industry in Japan, 1968-98," *Journal of Economic Geography*, 3, 37-56.