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REGIONAL CONCENTRATION OF ENTREPRENEURIAL ACTIVITIES

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ABSTRACT

Empirical evidence indicates that entrepreneurial activities tend to concentrate geographically. Strategic complementarities, knowledge spillovers and network externalities are regarded as the principal sources of such phenomena. Although conspicuous examples point at the presence of positive feedback mechanisms, agglomerations also occur in the absence of these features and in areas of considerably homogeneous economic potential. We build an evolutionary game theoretic model to investigate the conditions under which regions may evolve different rates of entrepreneurship assuming that (i) regions are economically similar, (ii) there is migration between regions, and (iii) individuals are predisposed to imitate others who are economically more successful.

INTRODUCTION

Entrepreneurial activities are prone to geographic concentration (Ellison and Glaeser, 1997; Krugman, 1991b; Malecki, 1997). Three types of externalities are considered to be the main causes these agglomerations, namely, strategic complementarities (Arthur, 1989; Krugman, 1991a), knowledge spillovers (Acs et al. 1992, Arrow, 1962; Romer, 1986) and network externalities (Aldrich & Zimmer, 1986; Katz & Shapiro, 1986; Minniti, 2005). Salient examples like Silicon Valley and Boston’s Route 128 substantiate this claim (Saxenian, 1994). Admittedly, the most prominent clusters develop around novel technologies and effective social networks (Audretsch & Feldman, 1996; Orsenigo, 2006). Nevertheless, entrepreneurial agglomerations also occur under different conditions and in areas of identical economic characteristics.

Existing models of strategic complementarities focus on the positive effects accruing from the interaction between incumbent and potential entrepreneurs. Newcomers to a region, spin-offs and late adopters of a technology, all benefit from the reduction of strategic risk and environmental uncertainty brought about by the actions of those who pioneered early developments (Arthur, 1994; Minniti, 2005). This paper argues, however, that there is another kind of strategic complementarity capable of yielding uneven distributions of entrepreneurial activity across regions, namely, one that characterizes the interaction between entrepreneurs and non-entrepreneurs. Undoubtedly, firm founders profit from the coordination of their decisions with others who share their intentions. However, a broader perspective reveals that they also benefit from the coordination with those economic agents who choose paid employment.

According to the literature on increasing returns, different levels of entrepreneurial activity across regions are a consequence of the existence of multiple equilibria (Arthur, 1989; 1994; Minniti, 2005). In these models, the initial conditions and the history of interactions determine the equilibrium that attracts the system, so that regions with sufficiently diverse historical paths lock into different rates of entrepreneurship. In these models, geographical areas do not interact with each other; they follow independent fates. Yet despite the fact that people are spatially bounded by culture, social ties and financial constraints, migration remains a pervasive demographical regularity. For instance, during the last sixty years, 5.23% of the U.S. population migrated on average every year to another county, state, division or region (with a remarkably low standard
deviation of 0.12 for the whole period). Therefore, it is indispensable to explore the role of demographic mobility upon the persistence of spatial concentrations of entrepreneurial undertakings.

Interregional interactions are not confined to demographic and economic exchange. Entrepreneurs, for instance, resort to cues, information and knowledge embedded in their social environment in order to mitigate uncertainty (Aldrich, 1979; Granovetter, 1985). Moreover, individuals have a propensity to imitate the behavior of prestigious and successful people, especially in situations characterized by complexity and insufficiently understood relationships (Richerson and Boyd, 2005). Success- as well as prestige-biased cultural learning affects preferences, beliefs, attitudes towards novelty, and even career choices. Although the scope of cultural transmission and knowledge spillovers is spatially limited, it stands to reason that new information and communication technologies have considerably broadened the geographic reach of social learning. Consequently, even when the diffusion of information and the observability of behaviors decay with spatial and relational distance, we expect cultural exchange to occur across regions and affect economic decisions.

These facts raise the question of what conditions could lead spatially separated but economically and culturally interconnected regions to evolve different levels of entrepreneurial activity, provided that they have similar economic potential. There is migration across regions, and individuals are predisposed to imitate others who are economically more successful. Following Henrich and Boyd (2008) we develop a cultural evolutionary game theoretic model of regional concentration in which individuals decide between entrepreneurship and paid employment. At the beginning of every period, each individual is matched with another individual from the same region to play the basic game. Subsequently individuals compare their just earned payoffs with those of another individual chosen at random. Based upon this comparison individuals assess whether to stick to their previous strategy or to switch. Finally, a percentage of the population in each region migrates to the other. We study the evolution and long-run properties of this dynamic system to assess the parametric conditions that foster the emergence and persistence of regions with idiosyncratic levels of entrepreneurial activity.

THE ROLE OF EXTERNALITIES IN ENTREPRENEURIAL AGGLOMERATION

The most striking feature of the geography of entrepreneurship is its spatial concentration, a phenomenon characterized by its remarkable persistence (Ellison and Glaeser, 1997; Krugman 1991b; Malecki, 1997). What forces lead firms to co-locate?

A basic explanation, which probably accounts for most early concentrations, relies on the existence of natural advantages, understood as immobile inputs that are essential for production (Ellison & Glaeser, 1997; Fujita et al. 1999). Natural advantages are supposed to explain the location of the wine industry in California, early industrial sites next to coalfields and the location of old cities nearby bodies of water. In spite of these examples, empirical evidence indicates that most patterns of agglomeration cannot be accounted for by intrinsic differences among locations (even when they may have played an important role in affecting initial location). Heterogeneous entry costs, arising from industrial policies and the provision of infrastructure, constitute variants of the natural advantage thesis, although the empirical evidence points at their transitoriness. A related argument rests upon the concentration of a highly qualified labor force in certain regions. However, as individuals are to a considerable extent free to choose their place of residence, concentration of skilled labor is more likely to be a consequence of agglomeration rather than a cause of it. Furthermore, given that regions typically include a wide sampling of people, the
existence of idiosyncratic talents is an unlikely explanation (Acemoglu, 2009; Richerson and Boyd, 2005).

Marshall (1920) identified three reasons for the concentrated localization of economic activities. First, co-location allows firms to reap the benefits of a pooled market for workers with industry-specific skills. This type of positive effect accrues to both entrepreneurs and employees as it improves the job-worker match and reduces the probability of employment shortage. Second, a concentrated industry can support the production of non-tradable specialized inputs such as capital infrastructure. Third, spatial proximity may give rise to gains in efficiency by fostering informational spillovers among firms in relation to production techniques, input suppliers and customers. Note that these three mechanisms hinge on the combined effect of increasing returns to scale and external economies engendered by the pooling of resources.

Rather than informational spillovers, Krugman (1991a) and the so called new economic geography (Krugman, 2009) focus on the role of increasing returns at the level of the individual firm and pecuniary externalities originating from demand and supply linkages. The existence of increasing returns to scale causes production to localize in a limited number of sites whereas costly transportation induces firms to locate in the proximity of customers, raw materials and labor force. Since customers and employees tend to overlap, a positive feedback naturally emerges (Arthur, 1989). The attempt to concentrate in locations where markets are large becomes a self-fulfilling prophecy because concentration will give ipso facto rise to large markets (Arthur, 1994; Fujita et al. 1999; Krugman, 1991a). The ‘backward linkage’ or intra-industry effect is reinforced by a ‘forward linkage’ or inter-industry phenomenon, in as much as consumption and production involve transactions with several goods. In these models, the final degree of concentration and regional divergence will depend on the relative strength of transportation costs, economies of scale and labor intensity.

Arthur (1989, 1994) emphasizes the role of strategic complementarities (Bullow et al., 1985) in the realm of technology adoption. These positive effects occur whenever the payoff to adoption of a certain technology increases with the proportion of adopters, (due for instance to compatibility, standardization, etc.). In some cases these externalities accrue continuously and in others, they erupt when a critical mass of users is surpassed, like in bandwagon models (Granovetter, 1978). Within this literature, increasing returns stem from the coordination of entrepreneurial choices.

Another important strand of literature on the link between externalities and agglomeration centers on the existence of informational spillovers. Two types of informational spillovers are distinguished in the literature, to wit, knowledge spillovers and network externalities. Knowledge spillovers occur when the knowledge emanating from capital investments by incumbent firms are not fully appropriated in existing organizations (Acs et al. 1994; Acs & Audretsch, 2005). In such scenarios there is an incentive to co-locate in order to benefit from these externalities. The localized nature of knowledge spillovers is often linked to its tacit nature (Kim & Aldrich, 2005; Orsenigo, 2006) and to its association with academic research (Acs et al. 1992). With regard to the last-mentioned interaction, the diffusion of knowledge generated by research universities has been found to be strongly fostered by geographic proximity, a fact that is particularly characteristic of complex technological innovations (Acs & Audretsch, 2005; Feldman, 1993; Saxenian, 1994).

Network externalities on the other hand, are non-pecuniary gains accruing to individuals in a social network in the form of ambiguity reduction, legitimizing of activities, vicarious learning, and access to specialized information enabling, among other things, technology transfer, mutual trust and financial assistance (Aldrich & Zimmer, 1986; Cooper & Folta, 2000; Malecki, 1997;
Saxenian, 1994; Thornton and Flynn, 2003). These effects are of outmost importance in the case of technological start-ups due to their lack of expertise and resources (Acs & Audretsch, 2005; Cooper & Folta, 2000; Feldman, 1993; Minniti, 2005). From a static perspective, models of network externalities argue that entrepreneurs co-locate because their social networks are already localized (Stuart & Sorenson, 2003). From a dynamic point of view, these models portray agglomerations as the outcome of coevolutionary processes characterized by strategic complementarities and sequential decision making (Arthur, 1989; Dosi, 1997; Nelson & Winter, 1982; Minniti, 2005).

In a nutshell, the pervasive element underlying the concentration of entrepreneurial activities is the existence of increasing returns as well as positive externalities accruing from the interaction with other economic agents. Rather than competition—which explains Marshallian agglomerative processes—the emergence of agglomerations in the literature on strategic complementarities knowledge spillovers and network externalities relies on a logic of coordination as it is the outcome of a process of mutual construction and collaboration (Gordon & McCann, 2000).

**DYNAMIC MODELS OF ENTREPRENEURIAL AGGLOMERATION**

Accounts of agglomerations based upon externalities, be them pecuniary, strategic-, network- or knowledge-based, are characterized by the existence of multiple stable equilibria. For this reason they are highly dependent upon initial conditions (Arthur, 1989; Krugman, 1991a). Under Krugman’s backward and forward linkages’ account, initial population size and transportation costs decide which region grows at the expense of the other. In the case of technological complementarities and information externalities, the history of interactions, especially early events, will determine which technology is adopted or which region attains a higher level of entrepreneurial activity (Arthur, 1989, 1994; Minniti, 2005). All these models are strategic in nature since the relative performance of individual actions critically depends on the behaviors of other individuals.

The main characteristics of the models built upon strategic complementarities are:

*Self-reinforcement mechanisms,* stemming out of positive feedbacks that occur when the adoption of a strategy by an agent encourages its further adoption. In the case of knowledge and network externalities the feedback mechanism rests upon the flow of information inducing further adoption. The returns to adoption may (but need not) be decreasing in the number of adopters, as when a market has a certain capacity (Minniti, 2005).

*Sequential decision making,* bounding individual’s choices to past observations. This is a crucial assumption in some models (although not a necessary one). In Minniti’s model of network externalities individuals observe previous adoptions of entrepreneurship, which progressively reduces their ambiguity. They remain out of the market until they gather enough information and therefore confidence to enter.

*Critical threshold levels,* representing commonly observed discontinuities in individual responses. Individuals join the group of adopters of a given behavior only if the bandwagon pressure exceeds an exogenously determined threshold (Granovetter, 1978). The existence of a critical mass encouraging adoption may induce quite sudden changes with relatively small parametrical variations (Arthur, 1989; Krugman, 1991b; Minniti, 2005).

*Heterogeneous thresholds,* reflecting individuals’ idiosyncratic preferences or propensities to adoption. As a result of this characteristic, the extent of bandwagon diffusion in a community and
consequently, the long-run level of adoption depend on the distribution of thresholds across individuals, as well as on the network of relations existing among members (Minniti, 2005).

Myopic decision making, arising out of bounded rationality. Agents focus on what other agents have so far chosen without aiming to predict the decisions of other agents. In terms of goals, agents are utility maximizers as they choose the action that maximizes their payoffs with the information at hand.

Observable actions, portraying the effects of social interaction. Choices are not only sequential, but known (or observable) to the other economic agents when they make their decisions.

Once and for, all decisions and path dependency resulting from the fact that agents in these models do not revise their decisions. It is the accumulation of individual past choices that determine the final outcome and its eventual lock in (Arthur, 1989). Therefore, path dependency entails potential inefficiency and irreversible outcomes.

Non predictability due to the presence of multiple steady states. The final outcome is decided by a host of small events that occur early in the history of the dynamics. Once the system locks into a particular path of equilibrium, the transition to other steady-state equilibrium is highly unlikely. Economic policy may be able to redirect the dynamics, yet this depends on whether it accomplishes the necessary parametrical change (Minniti, 2005).

THE EVOLUTION OF DIVERSITY

In models of informational externalities, the gains from co-location arise either from the interaction between entrepreneurs or from the interplay between entrepreneurs and sources of innovations, such as academic institutions and R&D departments (Acs et al. 1992; Arthur, 1994; Ellison & Glaeser, 1997; Minniti, 2005). The literature on forward and backward linkages, on the other hand, adopts a broader view, as it takes into account the returns from co-location accruing to all individuals, be them entrepreneurs, employees or customers. This kind agglomeration system displays what Gordon and McCann (2000) call ‘open membership’ since individuals belonging to them may in principle switch from one occupation to another, depending on market conditions. Intuitively, entrepreneurs and employees, insofar as they choose occupations that are strategic substitutes (Bullow et al., 1985) have much to gain from such anti-coordinated choices. Yet formal models of agglomerations have, to our knowledge, left the interaction between entrepreneurs and employees unmodeled and instead centered on intra- and interindustry trade. This focus leaves open the question of whether the division of labor that arises out of entrepreneurs-employees-interactions is capable of leading regions to idiosyncratic rates of entrepreneurship.

The new economic geography school has been deeply concerned with the ‘similar-similar problem’ (Krugman, 2009), namely, the exchange among similar countries and regions. According to it, trade between similar countries takes place because of the gains to specialization accruing from increasing returns (Krugman, 2009). Within this paradigm, patterns of trade and agglomerations are determined by particular constellations of population size, economies of scale and scope, transport costs, and market structure. As a branch of industrial organization, the focus of these models is on firms, markets and consumers. Our model complements this literature by addressing the ‘similar-similar problem’ from the individual perspective as it focuses on the impact that the choice of occupation can exert upon regional divergence of entrepreneurial activities.
The literature indicates that there is a wealth of factors with the potential to affect the degree of entrepreneurial concentration and attests to the fact that they are observationally equivalent, as far as the degree of concentration is concerned (Krugman, 1991b; Ellison & Glaeser, 1997; Glaeser et al. 1992; Porter, 1998). Although our knowledge regarding the nature of clusters and agglomerations in several industries and geographical areas is rich, conclusive evidence as to the common sources of most agglomerations remains elusive (Cooper & Folta, 2000; Orsenigo, 2006; Thornton & Flynn, 2003) partly because clusters are manifestations of coevolutionary processes rather than the necessary outcome of a certain set of initial conditions as in uni-directional causal phenomena (Gordon & McCann, 2000; Orsenigo, 2006). The present article uncovers a more general mechanism that may be at work in most agglomerations.

Uneven concentration is a phenomenon that goes well beyond purely economic activities. Demographic records from almost all countries and dates indicate that cities have a strong propensity toward agglomeration. Other sciences, such as biology, chemistry and physics also deal with agglomeration phenomena. Greenwood and Yule (1920) conceived two possible generating mechanisms, namely random processes acting upon a heterogeneous population of agents and contagion-like processes or positive-feedback mechanisms acting upon a homogeneous population. This topic is well beyond the scope of this paper, but it brings two visions of agglomerative forces that bear on our model to the fore.

The first vision regards clusters, regions and spatial agglomerations as the manifestation of intrinsic and unique forces. The second view on the other hand, conceives them as the expression of chance acting upon more or less qualitatively similar systems. As such, these two pure cases need and may not exist. Consider for instance the role of economic and social institutions. It has been argued that certain countries, regions and clusters are more developed or resilient than others because of their institutions, culture and industrial systems (Acemoglu, 2009; Saxenian, 1990). If we accept that entrepreneurial undertakings are embedded in social systems (Granovetter, 1985), which are themselves the result of evolutionary processes (Richerson & Boyd, 2005), then we should entertain the possibility that this intrinsic superiority may itself stem from mechanisms of the second sort acting upon originally homogeneous populations. For this reason, we argue that it is of outmost importance to understand how diversity evolves from initial similarity and why it persists (Leppälä & Desrochers, 2010; Henrich & Boyd, 2008).

A MODEL OF ENTREPRENEURIAL CONCENTRATION

Drawing from recent contributions in anthropology and entrepreneurship (Henrich & Boyd, 2008; Kuechle, forthcoming), we build a simple evolutionary game theoretic model. The model consists of a large population of homogenous individuals who simultaneously and without communication decide whether to enter into entrepreneurship (E) or into paid employment (~E). We assume that individuals interact pairwise after being randomly chosen. The payoff matrix is displayed in Figure 1. If only one player enters, the payoffs are $\pi$ to the entrant and $w$ to the player who stays out. If both players enter the market, competition drives individual profits down by an amount equal to $C$. No entrance (~E) yields a safe payoff equal to $w$ to both individuals. We assume that market entry entails a worse payoff than a safe job when both players enter and a higher payoff when only one enters the market (i.e., $\pi - C < w$ and $\pi > w$). In this game, individuals are better off if they can choose non-coincident strategies since those who enter the market will meet others who stay out and obtain higher payoffs on average. Admittedly, pairwise interactions of this sort reflect a small subset of all possible market structures, as they assume an
extremely small market capacity. However, this modeling simplifies exposition while perfectly capturing the phenomenon we are concerned with, namely, the choice of a strategy when its outcome depends on the strategies chosen by other individuals in the population. Results obtained for pairwise interactions can be extended without difficulty to situations in which individuals play the field and the capacity of the market is higher than one (see Kuechle, forthcoming).

The population is located in two separated regions which we call 1 and 2. The proportion of individuals choosing E in region 1 is labeled $p_1$ and the proportion of individuals choosing E in region 2 is labeled $p_2$ ($0 < p_1, p_2 < 1; i = 1, 2$). Because we always compare $p_1$ and $p_2$ at the same point in time, we omit subscripts denoting time periods. At the beginning of each period, every individual interacts with another one selected at random. We start with the general case that allows for interaction between regions. We follow Henrich & Boyd (2008) by assuming that there is a probability $d$ that an individual is paired with a randomly selected individual from the other region, so that the probability that an individual interacts with somebody who is co-located is $1-d$. In evolutionary game theoretic setups, individuals choose myopically, that is, they do not attempt to anticipate the choices of the others and follow simple heuristics that are responsive to the payoffs received by each strategy, as in reinforcement learning algorithms (Hofbauer & Sigmund, 1998).

Consistent with models of social learning, in which successful behaviors are disseminated through observational learning, imitation and teaching (Richerson & Boyd, 2005), we assume that, after having interacted, individuals have the chance to compare their just earned payoffs with those of another individual from either region. In this way, they can improve their information about the reward offered by the other strategy. If the two individuals who have been matched received the same earnings, they stick to their strategy. Otherwise, the player with the lower payoff increases the chances of switching to the more successful strategy according to the parameter $b$ which regulates the importance of social learning (Henrich & Boyd, 2008).

Although entrepreneurs are relatively constrained by their start-up location, evidence shows that some industries do exhibit entrepreneurial and organizational mobility (Cooper & Folta, 2000). Data on domestic migration in the US shows a clear and persistent pattern of general and moderate mobility. To account for such phenomena we assume that at the end of each round a proportion ($m$) of the population migrates to the other region after having compared strategies. This mechanism represents the flow of ideas, role models and knowledge between regions (Henrich & Boyd, 2008).

To analyze the dynamics of this model we follow extant results in McElreath and Boyd (2007, pp. 27-32) and Henrich and Boyd (2008). This literature shows that the change from one period to the next in the proportion of entrepreneurs in region 1 can then be written as $\Delta p_1 = p_1 (1-p_1) b (I_{1E}^E - I_{1~E}^E) + m (p_2 - p_1)$. The first term of this difference equation represents the effect of success-biased transmission, which results from the comparison of the own payoff with that of another player, whereas the second term represents the change in the proportion of entrepreneurs due to migration. Every period $m$ percent of the population of each region migrates to the other, thereby altering the frequency of entrepreneurs in both regions. In the previous recursion, $I_{1E}^E$ and $I_{1~E}^E$ represent the expected payoffs accruing to individuals located in region 1 from the choice of entrepreneurship and paid-employment, respectively. Using the information in Figure 1, these payoffs can be written as $I_{1E}^E = \pi (\pi-p_2C) + (1-d)(\pi-p_1C)$ and $I_{1~E}^E = w$ (Kuechle, forthcoming). The final expression for the one step change in the frequency of entrepreneurs in region 1 is given by $\Delta p_1 = p_1 (1-p_1) b [d(\pi-p_2C)+(1-d)(\pi-p_1C)-w] + m (p_2 - p_1)$, which is a function of the current frequencies of
entrepreneurs in both populations \((p_1 \text{ and } p_2)\). A similar procedure is followed to calculate the recursion for the change in the proportion of entrepreneurs in region 2, as a function of \(p_1\) and \(p_2\). This procedure yields the following equation \[\Delta p_2 = p_2(1-p_2) [d(\pi - p_1C) + (1-d)(\pi - p_2C) - w] + m(p_1 - p_2)\].

### The Dynamics of the Model

The equations for \(\Delta p_1\) and \(\Delta p_2\) describe the evolution in one time step of the frequencies of entrepreneurs in regions 1 and 2 as a function of individual behaviors, cultural learning and migration. To analyze the dynamics of this system of interdependent regions we identify stable equilibria. Equilibria are combinations of frequencies of entrepreneurial activity such that no further change occurs once they are reached. An equilibrium is locally stable if the system returns to it after the occurrence of small perturbations. The autarkic version of this game –to wit the model consisting of only one region– has a unique evolutionary stable equilibrium in which the proportion of entrepreneurs is given by \([\{\pi - w\}/C]\) (Kuechle, forthcoming). When the frequency of entrepreneurs reaches this level, no individual has an incentive to switch occupations. The fact that this equilibrium is globally stable means that regardless of the initial conditions and the size of the perturbations, the system will return to it. The two-region model that we consider in this paper has a different structure due to the interactions among the regions built in the processes of migration and social learning.

To study the dynamics of this system we set \(\Delta p_1 = \Delta p_2 = 0\) and look for the solutions, \(p_1^*\) and \(p_2^*\), to the system of two equations in two unknowns. We write \(p_1^*\) and \(p_2^*\) to denote equilibrium frequencies of entrepreneurs in a generic way. Since the system is non-linear, it has several equilibria. Apart from two trivial equilibria, namely, \(p_1^* = p_2^* = 0\) and \(p_1^* = p_2^* = 1\), which are not stable for sensible combinations of parameters, our dynamic system has one non-agglomeration equilibrium and two agglomeration-equilibria. In the non-agglomeration equilibrium (NA), both regions display the same proportion of entrepreneurs, namely, \(p_1^{NA} = p_2^{NA} = p^{NA} = [(\pi - w)/C]\). Note that this rest point coincides with the autarkic solution. Intuitively, the probability of adoption of entrepreneurship increases with the expected profit in the absence of competition (\(\pi\)) and decreases with the opportunity cost of entry (\(w\)) and the expected individual losses due to competition (\(C\)). This equilibrium can be reached either by a population consisting of a proportion \(p^{NA}\) of entrepreneurs and a proportion \(1-p^{NA}\) of employees or by a population in which every individual adopts entrepreneurship with a probability equal to \(p^{NA}\) (Kuechle, forthcoming).

To calculate the agglomeration (A) equilibria we start with the case in which \(d=1\) (meaning that individuals interact only with the population of the other region) because it provides clear cut analytical results. As in Henrich and Boyd (2008), the analysis of the case in which \(0<d<1\) requires multiple calculations and simulations. However, they show that the results under the assumption that \(d=1\), which are the ones we present in the present paper, are robust. The two agglomeration equilibria are the roots of the quadratic equation that results from the system of recursions when \(\Delta p_1 = \Delta p_2 = 0\) under the condition that \(p_1^A\) and \(p_2^A\) are not equal. Consistent with the literature on increasing returns, the two agglomeration equilibria are interchangeable in the sense that early small events determine which region has the higher level of entrepreneurial activity (Arthur, 1989; Minniti, 2005). To completely assess the dynamics of the interregional model, we perform the stability analysis. To accomplish this, we follow standard methods in Hofbauer and Sigmund (1998, pp.119-121). According to the calculations, the non-agglomeration equilibrium, to wit, \(p^{NA}\) is stable if and only if \(2m > (b/C)(\pi - w)(C - \pi + w)\). In this scenario the agglomeration
The important feature of the dynamic analysis is that both agglomeration and non-agglomeration equilibria cannot be simultaneously stable. Either the two regions are pulled to the same level of entrepreneurial activity or they are pulled to different steady states. Figure 2 depicts the location of the agglomeration equilibria and the non-agglomeration equilibrium for particular values of the parameters as a function of the migration rate. The non-agglomeration equilibrium $p^{NA}$ is equal to 0.8 and for a migration rate equal to $m=0.03$, the proportion of entrepreneurs in each region are $p_1^A=0.91$ and $p_2^A=0.45$ respectively. The values of the parameters of the model determine how likely it is that this system evolves agglomerations. The point at which $2m=(b/C)((\pi-w)(C-\pi+w)$ is referred to as the agglomeration threshold (Henrich and Boyd, 2008). Figure 2 also shows that for migration rates smaller than 4%, agglomeration equilibria exist and are stable. The non-agglomeration equilibrium exists but it is not stable. However, as the migration rate approximates the migration threshold, the proportion of entrepreneurs in both regions tends to equalization. For migration rates higher than this threshold only the non-agglomeration equilibrium is stable and it remains unaffected. Finally, note that if the migration rate is zero, then both regions fully specialize into the alternative occupations. This is feasible because there is interregional economic interaction.

The Parameters and the Persistence of Agglomerations

In this section we explore the impact of the different parameters of the model upon the stability of the agglomeration equilibria to assess the extent to which we can expect agglomeration to prevail in the long run. As stated in the previous section, we expect agglomerations to emerge and persist when $2m<(b/C)((\pi-w)(C-\pi+w)$. This means that parameters that make the right hand side larger or the left hand side smaller have the effect of increasing the chances that agglomerations emerge. By the same token, parameters that lower the right hand side or increase the left hand side foster regional equality. We start the analysis with the migration rate $(m)$. Although social ties and financial resources constrain spatial mobility, we have seen that rates of domestic migration tend to remain considerably stable over long periods of history. In our model, high rates of migration increase the left hand side of the previous inequality and will therefore act against the emergence of entrepreneurial agglomerations. However, as Figure 2 shows, agglomerations are compatible with non-negligible and empirically meaningful rates of migration.

The returns to entrepreneurship depend on two parameters, to wit, profit $(\pi)$ and the costs of competition $(C)$. In our game, entrepreneurship and paid employment are strategic substitutes, meaning that individuals are better off when they adopt different strategies. If an entrepreneur meets an employee she earns full profit. However, if she meets another entrepreneur she earns $\pi - C$ due to increased competition. We first consider the effects of $\pi$. Taking the derivative of the right hand side of the inequality $2m<(b/C)((\pi-w)(C-\pi+w)$ with respect to $\pi$, we observe that this derivative is positive if and only if $\pi-w<C-\pi+w$ and negative if and only if $\pi-w>C-\pi+w$. This means that if profits increase while all other parameters remain constant, agglomerations will emerge and persist with higher probability only when $\pi-w<C-\pi+w$. To understand the meaning of this condition consider that $\pi-w$ represents the advantage of entrepreneurship over paid employment when facing an individual who chooses paid employment, whereas $C-\pi+w$ stands for the opportunity cost of not having chosen paid-employment when interacting with another entrepreneur (or the relative advantage of paid employment when facing an entrepreneur). An increase in $\pi$ increases the relative performance of entrepreneurship over paid employment and
this induces agglomeration only when wages are relatively high, which is the situation represented by $\pi - w < C - \pi + w$. An example may help illustrate the difference between the conditions under which higher profits foster agglomeration. For $\pi = 100$, $C = 50$ and $w = 80$, $\pi - w = 20 < C - \pi + w = 30$, whereas for $\pi = 100$, $C = 50$ and $w = 60$, $\pi - w = 40 > C - \pi + w = 10$. For the first set of parameters higher profits facilitate the emergence of profits, whereas for the second set they foster regional equality. These results can be extended beyond the limited case of pairwise interaction. If instead of pairwise interaction players interacted with the population and the capacity of the market was set at a more realistic level, these two terms would respectively represent the benefit to entry when the market has not yet reached its capacity (under entry) and the cost of entry when this capacity has been surpassed (over entry).

Wages have the opposite effect upon regional diversity than profits. The derivative of the right hand side of the inequality $2m(b/C)(\pi - w)(C - \pi + w)$ with respect to $w$ is positive if and only if $\pi - w < C - \pi + w$ and negative if and only if $\pi - w > C - \pi + w$. This means that an increase in wages will promote persistent agglomerations when the relative advantage of entrepreneurship is larger than the relative advantage of paid employment, in other words, when paid employment is in relative disadvantage. This case occurs when wages are relatively low with respect to the expected returns to entrepreneurship. In terms of the previous example higher wages increase, ceteris paribus, the range of conditions conducive to agglomerations when $w = 60$ and foster regional equality when $w = 80$.

The cost of competition, $C$, has an unambiguous effect upon the tendency to evolve idiosyncratic levels of entrepreneurship and paid employment. The derivative of the right hand side of $2m(b/C)(\pi - w)(C - \pi + w)$ with respect to $C$ is always positive. This means that increases in the costs of competition - and hence in the efficiency loss due to unsuccessful coordination - induce regions to regional divergence.

The parameter measuring the strength of social learning, namely $b$, has also an unequivocal effect upon the stability of agglomerations. Increases in $b$ have a stabilizing effect upon the tendency to concentrate. Recall that $b$ strengthens the responsiveness of behaviors to observed payoffs’ differences. After an individual is matched at random with another to compare payoffs, two basic scenarios are feasible. First, both players chose the same strategy, so that nobody switches. Second, they chose differently, so that the player with the lower payoff increases the chances of switching to the alternative strategy with a strength that positively depends on $b$. If $b = 0$, individuals are equally likely to switch and to stick to their previous behavior. But if $b = 1/(\pi - w)$, which is the maximum value it can take for the updating procedure to yield probabilities in $[0,1]$, payoffs’ differentials fully impact the propensity to change behaviors. From a psychological perspective, $b = 0$ represents a situation in which individuals are completely indifferent toward the fate of others and $b = 1/(\pi - w)$, a situation in which they are fully influenced.

Consistent with the literature on increasing returns and multiple equilibria (Arthur, 1994; Minniti, 2005), the inequality $2m(b/C)(\pi - w)(C - \pi + w)$ shows that sudden changes in the value of the parameters of the model may disrupt the status quo by inducing a shift from agglomeration to non-agglomeration equilibria or vice versa. As noticed by Minniti (2005) this feature of the model, sheds light upon the limits of uninformed policy interventions.

Finally, we relax the assumption $d = 1$ and let $0 < d < 1$, so that individuals interact with other people in both regions ($d = 0$ means that individuals interact only with other people in their own region). The non-agglomeration equilibrium is the same as before, whereas the agglomeration
Agglomeration phenomena involve complex processes and dynamic interdependencies that merit careful examination if one intends to build a theory of spatial distribution of economic activities. No single model can probably capture the emergence and persistence of every pattern of co-location. Yet there are fundamental forces that are considered to be at the heart of the regional
equilibria cannot be solved for analytically. Therefore, we restrict ourselves to the dynamics of the non-agglomeration equilibrium and presume with Henrich and Boyd (2008) that the system remains qualitatively unchanged, as far as the agglomeration equilibria are concerned. Regarding the definition of the agglomeration threshold, which is now given by $2m=(2d-1)(b/C)(\pi-w)(C-\pi+w)$, the only difference with respect to the case in which $d=1$ is the presence of $(2d-1)$. Since $d<1$, its presence has the effect of decreasing the range of conditions leading to regional diversity.

**Agglomerations and the Efficiency of the Global System**

We have characterized the situations leading to multiple equilibria and their stability and showed that persistent regional divergence can occur in the presence of migration and when regions have similar economic potential. We have so far remained silent as to the efficiency consequences of such dynamics. In this section we analyze total population payoffs under different equilibrium configurations.

To accomplish this we calculate the equilibrium payoffs of both occupations at the regional level. For simplicity, we consider the case in which $d=1$, so that interactions occur between regions. The equilibrium payoff in region 1 ($I_1$) is the sum of the expected payoff of each occupation weighted by their equilibrium frequencies in the region. In other words, $I_1(p_1^*, \ p_2^*)=p_1^*I_1^1(1-p_1^*)I_1^2$. Similarly, we define $I_2(p_1^*, \ p_2^*)=p_2^*I_2^1(1-p_2^*)I_2^2$ for region 2. To obtain the payoff for the whole economy, we add up these two payoffs. This yields $\pi(p_1^*, \ p_2^*)=I_1(p_1^*, \ p_2^*)+I_2(p_1^*, \ p_2^*)=(2-p_1^*p_2^*)\pi+\pi(\pi-C)(p_1^*)+p_2^*(\pi-Cp_2^*)$.

The highest global payoff, $\pi+w$, occurs when regions fully specialize, i.e. when either $p_1^*=0$ and $p_2^*=1$ or $p_1^*=1$ and $p_2^*=0$. However, this state need not be evolutionary stable (in our example this would happen only when the rate of migration equals 0). We have seen that if the agglomeration equilibrium is stable, then the frequency of entrepreneurs in both regions is given by $p_1^*=p_2^*=\pi(C-w)/C$. In this situation $\pi=2w$, reflecting the fact that if regions evolve to the same level of entrepreneurial activity, each earns on average $w$ (Kuechle, forthcoming). An equilibrium is reached only when no individual has incentives to change her behavior and this can be attained only if entrepreneurs and employees expect, on average, the same earnings. In autarky there are no gains from specialization and therefore the income of each region can, at most, be $w$.

If on the other hand, the system evolves to any of the interchangeable agglomeration equilibria, the income of the global economy is given by $\pi(p_1^*, \ p_2^*)=[2b\pi-b(\pi-w-C)(\pi-w)+mC]/[bC(\pi-w)(\pi-w-C)+2mC]$, which is higher than the total payoff under autarky ($2w$) but smaller than the total payoff under full specialization ($w+\pi$). To illustrate this result consider the example used in Figure 2, where $\pi=100$, $C=50$, $w=60$, $b=0.01$, $m=0.03$. The total payoff under agglomeration is given by $\pi(p_1^*=0.91, \ p_2^*=0.45)=133.45$. Under complete specialization ($p_1^*=0$, $p_2^*=1$ or $p_1^*=1$, $p_2^*=0$), the global payoff is 160 and under autarky ($p_1^*=p_2^*=0.80$) it is 120.

**CONCLUSION**
divergence of entrepreneurial undertakings. According to the literature, the key driving force is the widespread existence of increasing returns to scale and scope, and positive externalities arising from economic and social interactions (Krugman, 1991b).

Consistent with the literature on increasing returns (Arthur, 1994; Minniti, 2005), we have adopted an evolutionary game theoretic perspective capable of accommodating individual decision making, multiple equilibria, social learning and myopic decision making. We complement this literature by allowing for interactions between entrepreneurs and employees, regions of similar economic potential, interregional migration and success-driven social learning (Henrich & Boyd, 2008).

In a nutshell, the paper advances our understanding of the sources of agglomerations by showing that the rates of entrepreneurship may differ across regions even in the presence of considerable population mobility, homogeneous skills, despite the fact that the only force shaping decisions is a process of myopic social learning by which individuals imitate others who are economically more successful. In line with recent research on cultural evolution, our model supports the view that regional divergence need not be the consequence of economic heterogeneity but may also be the outcome of certain types of interactions in homogenous populations (Henrich & Boyd, 2008).

The model has two agglomeration equilibria and one non-agglomeration equilibrium. The agglomeration equilibria are interchangeable in the sense that early small events will determine which region has the higher level of entrepreneurial activity. The crucial feature is that both types of equilibria cannot be simultaneously stable. Our stability findings can be summarized as follows: First, the higher the exchange of people and ideas between regions - namely the higher the migration rate - the less likely it is that agglomeration equilibria persist. In the limit, the unbounded flow of information will act against agglomeration; although the spatial unevenness of entrepreneurship is compatible with significant rates of migration and diffusion of ideas. Second, profits and wages have opposite effects upon the stability of agglomerations. Higher profits accruing from the choice of entrepreneurship foster agglomerations only if wages are relatively high and conversely, wages make agglomerations more likely if they are a priori relatively low. Third, social learning, if strong enough, exerts a favorable effect upon the formation of clusters, as well as the increment of competition costs. Lastly, when stable, agglomerations enhance the performance of the whole economy.

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REFERENCES


Figure 1. Pairwise Interaction of the Symmetric Market Entry Game

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Figure 2. Equilibrium Solutions For Given Parameters

\[p_1^* = p_2^* = p^*\]

\(\pi = 100\)
\(b = 0.01\)
\(w = 60\)
\(C = 50\)

Migration rate (m)