Entrepreneurship and network externalities

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Abstract

Studies on agglomeration show that economic characteristics explain only a portion of variance in entrepreneurship rates across regions. To complement these studies, I argue that entrepreneurship tends to concentrate geographically, in part, because of the social environment. I suggest that, when making decisions, individuals follow social cues and are influenced by what others have chosen, especially when facing ambiguous situations. Such influence may be described as a non-pecuniary network externality. Using a non-linear path-dependent stochastic process, I build a model of entrepreneurial dynamics showing why communities with initially similar economic characteristics may end up with different levels of entrepreneurial activity.

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1. Introduction

Why does entrepreneurship flourish in some regions and not in others that have otherwise similar conditions? Silicon Valley and Boston’s Route 128 in the U.S. and Baden-Wurttemberg and Emilia-Romagna in Europe are just a few examples showing that entrepreneurial activity tends to cluster geographically. Traditionally, economies of scale and scope and the resulting reduction in transaction costs are identified as the main reasons for these agglomerations (Baum and Singh, 1994; Fujita et al., 1999; Fujita and Thisse, 2002; Greenhut et al., 1987; Wade, 1995). Often, however, science parks created to replicate processes observed elsewhere fail (Côté, 1991; Massey et al., 1992). Also, otherwise similar
communities often develop very different levels of entrepreneurial activity (Gimeno et al., 1997; Lomi, 1995). Overall, economic variables have been shown to account for only a portion of the variance in entrepreneurial activity across regions. Thus, actual or potential economic conditions cannot be the entire story. To understand entrepreneurial decisions and the development of entrepreneurial activity better, one must also look at the importance of the local social environment (Aldrich and Fiol, 1994; Blau, 1994; Granovetter, 1985). When proper social networks are in place, agglomeration works and follows the form and patterns identified by the new economic geography literature.

Although most economic agents are affected by location, entrepreneurs and small firms are among those more subject to local influences. By definition, an entrepreneurial venture requires the introduction of innovations and the simultaneous handling of many tasks (Schumpeter, 1934). Actions involving innovation and multiple tasks, however, present ambiguous environments (March and Olsen, 1976). The entrepreneur, for example, may lack knowledge about the subsidiary activities necessary to the working of the venture. More important, when the business environment is not transparent, the set of necessary tasks and their characteristics is fuzzy, and the entrepreneur cannot be assumed to know the true structure of her decision-making model. Thus, entrepreneurship requires the ability to cope with ambiguity. If an entrepreneur is willing to act on a perceived opportunity, it is because she believes that she possesses a comparative advantage in her chosen market, but she does not have a comparative advantage in coping with ambiguity. Thus, she focuses her attention on her specific talent while coping with ambiguity by leveraging cues and information provided by the behavior of other entrepreneurs.

Everything else being the same, the larger the number of entrepreneurs she observes, the lower the ambiguity she experiences. By observing others, our potential entrepreneur acquires information and skills. She meets other individuals who have similar or complementary expertise. She learns the ropes of how to find competent employees, inputs at affordable prices, financial support and, most important, potential buyers. Throughout this process her social environment becomes important, and her participation in a broadly defined network helps her to define the contour of the set of her entrepreneurial tasks. The existence of a significant number of entrepreneurs also legitimizes her activity and enables her to exploit a number of established routines. In fact, researchers have shown that when choosing in an ambiguous environment, agents tend to base their decisions on social cues (Aldrich, 1999). Also, Aldrich and Zimmer (1986) have shown that participation in social networks is a crucial element for entrepreneurs. Finally, Saxenian (1990) has argued that much of the success of Silicon Valley is to be attributed to its social environment.

Since prospects of employment, education, and other economic circumstances differ across individuals, the population is heterogeneous with different individuals facing different opportunity costs when acting to exploit an opportunity they recognized. However, as with many other phenomena, perceptions about the desirability of becoming an entrepreneur are also formed and revised given the set of information available to each agent (Lafuente and Salas, 1989; Saxenian, 1990). A large part of such a set is collected locally, within the social network of the individual (Aldrich and Zimmer, 1986; Cooper et al., 1989). In this paper I argue that such influence may be modeled as a network externality in which entrepreneurship is assumed to exhibit increasing returns with respect to adoption. In high entrepreneurship areas, the large concentration of entrepreneurs lowers the ambiguity at-
tached to entrepreneurship and promotes its choice as a viable source of revenues. Thus, in addition to economic circumstances, the local amount of entrepreneurial activity is itself an important variable in determining individual decisions whether to act upon a recognized opportunity. In other words, I argue that entrepreneurship creates a “culture” of itself that influences individual behavior in its favor.1

The paper complements recent works on agglomeration phenomena and fills a gap in the literature. Drawing from recent contributions in sociology and economics, I take an interdisciplinary approach and present a simple dynamic model of the emergence of alternative levels of entrepreneurial activity in different communities. Recently, much empirical work has pointed out the importance of the social networks for the entrepreneurial process. To my knowledge, however, an analytical framework capable of describing the intangible consequences of individuals’ interdependence to the entrepreneurial process is yet to be developed. I contribute to the elimination of this omission by introducing explicitly a non-pecuniary externality into a model of entrepreneurship adoption. The model supports a wide variety of patterns of entrepreneurial behavior and may be used to develop some testable hypotheses. In addition, the model suggests important implications concerning the effectiveness of public policy and programs intended to foster entrepreneurial activity.

2. Entrepreneurship and social environment

Traditionally, the theory of entrepreneurship is associated with the methodological subjectivism of the Austrian School (Kirzner, 1973, 1979; Knight, 1921; Schumpeter, 1934). For a long time, in fact, theorists working with analytical models have neglected entrepreneurship and simply treated it as part of the residuals that cannot be attributed to any measurable productive input (Baumol, 1993, 1983). Only recently entrepreneurship has been modeled explicitly as a form of human capital accumulation usually linked to the long run size of the firm (Bates, 1990; Iyigun and Owen, 1998; Otani, 1996). These works have shown, both theoretically and empirically, that the availability of external financing is a crucial determinant of the amount of entrepreneurial activity in a community (Evans and Jovanovic, 1989; Evans and Leighton, 1989; Kihlstrom and Laffont, 1979). Along similar lines, other economists have modeled entrepreneurship in the context of the optimal distribution of personal resources. For example, it has been shown that individuals’ attention span can be allocated optimally only among a very limited number of activities and that this is problematic for entrepreneurs trying to evaluate new projects for possible adoption (Murphy et al., 1991).

In the last decade, sociologists and organization theorists have also provided significant contributions to the theory of entrepreneurial behavior. In particular, they have shown that social networks and embeddedness are crucial factors in the decision whether to become entrepreneurs (Gulati, 1999, 1998; Uzzi, 1999). To my knowledge, however, very few studies have combined the economic insight that entrepreneurs react to economic incentives with

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1 Along these lines, psychologists have argued that a relatively high rate of entrepreneurial activity promotes a positive social attitude toward entrepreneurship and causes it to become a better appreciated and therefore more desirable income producing activity.
the sociological insight that culture also influences their behavior. Empirical evidence, on
the other hand, routinely shows that both elements are important. This paper is an attempt
to study the role played by both economic and social variables on entrepreneurial decisions
and to assess their relative importance, if any, for policy implications.

The decision to become an entrepreneur requires that the agent be able to cope with the
uncertainty associated with the introduction of her innovation. That uncertainty is associ-
ated with the probability of failure. In an uncertain environment, the range of alternative
options, the distribution of possible outcomes for each alternative option, and the probability
distribution of each outcome are known. There is no ambiguity.

In addition to uncertainty, however, an entrepreneur may face also ambiguity. When
ambiguity exists, information about one or more of the conditions of the environment is
fuzzy, and agents cannot be assumed to know the necessary decision-making model (March
and Olsen). Thus, the entrepreneur’s problem is not that she lacks information, but that
because of ambiguity, she does not know the true structure of the situation. Of course,
this means that rationality is bounded, although the only constraint on the entrepreneur’s
information processing ability may be the existence of ambiguity. Notice that ambiguity
aversion is not risk aversion; risk aversion is the curvature of a well-defined utility function
that exists in principle even when the agent faces no risk or uncertainty. Ambiguity aversion,
on the other hand, exists only when the agent has an incomplete model of the structure of
the situation.

Aldrich argues that when choosing in an ambiguous environment, agents tend to base
their decisions on social cues. Also, it has been shown that organizations are the more likely
to adopt an innovation the larger is the number of already adopting organizations because of
stronger expected evaluations (Scharfstein and Stein, 1990). Also adoption rates are often
perceived as evidence that adopters possess informational advantages above non-adopters
(Banerjee, 1992). In fact, economic action does not take place in a vacuum; rather it is em-
bedded in networks of social relationships. I argue that the presence of other entrepreneurs
reduces ambiguity and allows the entrepreneur to concentrate more on her chosen activ-
ity. Such influence may be modeled as a network externality in which entrepreneurship
is assumed to exhibit increasing returns with respect to adoption. The externality under
consideration is a non-pecuniary externality, but it does not operate through changes in
the returns to investment in human capital or in technology adoption as typical in recent
literature. We may call it a perceptual externality. In high entrepreneurship areas, the large
concentration of entrepreneurship promotes its choice as a viable source of income. Thus,
in addition to economic circumstances, the local amount of entrepreneurial activity is itself
an important variable in determining individual decisions whether to act upon a recognized
opportunity.

My argument rests on the observation that when the number of entrepreneurs is rela-
tively large, more information about the characteristics, requirements, needs, rewards and
frustrations of entrepreneurship is available. Thus, the social environment contributes to
reducing the ambiguity associated with entrepreneurial decisions. Broadly speaking, my
“social environment” is similar to Marshall’s who, when discussing spatial concentration,
suggested that “the mysteries of the trade become no mysteries; but are as it were in the
air” (Marshall, 1920, p. 271). My idea of social environment is also somewhat analogous to
Coleman’s definition of the “first form” of “social capital,” in which the latter is described
as the ability of information to flow through a community and form the basis for action (Coleman, 1990).

In recent years, social capital has become an area of active debate in various disciplines (Portes, 1998; Coleman, 1990; Durlauf and Young, 2001). Although the concept is mainly used by sociologists, economists trying to enrich the standard economic problems of self-interested agents with more sociological accuracy have also paid attention to the subject (Brock and Durlauf, 1995; Montgomery, 1991). Unfortunately, a generally accepted definition of social capital does not exist, and the term is used to describe a variety of things. As a result, some researchers have been critical of the literature since the variety of meanings attributed to the term prevents a rigorous use of the notion (Durlauf, 2002; Woolcock, 2001). Coleman, for example, argues that social capital may take “three forms.” First, it may describe the ability of information to flow through a community in order to provide a basis for action. Second, social capital may consist of obligations and expectation that depend on the trustworthiness of the environment. Third, social capital may describe the existence of norms accompanied by possible sanctions. Several other definitions also exist. In some cases, for example, social capital is used to describe labor market connections (Cooper et al., 1989) and, in yet other cases, to describe the existence of “good behaviors” in a specific group (Putnam, 2000).

To some extent, the “social environment” concept used in my paper is related to that of “social capital.” In my paper, however, the expression “social environment” has a very precise meaning. Specifically, it describes individuals’ ability to observe someone else’s behavior and the consequences of it. The social environment is not the planned outcome of the decisions of purposeful actors; rather it emerges as the unintended consequence of a sequence of decisions taken by individuals and serves as a conduit for information.

In my model, the social environment is endogenously determined; new individuals coming into the community observe it and internalize it in their information set at no costs. In other words, the social environment is simply a mechanism describing how information may reinforce certain types of behaviors. No purposeful intent on the side of incumbent entrepreneurs is necessary. Also, in my model, no value judgment is implied about high or low levels of entrepreneurship. In other words, the social environment is seen as a channel reducing the ambiguity associated with entrepreneurship but no inference about the desirability of more or less entrepreneurship is implied. In conceptual terms, my social environment is also perfectly consistent with established economic models on interdependence such as those found, for example, in game theory (Binmore, 1998) or in literature on social interaction (Becker, 1974; Brock and Durlauf, 2000; Gleaser et al., 1999).

3. The geographic concentration of entrepreneurship

When proper social networks are in place, agglomeration works and follows the form and patterns identified by the new economic geography literature. My argument complements the existing literature on geographical concentration by showing that, in addition to economic variables, the social environment is also an important cause of agglomeration, which is a clustering of activity created and sustained by some type of self-reinforcing phenomenon. In the agglomeration literature, significant differences in population density or
economic activity across locations are shown to stem from cumulative processes involving some form of increasing returns rather than from pre-existing exogenous differences.

Indeed, the widespread use of increasing returns in economic theory has allowed the development of a new economic geography capable of analyzing agglomeration phenomena (Krugman, 1991; Krugman and Venables, 1995; Puga and Venables, 1996). In these models, the causes of spatial concentration are attributed to knowledge spillovers, to vertical linkages associated with large concentrated markets, to transportation costs, and to economies of scope in the market for specialized labor (Fujita et al., 1999). The presence of one or more of these circumstances provides a rationale for the concentration of production in certain locations and, therefore, agglomeration.

Because of evident non-linearities in the distribution of economic activity across locations, the literature on agglomeration has also been more receptive than other branches of economics to the application of techniques based on discontinuities (Rosser, 1991). In practice, the economics literature on agglomeration looks at clustering emerging from an initially uniformly distributed population as the result of instabilities between agglomerative and degglomerative forces (Fujita et al., 1999; Rosser, 1991). For example, Papageorgiou and Smith (1983) explain local instability by building a model in which agglomeration results from the relative size of congestion costs, which discourage clustering, and positive locational economies, which encourage clustering. Along similar lines, Weidlich and Haag (1986) provide a three-region model in which migration is driven by an agglomeration parameter. Finally, Weidlich (2000) expands further the use of non-linear dynamics and other methods originating in statistical physics to model the evolution of urban centers caused by migration patterns of interacting populations.

In these models, as in my own, movements toward and away from clustering are associated with the existence of non-linearity, critical threshold levels, and the possibility of multiple equilibria. Specifically, my paper complements recent agglomeration models by introducing the social environment as an additional source of clustering. In my model, the effect of the social environment is captured through a non-pecuniary network externality that influences individuals’ decisions about entrepreneurship and, by contributing to the agglomeration of entrepreneurship in some geographic areas, produces divergence in the long run equilibrium of initially similar communities. Clearly, my argument complements recent agglomeration models whose goal is to study situations in which a small and possibly temporary asymmetric shock across locations may generate large permanent differences across initially homogeneous areas or production activities.

In my model, the strength of the network externality is also a measure of the degree of interdependence among agents. The relative strength of this interdependence, in its turn, can be modeled through bandwagon effects (Granovetter, 1978; Granovetter and Soong, 1983). In a bandwagon model, a community is defined as a set of individuals in which one agent’s decision to adopt a certain behavior generates a positive feedback mechanism. The feedback mechanism provides information to new agents and encourages further adoptions. In this context, thresholds are used to account for the fact that individuals have different participation propensities and that each member will join in only if the bandwagon pressure exceeds the member’s threshold. As a result, the extent of bandwagon diffusion in a community depends on the distribution of thresholds across members, as well as on the network of relations existing among members.
In bandwagon models, returns to any adopter may decline with the number of adopters, yet more adoption takes place because of positive network externalities (Katz and Shapiro, 1994, 1986). In our case, ambiguity makes agents uncertain about the desirability of joining the entrepreneurial bandwagon. However, as more and more agents choose to become entrepreneurs, more information, experience and know-how about entrepreneurship become observable and ambiguity declines. Of course, because of ambiguity, the final make-up of the community with respect to entrepreneurship is unknown, and multiple possible outcomes exist. In general, in bandwagon models multiple equilibria result from the introduction of different agent types, where the proportion of each type in the population is arbitrarily chosen. Thus, it is the exogenous distribution of types that determines what long-run equilibrium will ultimately emerge. In an alternative, an effective description of interdependence can be obtained by letting the unfolding dynamics of the entrepreneurial process select what characters will dominate over time and, as a result, endogenize the distribution of individual types rather than fixing it ex-ante with ad hoc assumptions.

Many problems with network externalities follow a pretty general non-linear probability structure. Thus, the use of non-linear path-dependent stochastic processes allows the study of multiple equilibria by means of simple allocation models. Non-linear path-dependent processes, also known as non-linear Polya processes, have been used in social sciences since the early 1980s (Arthur, 1989; David, 1985; Kindleberger, 1983). In these dynamic systems a positive feedback causes certain patterns to be self-reinforcing. Of course there is a multiplicity of such patterns, and since these systems tend to be sensitive to early dynamic fluctuations, they are very well suited for describing how local externalities matter in determining the entrepreneurial make-up of a region. Indeed, they show how the accumulation of different decisions taken by different individuals may push the dynamics of the entrepreneurial process into one among many possible patterns and, eventually, lock-in the structure (Arthur). Furthermore, these models support empirical findings showing the existence of non-linearities in social interdependence (Crane, 1991; Gleaser et al., 1999).

In this paper, the model focuses upon individuals’ interdependence with respect to entrepreneurship without making ad hoc assumptions about agents’ initial characteristics. By considering different sequences of new individuals entering the market, the model describes the emergence of alternative patterns of entrepreneurial behavior as unintended consequences of individual choice, and the effects of such patterns on the choice of new agents. Specifically, to derive my results, I use a simple example of non-linear path-dependent stochastic processes represented by a single monotonically increasing function, $g$, mapping proportions into probabilities. Also, I assume that the sequence of choices with respect to entrepreneurship generates a positive feedback that, over time, magnifies the effects of these choices. When this happens, increasing returns to adoption exist, and the outcome is neither unique nor predictable. In this paper, agents’ choices are rooted in a maximization problem,  

$^2$ Traditional economic theory suggests that a sequence of repeated choices generates diminishing returns and, over time, leads to the best outcome possible under the circumstances. This means that, given its initial endowment, there is a unique and predictable equilibrium toward which the economy moves. In other words, given the prevailing legal and economic circumstances, it is always straightforward to predict what level of entrepreneurial activity will prevail in a region at any point in time. Thus, differences in entrepreneurship rates across communities are explained without resorting to multiple equilibria but by assuming exogenous changes in economic characteristics.
and path-dependent Polya processes are used to account for the possibility of alternative
levels of entrepreneurial activity and to describe the importance of the social environment
in the development of alternative entrepreneurship patterns.3

4. Individual choice and relative returns to entrepreneurship

Consider a community of agents where income is obtained by being an entrepreneur or
by working as a wage earner. If $E$ is the number of entrepreneurs, and $N$ is the total number
of individuals, then $e = E/N$ is entrepreneurship rate. Agents are heterogeneous with respect
to employment opportunities and personal preferences across work and leisure. Each agent
compares the expected net revenues from entrepreneurship with that of non-entrepreneurial
work. To make this comparison, the agent must know what her net revenue from each activity
would be assuming that she supplies the optimal quantity of labor. In order to calculate her
net revenue from each activity, she solves two maximization problems, one if she chooses
entrepreneurship and one for her best option outside entrepreneurship.

For non-entrepreneurial activity, total revenue is the product of the number of hours
supplied and the wage rate, $w$, whereas the agent’s total costs, which include foregone
leisure, are a quadratic in the number of hours supplied, $s$.4 The net revenue function for
agent $j$ has the form

$$y = ws - (\alpha_1 s + \alpha_2 s^2).$$

Optimality requires $w = \alpha_1 + 2\alpha_2 s$; therefore

$$s = \frac{(w - \alpha_1)}{(2\alpha_2)},$$

(1)

where $w > \alpha_1$, $\alpha_1 > 0$, $\alpha_2 > 0$.

Eq. (1) indicates the optimal quantity of labor, $s$, that agent $j$ should supply given her
personal preferences and the wage rate. Substituting $s$ into $y$, and introducing the subscript
ne to denote non-entrepreneurial activity, we obtain

$$y_{ne} = \frac{1}{4\alpha_2}(w_{ne} - \alpha_1)^2.$$  

(2)

Eq. (2) describes the net revenue from the non-entrepreneurial activity. In addition, we can
assume that the higher the rate of entrepreneurship, the more brisk is the demand for labor;

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3 In studies that use path-dependent processes, the individual’s optimization problem generating the process is
often absent and economic agents are treated as statistical units. Indeed, path-dependent Polya processes describe
the aggregation of individual decision making rather than the architecture of individual decision making itself.
This absence, however, is not an intrinsic weakness of such models, and the omission may be corrected by simply
substituting the random event usually used to trigger the process with a description of how individuals choose
among alternative available options.

4 I have omitted the linear constraint on $s$, which cannot exceed 24 h per day. However, it is reasonable to
assume that the agent will find an interior solution; she will choose to enjoy some leisure. Explicitly introducing
the constraint on $s$ would simply clutter up the analysis.
therefore, the wage rate, \( w_{ne} \), is dependent on the rate of entrepreneurship. That is,

\[
  w_{ne} = \gamma_0 + \gamma_1 e,
\]

where \( \gamma_0 > 0 \) and \( \gamma_1 > 0 \).

Similarly, introducing the subscript \( e \) for entrepreneurship, we obtain

\[
  y_e = \frac{1}{4\sigma^2} (w_e - \alpha^1)^2,
\]

where \( w_e \) is the average revenue from entrepreneurial effort. This average revenue is also a linear function of \( e \). That is,

\[
  w_e = \beta_0 + \beta_1 e,
\]

where \( \beta_0 > 0 \) whereas \( \beta_1 \) can be both positive or negative.

When \( \beta_1 < 0 \), as the number of entrepreneurs increases, more resources and services become available and nascent entrepreneurs benefit from external economies. If \( \beta_1 > 0 \), instead, the growing number of entrepreneurs increases competition and reduces entrepreneurial revenues. Overall, Eqs. (3) and (5) describe a twofold pecuniary network externality influencing the returns to both work and entrepreneurship.

The entrepreneurial decision, however, is also affected by a non-pecuniary externality. In an environment without ambiguity, the agent would choose entrepreneurship if and only if \( y_e > y_{ne} \), but in fact, a potential entrepreneur may choose to remain a worker even when \( y_e > y_{ne} \). This is because the agent’s ignorance of the entrepreneurial process creates ambiguity, to which the agent is averse. Ambiguity is not uncertainty; uncertainty is Knightian “risk” and exists when the agent knows all possible states or outcomes and attaches a probability to each. Ambiguity, on the other hand, exists when the agent does not know the structure of her situation. She cannot attach probabilities to all possible states or outcomes because she cannot list them.

Different agents are likely to have different degrees of ambiguity aversion. Thus, for each agent and each entrepreneurship rate \( e \), there is an ambiguity premium that makes her indifferent between her entrepreneurial income and a smaller certainty equivalent produced by any other activity. As the entrepreneurship rate increases, the existence of role models, information, and examples reduces the perceived ambiguity of entrepreneurship and reduces the required premium.\(^5\) Let us assume that for each agent, \( j \), the ambiguity premium takes the simple form \( p^j = \rho_j / (1 + e) \) where the value of \( \rho \) varies from person to person. Then the agent chooses entrepreneurship if and only if \( y_e - y_{ne} > \left( \frac{\rho_j}{1 + e} \right) \).

Let the relative return to entrepreneurship, \( r^j \), be defined by

\[
  r^j = -\rho^j + (1 + e)(y_e - y_{ne}).
\]

Substituting (2)–(5) into (6) yields

\[
  r^j = a_0^j + a_1^j e + a_2^j e^2 + a_3^j e^3,
\]

\(^5\) This claim follows directly from the assumption that entrepreneurship exhibits increasing returns to adoption. It is important to notice that what matters is the entrepreneur’s perception of ambiguity and not any objective change in her prospects or in the environment in which she operates.
where

\[ a_0' = (\beta_0 - \gamma_0) \left( \frac{\beta_0 + \gamma_0 - 2\alpha_0}{4\sigma_2} - \rho \right) , \]

\[ a_1 = \frac{1}{4\sigma_2} [2\beta_0\beta_1 - 2\gamma_0\gamma_1 - 2\gamma_1\beta_1 + 2\alpha_1\gamma_1 + \beta_0^2 - \gamma_0^2 - 2\alpha_1\beta_0 + 2\alpha_1\gamma_0] , \]

\[ a_2 = \frac{1}{4\sigma_2} [\beta_1^2 - \gamma_1^2 + 2\beta_0\beta_1 - 2\gamma_0\gamma_1 - 2\gamma_1\beta_1 + 2\alpha_1\gamma_1] , \]

\[ a_3 = \frac{1}{4\sigma_2} [\beta_1^3 - \gamma_1^3] . \]

The agent chooses entrepreneurship if and only if \( r_j > 0 \). Consistent with the fact that individuals are heterogeneous, \( r_j \) depends on \( \rho \), which is agent specific. In addition, \( r_j \) depends on the entrepreneurship rate. Finally, when \( e = 0 \), \( r_j = a_0' \).

Let the community be formed by a continuum of individuals uniformly distributed along the closed interval \([a_0', a_1']\), where \( a_0' \neq a_i' \forall j \neq i \), so that individuals are heterogeneous and \( a_0' > a_0 > a_j' \forall j \in [0, 1] \). In addition, to insure that not all agents become entrepreneurs under all circumstances, let us assume \( a_0' < 0 \). For each individual \( j \), the relative-return function is of the type

\[ r_j = a_0' + f(e) , \tag{8} \]

where \( f(e) = a_1' e + a_2' e^2 + a_3' e^3 \).

The superscripts \( j \) now attached to all parameters indicate that marginal rates of change differ across individuals and that for each individual, the relative-return function, \( r_j \), is a vertical displacement from the common function \( f \) described by Eq. (8). Also, for each individual, the relative return function is a cubic in \( e \). For appropriate values of all \( a_i \), the shape of \( f \) reflects increasing returns to adoption with respect to entrepreneurship. That is, every thing else being the same, the more entrepreneurs there are, the higher is \( r_j \).

Fig. 1 shows the relative-return function for some representative individuals. Relative returns to entrepreneurship are measured on the vertical axis, whereas the horizontal axes measures the actual rate of entrepreneurial activity. The shape of \( f \) depends on the rates of return to both entrepreneurship and other activities with respect to the entrepreneurship rate.\(^6\) Note that most individuals’ choice depends on the entrepreneurship rate and that different levels of entrepreneurial activity may mean different choices. In Fig. 1, for example, the individual identified by the intercept \( a_0' \) becomes an entrepreneur only if \( e \geq A \). On the other hand, some individuals always choose entrepreneurship, regardless of the entrepreneurship rate, while others always choose other activities. In the figure, such “limit” types exhibit relative-return functions that never cross the horizontal axis.

\(^6\) Clearly, the function in Fig. 1 is only an example. The shape of the relative return function depends on the values of its coefficients.
5. A dynamic model of entrepreneurial activity

If social habits have no influence on people’s decisions, knowledge of each individual’s personal characteristics is sufficient to determine whether she will become an entrepreneur. In such a case, regardless of the level of entrepreneurship, choices are known a priori and the collective outcome is simply the sum of all individual choices. In reality, however, this does not happen. Agents’ decisions are, at least to some extent, interdependent. Moreover, while agents’ subjective relative-return functions may be known, the timing and type of their potential opportunities is unknown. As a result, the sequence of their choices with respect to entrepreneurship is unknown too. Chance events may produce a sequence of choices that gives an initial advantage to, say, entrepreneurship. Entrepreneurship may then become more appealing to a wider proportion of potential adopters and, eventually, the community moves toward a high level of entrepreneurial activity. Different events, however, may produce a different result. Thus, if the relative returns to entrepreneurship are increasing, multiple equilibria arise and fluctuations in the order of choices may produce differences in the final level of entrepreneurial activity (Arthur et al., 1983). In my model of choice between entrepreneurship and other activities, the realized proportions of both choices are summarized by the entrepreneurship rate. Thus, exploiting the dynamic properties of non-linear path-dependent processes, I derive a function $g(e)$ mapping the entrepreneurship rate into the probability that individuals newly entering the community will choose to become entrepreneurs.
Consider a vector, $v$, that records the realized proportions of all possible event types. In our case, $v$ has two elements, one recording the level of entrepreneurship and one recording the level of non-entrepreneurial activity. Clearly, all elements in the vector are between zero and one and their sum equals one. In non-linear path-dependent processes, the probability of each event type in the future may be described as a function of that vector. Such a function, $g(v)$, is a vector mapping a set of proportions into a vector of probabilities. In my model, there are only two possible events: Either individuals become entrepreneurs or they do not. Furthermore, each of them makes a decision based on $r_j$ which, in turn, depends on the existing entrepreneurship rate. Thus, it is possible to derive a simple function $g$ that maps the existing amount of entrepreneurial activity, $e$, into the probability that new individuals will become entrepreneurs. (The second component of $v$ is redundant, so we may substitute the scalar $e$ for the vector $v$.) From Eq. (8) and the assumption that individuals are distributed uniformly over the closed interval $[a_0, a_1]$, it follows that

$$g(e) = \frac{a_1 + f(e)}{(a_1 + f(e)) - (a_0 + f(e))} = \frac{a_1 + f(e)}{a_1 - a_0}. \quad (9)$$

Eq. (9) describes the interdependence among individual decisions by showing how each agent is influenced by what other agents have chosen before her. This can be seen in Fig. 2 by recalling that the probability of the next agent choosing entrepreneurship is a function of the proportion of agents for whom, at the current entrepreneurship rate, $r^j > 0$. In Fig. 2, for example, the distance $BE$ describes the proportion of individuals who prefer entrepreneurship over the alternative activity if the level of entrepreneurship is $E$. The

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$^7$ As an example, consider an urn containing one white and one red ball. Assume that, randomly, one ball is selected from the urn and, after its color is observed, is returned to the urn together with a third ball of matching color. If the game is repeated over and over, in each round, the probability of selecting a red(white) ball is equal to the proportion of red(white) balls already in the urn.
ratio $BE/BC$, where $BC = a_1^{j=0}a_0$, measures the probability that the next individual coming into the community will choose to be an entrepreneur. In fact, Eq. (9) is simply a linear transformation of the average relative return function $r^j$, and the function $g(e)$ maintains the shape of $f(e)$.

In non-linear path-dependent processes, the self-reinforcing nature of the events described implies that the shares of each event type converge to a stable fixed point of $g(v)$. As the number of event realizations increases, $v$ tends, with probability one, to a limit vector $v$ randomly selected from the set of all possible limit vectors. This mathematical property enables the model to show why entrepreneurship tends to concentrate geographically. Let us imagine a community with a number of potential newcomers. Each newcomer, $j$, chooses either entrepreneurship or some alternative activity. In every period, let new agents enter the community and choose each activity with probabilities that are a function of the proportions of each type already existing in that community. Let $e_n$ be the proportion of entrepreneurs that determines the rate of entrepreneurship, after $n - 1$ agents have made their choice, and let $g$ be a continuous and twice differentiable function mapping proportions into probabilities. Each agent added to the community chooses entrepreneurship with probability $g(e_n)$. The action is repeated over and over. Relevant to my analysis of entrepreneurship patterns is that $e_n$ tends, with probability one, to a limit random value $e$ selected from a finite set of possible values. The set of possible values includes all, and only, the stable fixed points of $g$.

A closer look at the dynamics of the system helps in demonstrating how the process behaves as more and more individuals are considered. Such dynamics can be divided into a stochastic and a deterministic part. At time $1$, the size of the population is $N$ and the number of entrepreneurs is $E_0$. At time $n$, $e_n$ is the “entrepreneurship rate” facing the person choosing in period $n$. At time $n + 1$, the population is $(N+n-1)$ and the number of entrepreneurs is $E_n$. Thus, $e_n = E_n/(N+n-1)$ is the rate of entrepreneurial activity after $n$ individuals have made their decision. It follows that for next period, the rate is given by

$$e_{n+1} = \frac{E_{n+1}}{N+n}.$$ 

Since individuals have only two alternatives, that is to become or not become entrepreneurs, the entrepreneurship rate is a random variable given by

$$e_{n+1} = \begin{cases} \frac{E_n}{N+n} + \frac{1}{N+n} & \text{with probability } g(e) \\ \frac{E_n}{N+n} + \frac{0}{N+n} & \text{with probability } 1 - g(e) \end{cases},$$

that is

$$e_{n+1} = \begin{cases} e_n \left(1 - \frac{1}{N+n}\right) + \frac{1}{N+n} & \text{with probability } g(e) \\ e_n \left(1 - \frac{1}{N+n}\right) & \text{with probability } 1 - g(e) \end{cases}.$$ (10)

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8 For the system to work, the number of fixed points of $g(x)$ must be finite (see Arthur et al., 1987).

9 The following paragraph is a version, modified to fit my model, of the general explanation of the dynamics of path-dependent processes given in Arthur et al. (1987).
Thus, the expected value of the entrepreneurship rate is given by

$$E(e_{n+1}) = e_n \left(1 - \frac{1}{N+n}\right) + \frac{g(e)}{N+n}.$$  \hfill (11)

Eq. (11) may be rewritten as

$$E(e_{n+1}) = e_n + \frac{g(e) - e_n}{N+n}.$$  \hfill (12)

Eq. (12) describes the deterministic portion of the dynamics of this system. The stochastic portion is described instead with the aid of the random variable

$$\lambda(e) \begin{cases} 
    1 & \text{with probability } g(e) \\
    0 & \text{with probability } 1 - g(e) 
\end{cases}.$$  

From Eqs. (10) and (12), it follows that

$$e_{n+1} = e_n + \frac{1}{N+n} [g(e) - e_n] + \frac{1}{N+n} [\lambda_n(e) - g(e)].$$  \hfill (13)

The stochastic portion of the system’s dynamics is given by the third term on the right of Eq. (13), and its expected value is zero. Notice that when $g(e) \geq e_n$, $E(e_{n+1}) \geq e_n$. This shows that the system is attracted to the stable fixed points of $g(e)$. As long as $g$ is continuous and twice differentiable, as the number of agents increases, $e$ will tend randomly toward one among all possible limit points. That is, the entrepreneurship rate will converge with probability one to a stable fixed point of $g(e)$.

Fig. 3 shows a possible $g(e)$ function. $A$, $B$, and $C$ are its fixed points, but while $A$ and $C$ are stable, $B$ is not. When the $g$ function is approaching point $A$, the probability of the next agent choosing entrepreneurship is higher than the entrepreneurship rate, and the latter tends to increase. Between points $A$ and $B$ the probability of next agent choosing entrepreneurship
is lower than the entrepreneurship rate, so the latter tends to decrease. Between \( B \) and \( C \) the probability of next agent choosing entrepreneurship is higher than the entrepreneurship rate, so the latter tends to increase. Finally, between \( C \) and 1 the probability of next agent choosing entrepreneurship is lower than the entrepreneurship rate, and the latter tends to decrease. The system will settle at either \( A \) or \( C \). Indeed, when there are multiple stable points, which one is chosen depends on the accumulation of choices that occurs as the stochastic process unfolds. In other words, where the region settles, whether at \( C \), the high entrepreneurship level, or at \( A \), the low entrepreneurship level, depends on the relative returns to entrepreneurship. Of course, the values of \( A \), \( B \), and \( C \) are all community specific.

Given the values of the parameters in Eq. (8) and its relevant domain for \( 0 < e < 1 \), two alternative cases are possible. In the first case, \( \beta_1 > \gamma_1 \), the pecuniary network externality generated by the entrepreneurship rate on entrepreneurial revenues exceeds the one on non-entrepreneurial revenues. Thus, the pecuniary and non-pecuniary externalities reinforce each other and make entrepreneurship particularly attractive. In this case, \( g(e) \) possesses only one stable point, and the community settles trivially at the rate of entrepreneurship.
corresponding to that point. In the second and more interesting case, \( \beta_1 < \gamma_1 \), the pecuniary network externality created by the entrepreneurship rate on non-entrepreneurial revenues exceeds the one generated on the average revenues to entrepreneurship, thereby reducing the attractiveness of the latter choice. The non-pecuniary externality, however, counteracts that negative influence by reducing the ambiguity associated with becoming an entrepreneur. In this case, increasing entrepreneurial competition or a large premium attached to dependent labor pushes individuals’ relative returns in favor of non-entrepreneurial activities. Simultaneously, however, the positive effect generated by the non-pecuniary externality counteracts this negative pressure, and the entrepreneurship rate may continue to rise. Thus, the net effect of the pecuniary and non-pecuniary externalities on individuals’ choices with respect to entrepreneurship is uncertain, and multiple equilibria arise.

The S-shaped function depicted in Fig. 3 illustrates the second scenario, when \( a_2 > 0 \) and \( a_3 < 0 \). As an example, let \( e^* = 0.5 \), \( f^* = 2.25 \), \( a_1 = 0 \), \( a_2 = 4.5 \), \( a_3 = -3 \), and the range of \( a_{ij} \) be in the interval \(-1.6 \) (lower bound) to \( 0.02 \) (upper bound). As a result, the fixed points of \( g(e) \) are 0.0128 (stable), 0.5648 (unstable), and 0.9224 (stable). Fig. 4 shows the corresponding \( f(e) \) min, \( f(e) \) max, \( g(e) \) and \( y = e \). Fig. 4a shows an enlargement of the area
Fig. 5. Evolution of the rate of entrepreneurial activity when $\beta_1 > \gamma_1$.

Fig. 6. Evolution of the probability of becoming an entrepreneur when $\beta_1 > \gamma_1$. 
Fig. 7. Example of $f(e)_{\text{min}}, f(e)_{\text{max}},$ and $g(e)$ functions when $\beta_1 < \gamma_1$.

around $e = 0$. Fig. 5 shows the results of 10,000 simulation steps starting with $N = 100$. Taking the initial number of entrepreneurs to be $E_0 = 0, 10, 30, 50, 60, 80, 90, 95$, the graph shows the evolution of the rate of entrepreneurial activity over time. Finally, Fig. 6 shows the evolution for $g(e)$; in other words, it shows the evolution of the probability to become an entrepreneur. It is apparent that $g(e)$ converges more rapidly to one of the stable fixed points. Fig. 7, instead, shows an example when $\beta_1 > \gamma_1$. In this case $a_2 < 0$ and $a_3 > 0$. Fig. 8 shows the existence of unambiguous convergence toward the only stable point of $g(e)$.

6. Entrepreneurial activity and policy effectiveness

A closer look at the dynamic properties of the model offers some interesting insights on the progressive development of alternative entrepreneurship patterns and their dependence on the history of a community with respect to entrepreneurship.

First, the model allows individuals to make mistakes. That is, individuals do not necessarily form rational expectations. This assumption is consistent with the premise that
agents’ estimates of returns are based on their own perceptions of the costs and benefits involved in each activity, not on what these costs and benefits actually are. Technically, the introduction of rationality would diminish the descriptive power of the model while generating the same qualitative results. Indeed, let us assume that individuals do form rational expectations. In my model, individuals may find themselves choosing in two different situations: (1) when the entrepreneurship rate has already settled at its long run equilibrium (whether it be a high or low entrepreneurship equilibrium is not relevant), or (2) when the dynamics of the process is still unfolding. In the first case, when the region is more or less close to a long-run equilibrium, the current entrepreneurship rate approaches the long run entrepreneurship rate, and the decisions of my agents are similar to those of agents with rational expectations, possibly with convergence happening faster in the case of rational expectations. In the second case, when the entrepreneurship rate is still very different from the long run equilibrium, both agents are equally ignorant of what the long run equilibrium will be. Rational agents, however, do know that they face a lottery in which the community will end up in either a high or a low entrepreneurship equilibrium, and this knowledge may alter the critical values at which entrepreneurship is chosen. Thus, if the future is discounted
at a high rate, any such alteration will be modest and, again, the behavior of both agent types will be similar. If, on the other hand, the future is discounted at a low rate, rational agents will rush the community toward its long run equilibrium. Since the purpose of this model is to describe the development of alternative patterns of entrepreneurial activity, a framework that stresses transition dynamics seems more appropriate.

Second, by allowing multiple equilibria to exist, the model shows that ex-ante knowledge of local economic conditions, though necessary, is not sufficient to anticipate what level of entrepreneurial activity will prevail. That is, the model shows why the existence of certain economic incentives, though necessary, is not sufficient to guarantee the development of much entrepreneurial activity or innovation. This explains, for example, the existence of regions that, in spite of similar initial characteristics, end up not looking alike. Third, if entrepreneurship exhibits increasing returns to adoption, then the entrepreneurial process is non-ergodic. A process is ergodic if, for any given sequence of choices, \( \{x_n\} \), \( x_n \to x \) with probability 1 as \( n \to \infty \). Randomly, a particular sequence of choices causes the process to bend toward a specific level of entrepreneurial activity among all the possible ones. A
different sequence, however, would have bent it toward an alternative level. By showing that agents’ choices are influenced by what others have chosen, non-predictability and non-ergodicity highlight the importance of the social environment in shaping the entrepreneurial make-up of a region.

Since the entrepreneurial history of a community creates such an externality on agents’ decisions to become entrepreneurs, the model has also relevant policy implications. As shown in Fig. 2, each individual has a decisional threshold, namely the point at which personal relative returns become positive and the individual decides to become an entrepreneur. At any point in time, the sequence of individuals’ decisions made on the basis of these thresholds determines the local amount of entrepreneurial activity. For any region, however, there is also an amount of entrepreneurship that represents the regional threshold. That is, the point beyond which a region moves toward a high level of entrepreneurial activity represented, for example, by point $B$ in Fig. 3. Suppose, for instance, that a community starts at some low level of entrepreneurship such as at point $A$ in Fig. 3. Since point $A$ is self-perpetuating, any attempt to increase the incidence of entrepreneurship would be

![Potential functions corresponding to $g(e)$ function in example 1.](image)

Fig. 10. Potential functions corresponding to $g(e)$ function in example 1.
successful only if it can make the system gravitate toward point $C$, the self-perpetuating high-entrepreneurship equilibrium. This means that, no matter how big or expensive, if the policy fails to affect individuals’ relative returns sufficiently, its effects will, at best, be transitory. In fact, the shape of the function $g(e)$ determines the effectiveness of the policy.

As an example, let us consider a policy change that raises all the intercepts of the $r_j$ functions. The potential function of $g(e)$ defined as

$$\phi(e) = -\int_0^e (g(e') - e') \, de'$$

(14)

is a good measure of the attractive strength of its fixed points and can be used to gauge the effectiveness of an exogenous shock to the system. The depth of the potential valley around each fixed point is a measure of its strength against random fluctuations. A difference of potential between two points describes the strength or speed of evolution of $e$ toward the state with lower $\phi(e)$. Also, the region around a local minimum and between two local

![Fig. 11. Effect of a policy shift on $g(e)$ function – example 2.](image)
maxima of $\varphi(e)$ defines the basin of attraction of the local minimum. The strength of the basin of attraction against parametric changes caused, for example, by an exogenous policy is approximated by the corresponding potential difference too. An upward shift of $g(e)$ gives rise to a change in the overall shape of $\varphi(e)$ so that the low-entrepreneurship stable fixed point becomes more shallow while the high-entrepreneurship stable fixed point becomes the global minimum. Thus, policy effectiveness may be evaluated by looking at the behavior of the potential function. Intuitively we might say that the closer $g(e)$ is to the 45-degree line, the more effective a given policy will be.

To illustrate this point, let us consider two possible $g(e)$ functions. Fig. 9 shows the $g(e)$ function before and after a policy shift of 0.08. For this function, $a_1 = 0.0$, $a_2 = 4.5$, and $a_3 = -3$. Before the policy shift, the range of intercepts for $r^j$ is $c = [-1.6, 0.02]$ and the function has fixed points at 0.0128 (stable), 0.5648 (unstable), 0.9224 (stable). After the shift the range of intercepts for $r^j$ becomes $c = [-1.52, 0.1]$ and the fixed points become 0.0776 (stable), 0.4352 (unstable), 0.9872 (stable). The corresponding potential functions $\varphi(e)$ are shown in Fig. 10.
The second $g(e)$ function is shown in Fig. 11. For this function, $a_1 = 3.63$, $a_2 = 4.2$, and $a_3 = -4$. Before the policy shift, the range of intercepts for $r_j$ is $c = [-4.5, 0.02]$, and the fixed points are 0.0255 (stable), 0.2554 (unstable), 0.7692 (stable). After the shift, the range of intercepts for $r_j$ becomes $c = [-4.42, 0.10]$ and the only fixed point is 0.8145 (stable). The corresponding potential functions $\varphi(e)$ are shown in Fig. 12.

The graph of the function plotted in Fig. 9 seems further from the 45-degree line than does the graph of the function plotted in Fig. 11. Depending on the shape of $g(e)$, the same policy shift of 0.08 may result in a relatively minor strengthening of the attractiveness of the preferred stable point (Fig. 9) or in the collapse of the potential function landscape to only one, high-entrepreneurship fixed point (Fig. 11). When the latter case happens, the policy is highly effective. On the other hand, in the first case the policy fails to influence agents’ behavior permanently with respect to entrepreneurship.

7. Conclusion

Empirical observations show that entrepreneurship tends to concentrate geographically and that while some communities exhibit high rates of entrepreneurial activity, others, with similar initial characteristics, do not. To complement recent literature on agglomeration, I suggest that one important cause of such concentration is the self-reinforcing nature of entrepreneurship. If entrepreneurship exhibits increasing returns to adoption, then it can be shown that the social environment, by providing information and role models, influences new individuals entering the economy and encourages them to choose entrepreneurship independently of their ex-ante preferences and constraints.

To derive my results I use a simple example of a general class of non-linear path-dependent stochastic processes. For each individual I have assumed the existence of only two choices, to become an entrepreneur or to become a wage earner. And I have chosen a family of relative-return functions all described by vertical displacements of the same function. As a result, I am able to derive a single monotonically increasing function, $g$, that uses the existing level of entrepreneurial activity as an indicator of future levels of entrepreneurship. Under certain conditions, the dynamic pattern of entrepreneurship is shown to be unpredictable and non-ergodic. Unpredictability accounts for differences in the rate of entrepreneurial activity across otherwise similar communities. Non-ergodicity explains that such differences are rooted, at least in part, in the local social environment.

Within the context of recent literature on entrepreneurship, the contribution of the paper is twofold. First, the paper supports and complements the literature on agglomeration phenomena and contributes to our understanding of the origins of entrepreneurial activity and of the causes of its development within regions. Specifically, the model suggests an explanation for entrepreneurial activity tending to concentrate geographically not only for the same type of industry but across industries as well. Second, the paper highlights the importance of the entrepreneurial history of a community in determining a policy’s effectiveness or lack thereof. In particular, the model suggests that cultural habits and perceptions are hard to break, for whole communities as well as for individuals. Thus, the possible lack of effectiveness is explained by the fact that the adjustment mechanism is, itself, a path-dependent process. Therefore, depending on the relative strength of the potential function of
\( g(e) \) against random fluctuations, the same policy may have very different results in different communities.

Finally, although suggestive, the conclusions and implications of the paper provide many additional questions worth of further investigation. For example, it would be desirable to revisit the issue of pecuniary and non-pecuniary externality in entrepreneurship using alternative forms for the relative return function. Second, in its current formulation, the model does not allow the possibility of switching. That is, agents make their choice once and are not allowed to learn from their experience nor to adapt to a fast changing environment. Third, the spreading of entrepreneurship in a community could be formulated in an alternative way by using simulated spin-glass or NK models. Unlike the one presented in this paper, where connectivity among agents is complete, such models would allow the analysis of different degrees of connectivity. In other words, they would make it possible to distinguish the relative importance of strong versus weak ties in determining entrepreneurial decisions.

Since there is wide agreement that monetary rewards are not the only reason, further research is needed to understand what causes an individual to become an entrepreneur. If we take entrepreneurship seriously, we recognize its complexity. The rules and practices of the entrepreneurial processes are complex. They are embedded in the socio-economic environment of the entrepreneur and include past experiences and random accidents. Hopefully, we are on our way to understand better entrepreneurial behavior and to find new ways to simplify the complex.

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**References**


