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Inevitably reborn: The reawakening of extinct innovations☆

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Abstract

In our innovation-driven world we tend to lay concepts that have lost their attractiveness to rest and rush to embrace the next giant leap. However, in most fields of creation, patterns of reawakening of old, extinct innovations can be found. It often looks as if new technological and social concepts have a life of their own, survival instincts and adaptive properties: They simply refuse to die. Should these phenomena be resolved on an ad hoc basis or are they grounded in the foundation of social behavior or evolutionary processes of technology? In conditions in which continuum equations would predict the extinction of a population, the presently offered *microscopic representation* proves that individuals self-organize in spatiotemporally localized adaptive patches that ensure their survival, resilience, and development as a collective. A similar treatment can explain why so many innovations are inevitably reborn. Accordingly, in assessing the value of social ideas, trends and even wants we ought to consider longer time frames following the decline of innovations, otherwise we might prematurely and erroneously discard successful promising concepts.

Keywords: Innovation; Spatiotemporal; Reawakening

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1. Introduction

We are often amazed to learn about ideas that outlive their human carriers. However, we may ask ourselves why the next example does not naturally weld with our mental model of idea life span and why such an "exception" reoccurs so often?

In 1700, a Dutch amateur inventor assembled a pair of skating boots with a row of small wheels arranged in a straight line along the sole [1]. After the innovation was well diffused and became the common skating method, another inventor by the name of J.L. Plimpton developed roller skates, with wheels arranged in parallel rather than in-line, enabling stability, convenient adjustment to different sizes, and easy learning for beginner skaters. Consequently, the 1700 invention was abandoned, and it vanished—but not forever. In 1980, the Olson brothers found a pair of in-line skates left in an old toy warehouse. The outcome was the remaking of on-line skates known today as roller blades. Today, roller blades are one of the most remarkable market successes, shaping both cultural and sport trends. A search among products (the VW Beetle), music (the Beatles), technology (the return of the mainframe architecture of computers), architecture (e.g., Paladio's neoclassical architectural designs), and most other fields of creation, reveals similar patterns of reawakening of old, extinct innovations.

It looks as if ideas have a life of their own, survival instincts and adaptive properties: They simply refuse to die. We can stretch out the lives of innovations, be they business ventures, artistic ventures, and the like, before rival forces "creatively destroy" them [2]. However, when they fade away, we tend to lay the old innovation to rest, sometimes even abandon it altogether along with its historical records, and rush to embrace the next giant leap. Then, when it is doomed by the world as useless, its usefulness is retrieved. Thus, while certain ideas deserve to remain dead and buried (e.g., phlogiston and phrenology) others sometimes enjoy more than one lifetime, albeit in different shapes and forms that fit the changes that occurred in the society during the time they were "asleep."

In innovation management, such a phenomenon deserves attention in various aspects. In idea-generation stages, the quality of the initial pool of ideas that were collected has an influence on the outcome of the entire NPD (New Product Development) process [3]. However, coincidence and random search obtain poor results in terms of market opportunities, and more systematic methods are required [4,5]. Inspection of the past may reveal those old trends and preferences that dwell in needs that are more fundamental and therefore wait for a new technology or better version of a product to emerge. In the rest of the NPD process, knowledge about the past can make it more efficient. For example, in screening stages, perhaps past behavior can better indicate success and failure chances.

Although most of the innovation management activity should concentrate on focusing on the future, it might be worthy to have at least some glance at the past, and examine whether it is returning in the present. In these cases, the information obtained may be more reliable than asking consumers about information they do not know [6]. Saunders and Jobber [7] claimed that companies' long-term survival depends upon their replacement of existing products with new ones. We argue that leading old products and trends that replace the current have some advantages for those who are first to spot this market behavior.

Clearly, one can always single out an ad hoc explanation for the revival of most of the foregoing examples. However, if viewed from a broader perspective, it turns out that the phenomenon is universal: The vitality of many ideas tends to exceed the life horizon envisioned by its inventors and adopters, even if they follow the life cycle stages of growth, maturity, and decline. Careful analysis of case histories reveals that this dynamics cannot be solely attributed to a specific social–psychological trend or nostalgia. Furthermore, this phenomenon is not easily accommodated, and it even contradicts some of the well-established theories in social science, such as product life cycle [8]. Are these exceptional outliers of the normative approach or is there a unique generic dynamics that, in fact, underlies *all* of them? Should these phenomena be resolved on an ad hoc basis or are they grounded in the foundation of social behavior or evolutionary processes?

Recently, by using the *microscopic representation framework* [9], it was proven that the "victory of life" is a universal phenomenon that emerges generically in stochastic systems composed of individual autocatalytic elements. Within a simple model a hitherto hidden mechanism was uncovered describing the evolutionary patterns of abstract, mental artifacts under the pressure of environmental forces. The mechanism assumes simple generic features such as the proliferation and dying of the entities composing the system. In contrast, the usual macroscopic view of population density as a continuous function governed by (partial) differential equations misses the crucial mechanism responsible for the emergence, survival, diversification, and individuation of populations. Whereas continuum equations predict the extinction of a population, microscopic representation proves that individuals self-organize in spatiotemporally localized adaptive patches that ensure their survival, resilience, and development as a collective. As will be demonstrated below, a similar treatment can explain why so many innovations are inevitably reborn.

2. The universality of the phenomenon

As mentioned earlier, a rebirth phenomenon is evident in a wide range of categories. Not all cases are clear like the roller blades, yet "retro" or "vintage" trends were identified and reported to emerge since 1999.

One example is the office furniture industry, in which the retro segment is estimated to be $1.2 billion out of the $12 billion and was predicted by year 2000 to make up 25% of office furniture industry [10]. In the furniture category, this trend of fashion is also prompted by the lower costs. However, in other fields it is a pure aesthetics-driven trend.

Perhaps the most apparent case is the apparel fashion: Indeed, Cashill and Matteson [11] report that for the first time, designers are revisiting the 1980s that became "a decade of inspiration." The growing popularity of retro and vintage is attributed by Cashill and Matteson to the fact that now designers can capture the attention of consumers while making them feel "right at home." This trend of revisiting the 80s is supported by a large number of articles in fashion journals (see, e.g., Ref. [12]).

In the automobile industry the term "comeback" is used quite often. Following the Volkswagen new Beetle, the Mazda Miata, Chrysler PT Cruiser, and Ford Thunderbird comebacks were noted to signal "an era of retrostyling" [13]. Both the Volkswagen Beetle and the Chrysler PT Cruiser are modern versions of a 1930s-style car inspiring the claims that "Everything old is new again in the automotive business" [14].

A similar path can be observed in the cosmetics industry where companies reintroduce classic lipsticks by matching old-school colors with high-tech formulas. Two new brands from Estee Lauder (Apricot 2000 and Pink 2000) are 21st-century updates of 20th-century bestsellers [12].

Another revival of a past strong brand is in the sneakers category—the Adidas brand. The brand's retro 1970s has reported to leverage the company's worth from DM2.5 billion in 1993 to DM10 billion in 1998 [15].

Each one of the foregoing cases can be explained on an ad hoc basis. However, it seems that each case requires a *different* explanation, which may even be correct. It is the difference and extreme variance between those explanations that drives our interest—whether there is a common theory that governs this dynamics—and each explanation is just the spark that lights the fire.

3. Modeling the rebirth

To uncover a possible underlying dynamics of the rebirth we propose a *microrepresentation* technique. We present it below in two stages: (a) the concept of microrepresentation and (b) how we use it to model the rebirth.

3.1. Microrepresentation

Methods of understanding phenomena such as rebirth relate typically to the underlying complexity of the social systems that can be viewed as "adaptive complex systems." Complex systems are generally defined as systems that consist of a large number of individuals or entities that interact with each other, ultimately generating large-scale, collective (macro), visible behavior [16]. Although the interactions themselves may be simple in many such adaptive systems, the large scale of the systems at work allows the emergence of patterns that are hard to predict, hard to track empirically, and are often almost impossible to analyze analytically [9,16]. For example, Goldenberg and Efroni [17] show how market research cannot furnish firms with innovation ideas and attain pioneer status.

Various disciplines, such as physics, biology, and ecology, have developed theories and methods to investigate how complex systems evolve. In the social sciences, which recognize the inherent complexity of many systems such as markets and organizations, attention has been recently drawn to the analysis of complex systems and, specifically, to economic analysis [18] and to organizational management purposes (e.g., Ref. [19]). For example, Abrahamson and Rosenkopf [20] developed a computer simulation to understand social network effects on the diffusion of innovations. They demonstrated that an important factor, the structure of social networks, has a significant effect on the process. More recently, this new modeling approach was implemented in the context of new product adoptions: In

Goldenberg et al. [21] the strength of weak ties between communication networks over strong ties (and advertising) was evaluated. A saddle phenomenon of a severe drop in the adoption of new products, followed by recovery, was modeled and empirically validated [21]. The strength of complex-system studies stems from the fact that they enable linking micro- and macrosocial phenomena [22] that help to explain in detail apparent, yet not intuitive, behavior. To explicate the concept of microrepresentation, consider a simple yet effective method, the cellular automata modeling [21,23].

In contrast to modeling techniques that use the aggregated characteristics of the population to simulate changes in the characteristics of the whole population, cellular automata models are simulations of global consequences, based on local interactions of members of a population. These individuals might represent plants and animals in ecosystems, vehicles in traffic, people in crowds, etc. The models typically consist of an environment or framework in which interactions occur between different types of individuals that are defined in terms of their behaviors (procedural rules) and typical parameters; the state and the changing parameters of each individual are both tracked over time.

For example, a general cellular automata is composed of an array of cells, each of which can have discrete values (e.g., 0 and 1, in this example) that represent the states each individual can have. The transition from 0 to 1 is governed by two probabilistic rules: (1) an external influence that covers all the cells and (2) interactions between cells. A cellular automata model can represent diffusion of innovation process. In this case, the external influence indicates that marketing efforts and the interactions represent the word of mouth. The model is solved computationally by running a stochastic process where at each period each individual probability of adoption is determined by the two forces described. The technical realization consists of running the cellular automata on various ranges to detect complex and unpredictable aggregate behavior of the market. Results for a particular realization of one stochastic process are depicted in Fig. 1.

3.2. The mechanism of rebirth of innovations

Cellular automata modeling has a wide range of applications; however, for understanding rebirth a few modifications are required. The cells that represent consumers in the marketing application are static, leading to a limitation of a microrepresentation, which is not dynamic. The suggested mechanism of rebirth requires a dynamical representation. However, in our review of the marketing literature we did not find any model that belongs to this family of complexity approaches that address this requirement. Consequently, we were led to choose the *proliferation* (sometimes called *angels and mortals*) model [24], which already incorporates this modification.

Consider an infinite land populated by two types of agents: mortals (die after a specified rate) and angels (do not die). Both types undergo diffusion per unit time. In the model simple relations between the two types of agents can determine suppressing dynamics that might be previously considered as too complex to understand.

For our purpose, imagine an area inhabited by a population of agents A consisting, for example, of potential adopters of an innovation that are spread out uniformly with an average

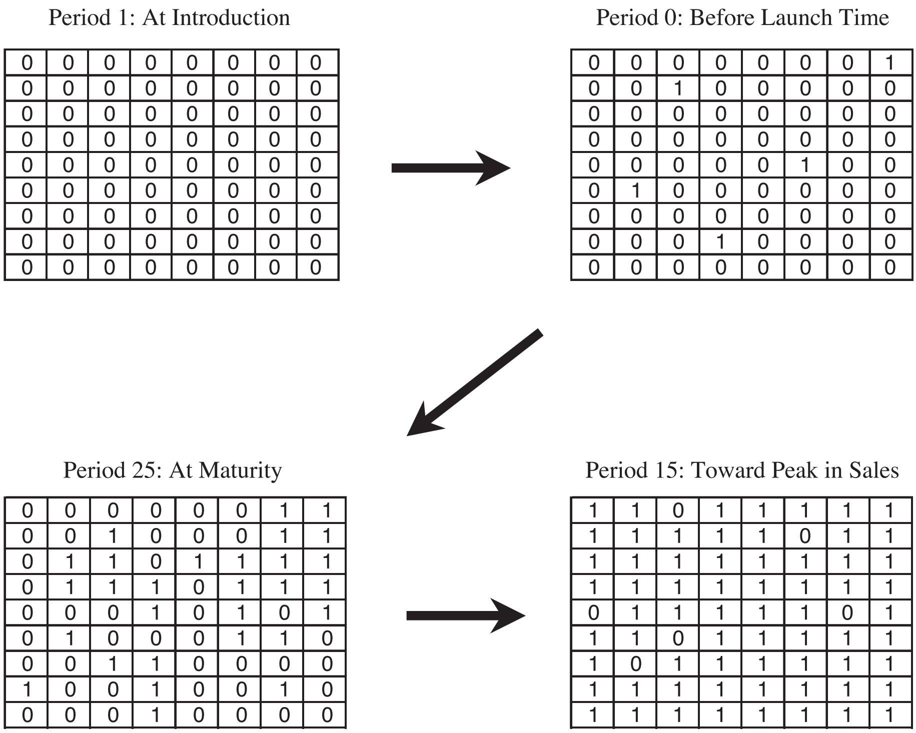

Fig. 1. Illustration of the cellular automata process: the value of zero represents a potential consumer who has not adopted the product and a value of one represents a consumer who has adopted the product.

density $n_A(0)$ and move around randomly, with diffusion coefficient D_A. For simplicity, these A's may be considered immortal but one can also introduce nonvanishing death and birth rates, mutation rates, and/or local or global competition.

Imagine now a second type of agents, B (individual versions of new product concepts or innovations), which are also spread over this area, with initial uniform density $n_B(0)$. The B's are diffusive too, hopping between neighboring sites at the rate D_B. The B agents die at a constant rate, μ (ϕ is the number of the B's that are left after a period):

$$\mathrm{B} \xrightarrow{\mu} \phi$$

An interpretation of this equation is as follows: A new innovation (idea or product) has a finite life span in which it needs to be noticed and picked up or used by someone, or it fades from society's collective memory. If not used within that finite life span, knowledge about an innovation dies, and thus, so does the innovation, ultimately. Now, the B's proliferate with probability rate ë when they meet the "catalyzer" A:

$$\mathrm{B} + \mathrm{A} \xrightarrow{\lambda} \mathrm{B} + \mathrm{B} + \mathrm{A}$$

The meaning of this equation is that innovation B proliferates through society only when persons A notice and use the innovation. A picks it up, keeps a copy of the innovation (innovations are not "used up" through adoption), and either passes a second copy of the innovation on to someone else or passes along enough positive knowledge about it that someone else has the opportunity to see the utility of the innovation and adopt it themselves. In this way, A essentially provides the impetus that keeps B alive[1]. What will happen next?

Based on continuity assumptions, it can be concluded that A (potential adopters) reaches a spatially homogeneous distribution: $n_A(x)=n_A$, whereas the B time variation ($\partial n_B/\partial_t$) is represented by the linear differential equation:

$$\frac{\partial n_B}{\partial t} = D_B \nabla^2 n_B + (\lambda n_A - \mu) n_B \tag{1}$$

The first term represents the uniformization effect of the B (innovation) diffusion while the μ term indicates that a certain fraction of B's die per unit time. $\lambda n_A n_B$ represents the proliferation of B's in the presence of A's (who provide the resources for B's existence). The equation is linear in n_B and after some time the solution approaches:

$$n_B(t) = n_B(0) e^{t(\lambda n_A - \mu) n_B} \tag{2}$$

Eq. (2) predicts that when $\lambda n_A < \mu$ the B population will decrease exponentially to extinction.

Consequently, if Eq. (2) were to govern the real world in which no innovation would spread, only vitally needed basic products (for local consumption) would survive and no new ideas or trends in art or culture would emerge. The world would be numb and paralyzed. *What is wrong here*?

In contrast to social science diffusion theories that adhere to continuous conditions, microscopic representation (which was described earlier) takes into account the quantized character of the elementary components of the various systems [25,26]. In this case, the effect of the discretization is crucial—it represents the difference between life and death: When the mechanism described above is treated in its discrete form, the B population thrives instead of becoming extinct. One way of treating this dynamics is by means of a simulation [27,28]: The dynamics described above can be represented by tracking each agent and each death/proliferation event. The actual way to execute it is the same as the simpler case of *cellular automata* that was described above. The rates of proliferation and death are "plugged" into the computer program and the process is simulated accordingly to allow for a complete track of the state of each agent in space. In other words, we assigned each B at every position a constant death probability within a given time interval ($\mu\Delta t$) and a diffusion probability ($2dD_b\Delta t$). A agents were assigned a similar, albeit lower, diffusion probability. Each couple of B agents located at the same lattice point has a probability of destroying each other, and each A and B positioned couple have constant probability ($\lambda\Delta t$) of creating a new B. Fig. 2 illustrates the dramatic difference between the predictions of the two approaches. The implausible extinction of all innovation (and adopters) that was a result of the continuum equations is now replaced with a realistic result of survival and of innovations and progress.

[1] Again, one may introduce saturation, nonlinear and/or competition terms for the B's of the form $B+B \rightarrow B$, but they would not change the essence of the phenomenon under discussion here.

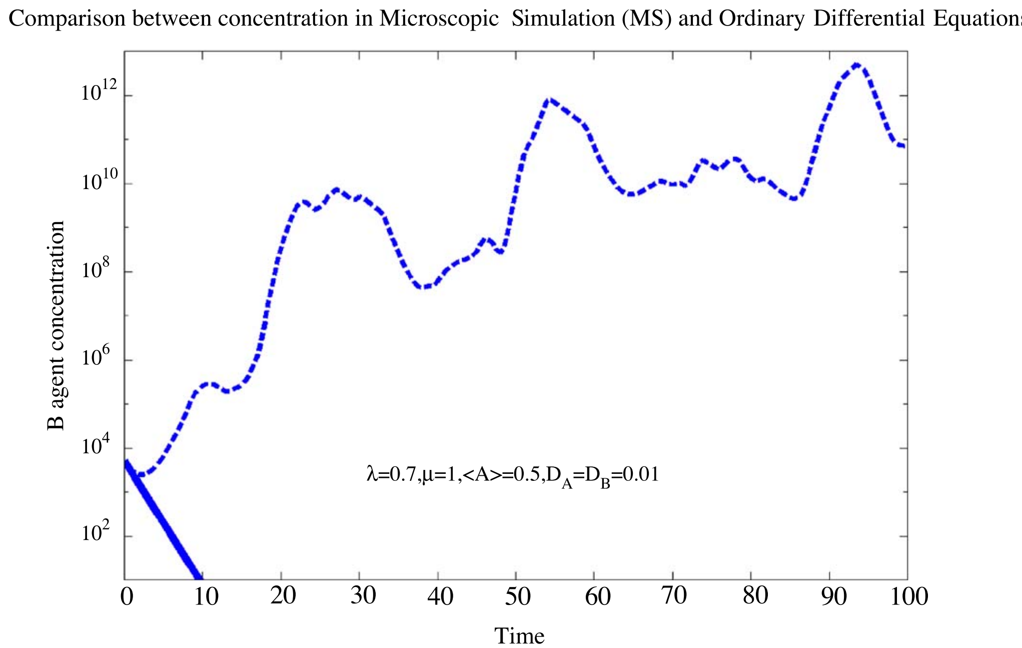

Fig. 2. While solving the deferential equations leads to a trivial solution (collapse to zero and extinction) the simulation provides a nontrivial solution (growth).

With this more sensible reality, let us now study the dynamics that leads to the cycle of life. To simplify the discussion, consider first the evolution of B following a single A representing a certain marketing opportunity (niche). A move diffusely in time effectuates a random walk that reflects the ever-changing market conditions. Clearly, in order to survive, the B (new themes and innovation) must trace A, and be localized in a patch (island) around the current A position. Note that this occurs in spite of the fact that each individual B does not prefer to move in the A direction: The probabilities of B jumping in each direction are always equal. The B collective follows the A's without any of the B individuals "knowing" that this happens. The market is more intelligent and efficient than any of the agents composing it. Each jump of A is followed by a temporal decrease of the B population, but overall B increases exponentially in between the A jumps:

$$n_{\mathrm{B}}(t) \approx n_{\mathrm{B}}(0)\mathrm{e}^{(\lambda-\mu-2dD_{\mathrm{B}})t} \tag{3}$$

where λ, μ and $2dD_{\mathrm{B}}$ stand for proliferation, death, and loss due to diffusion, respectively. The estimation is made by neglecting the flow of B's returning to the A location from neighboring sites. Fig. 3 depicts the results (through computational solution of the model) of how these islands develop and move (through a series of snapshots).

In the same approximation, the ratio between the height of the B density at the A location and the height of the B density at a neighboring site is easily estimated: λ/D_{B}. Consequently, each A jump corresponds to a sudden downward jump by a factor of λ/D_{B} in the height of the B hill. Because on average, there are $2dD_{\mathrm{A}}$ such jumps per time unit, the net effect of

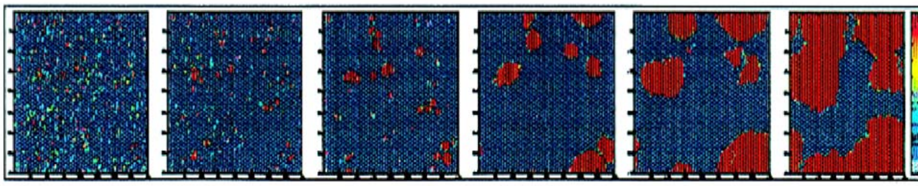

Fig. 3. A sequence of snapshots that shows how the islands develop and move (in the absence of saturation).

proliferation, diffusion, and death provides the B concentration at the A site as a function of time:

$$n_B(t) = n_B(0)e^{(\lambda-\mu-2dD_B ln(\lambda/D_B))t} \quad (4)$$

In simulations the results were consistent with Eq. (4): As long as the exponent in Eq. (4) is positive, the system escapes the gloomy death prediction of the continuum analysis, Eq. (2).

The interpretation of this relation is that even without individual awareness and /or communication/coordination, human beings as a group attain greater cohesiveness and offer the new concept's vitality to expand, to be promoted, and to grow. This is a more realistic result, compatible with the results of a number of major studies [29–31], than the mere statement that a product or a species diffuses freely in the "genomic" space.

After understanding that the dynamics of the collective islands is governed mainly by proliferation around "local" opportunities rather than by "inertial" diffusion, we are in a better position to understand the nontrivial spatiotemporal dynamics and the cyclic effects demonstrated by specific products/species. This is achieved by tracking the spatiotemporal propagation evolution of a B population in a randomly changing A (ecological niche, business opportunity, fitness landscape).

The main conceptual barrier that needs to be overcome in order to understand the resilience and "rebirth" of these systems is to realize that the localized B islands spontaneously develop adaptive features with which the A's and B's were not endowed at the outset. It is therefore hopeless to search for these features in the solutions of the equations acting on the aggregate functions that average over the original microscopic discrete objects A and B. The discrete character of the buy/sell transactions may ensure the survival of products in conditions in which the uniform market approximation predicts extinction.

The survival of the B's as a collective depends on the effective adaptive properties of the collective B objects—on their capability to search and find the A-rich territories. The individual B's are not adaptive and disappear when the basis for their existence is too weak, whereas as a collective, some of their descendents may survive in neighboring locations where the prevailing conditions are better. From there, they may reemerge in force when the conditions improve significantly. Similarly, an adaptive idea, innovation, or a new product will disappear from its original position when its basis is weakened, but will reemerge due to its long "tail" (its corollaries) in a nearby location where the new situation is more suited for its existence. If, however, the changes in the underlying A distribution are too rapid this idea

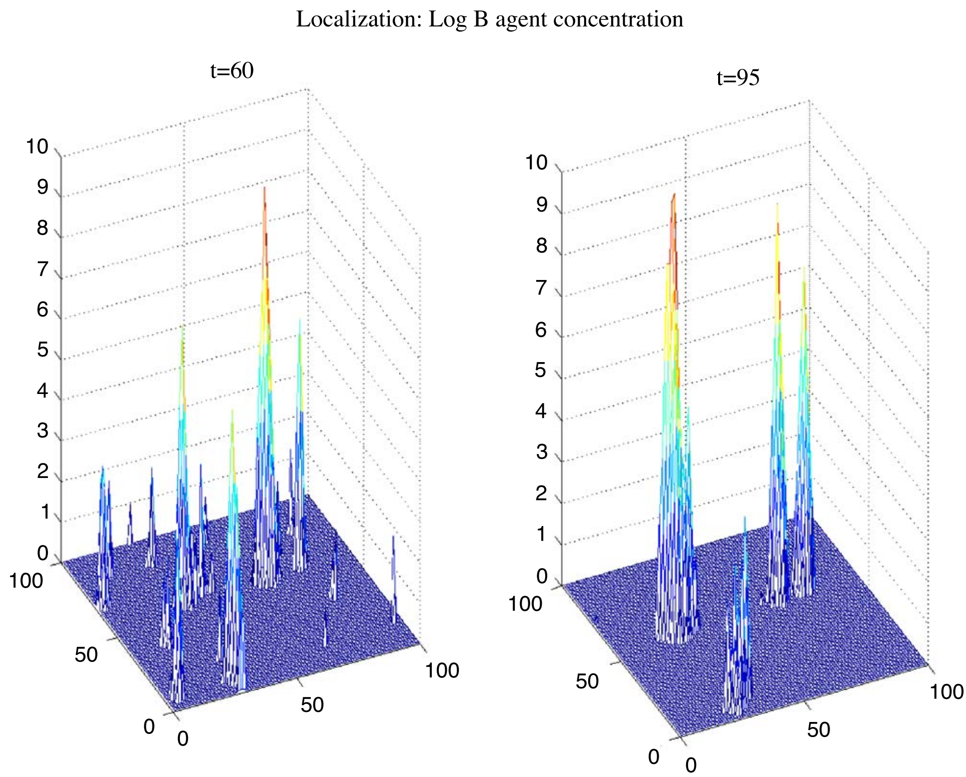

Fig. 4. The localization effect. Snapshots of B cell density spatial distribution at different times in the same system. One can clearly see the various islands appear and disappear. High-density B islands emerge around randomly occurring A aggregates. Once the aggregates disappear the B island collapses, unless a close enough A aggregate exists that can be "seeded" by B agents diffusing from the decaying islands. We present two randomly chosen snapshots at time frames 60 and 95.

is doomed to die[2]. This means that the discrete character of the B's implies that ideas can disappear suddenly and totally (like, say, extinct languages after their last speaker dies, technology after all consumers switched completely to a substitution). By contrast, in a continuum-variable description there will always be traces left (one thousandth of a speaker preserving the tradition, one storehouse that keeps an old version of roller blades). The survival and the revival of themes and extinct innovation occur as the result of a "localization" [32] process. The various B agents (ideas, products, designs, etc.) proliferate within islands of opportunity that emerge and whose effective adaptive dynamics is qualitatively different from the original dynamics characterizing the individuals. This localization is demonstrated in the results (Fig. 4).

[2] B can die not only because of the rapid changes of the distribution of A, but also because of initial random chance placement of A with respect to B and because of an initially assumed population density.

The jumps of the population from one "island" to another can take place when the microscopic fluctuations render the old location less advantageous than the new one. The tunneling process from one condition to another may be a painful and lengthy one: The population fluctuations may take a "critical" form implying variations of orders of magnitude in the total population. Moreover, the time lapses in species revival may be longer in magnitude than of the individual elementary processes (single sale, single offspring generation).

Fig. 5 illustrates the tunneling between the various locations that leads to fluctuations in the total population by orders of magnitude. As long as a location is stable, the population is large. When the conditions require change the total population decreases dramatically until the population eventually finds a new advantageous location/niche and the social theme (product, fashion) will then revive.

Note that the dynamics is not governed by masses of individuals moving from one location to another. Rather, the proliferating character of the individuals implies that the collective

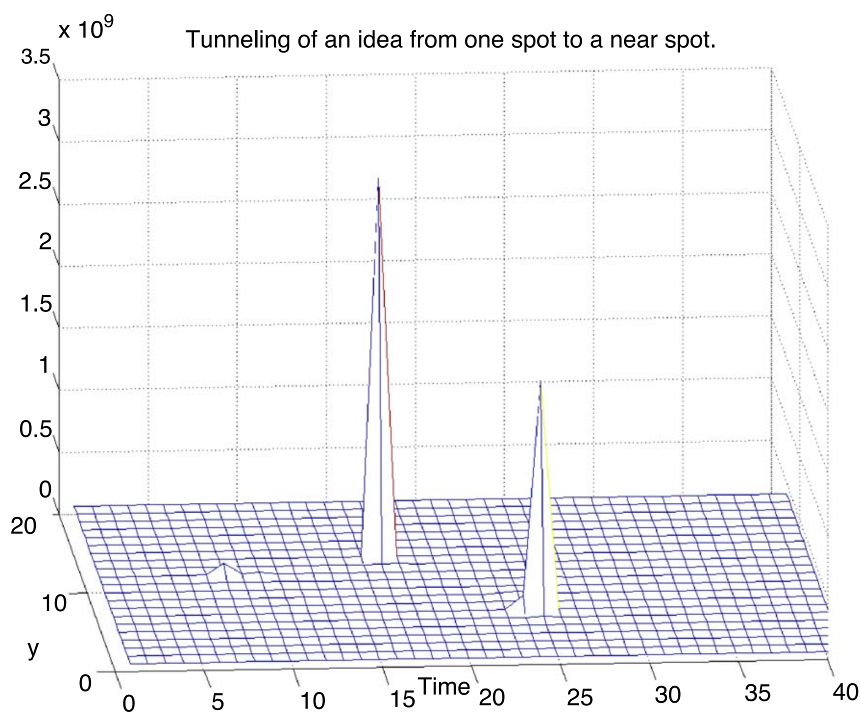

Fig. 5. The tunneling effect. The x axis represents time, the y axis represents an arbitrarily chosen spatial dimension, and the z axis is local B concentration. The high B concentration at $t=17$ and $y=12$ emerged around an aggregate that slowly formed at $y=12$ (we can see the initial seed at $t=7$). Eventually, this aggregate dissolved and the B island started to disappear. The diffusion properties of the A agents induce a high probability that a new aggregate should be formed nearby, as indeed occurs at $y=7$, $t=25$. The new A aggregate is seeded by B agents remaining in the region and creates a new B island. Note that the new island is simply the result of A movement from the old island and seeding by the few Bs remaining in the old island.

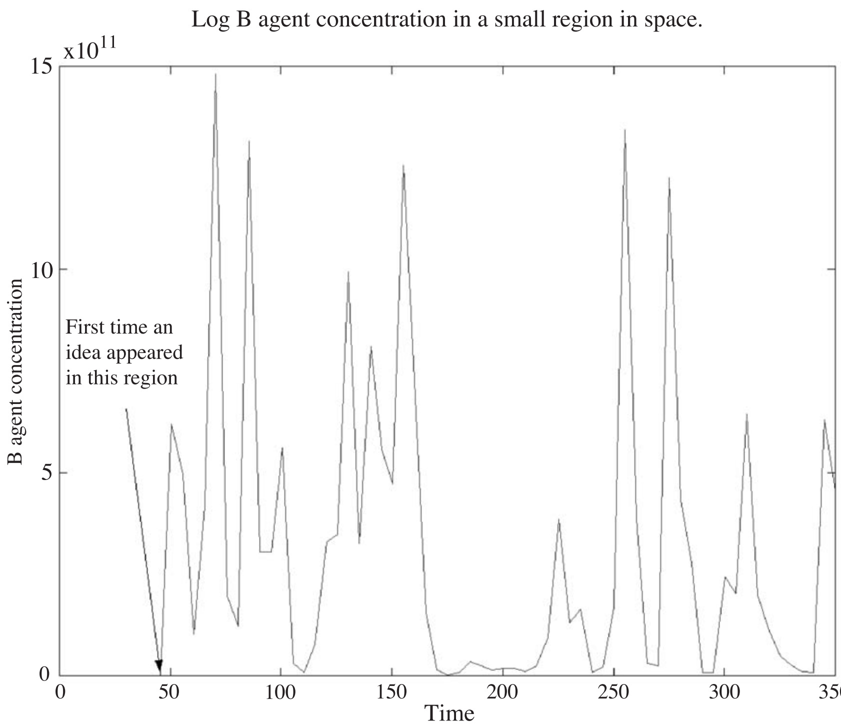

Fig. 6. The cyclicality effect.

dynamics is dominated by the arrival of first individuals (Eneas in Latio, little Johnny Appleseed in the Midwest, etc.) reaching a "fertile territory" and their proliferation therein. This is consistent with the results on the difference between the diffusion of masses and proliferation-enhanced propagation [27]. While in the first case the frontier between the old and the new population is diffused and advances as the square root of time, in the second case the frontier is sharp (though it might have a fractal shape) and its advance is proportional to the time itself.

One outcome of this dynamics is illustrated in Fig. 6. We see that cycles in social themes, products, and innovations are not always exceptional. This aspect is a direct consequence of the presented model, enabled by the fact that it is an evolutionary one. Another interesting observation is that such effects have been documented in population dynamics by ecological [14,33] and bacteriological population [34], and archeological [35] experiments and measurements. If correct, this dynamics is in fact part of a more general framework that dictates technological and social evolution.

3.3. Summary

In the context of economics, the formation of islands in search for stochastic fluctuations in the A distribution can be interpreted as the formation of herds of investors looking for exploitable deviations from the optimal market equilibrium (if one interprets it in real space, the islands are "Silicon Valleys"). The natural emergence of herds in this model shows that the herding behavior is not as irrational as one might think: It appears even in systems of agents deprived of any cognitive bias. Of course, in reality the herding effect might be enhanced by psychological factors, but those are not *necessary* for the herding to emerge. It is an expression of, perhaps, nonintuitive but real effect under discussion in this paper: In autocatalytic systems, *microscopic noise* leads to *macroscopic patterns*.

On a more quantitative note let us mention that the fate of an idea or an innovation may fall in one of three regimes according to the particular conditions:

1. All the B's eventually die (failures)—this happens when their motion is slow compared with the changes in the environment.
2. The B's fill all the available space until they saturate it (e.g., TV, computers, telephones, the wheel, capitalism)
3. The B's exhibit a mechanism of rise and fall (concepts that enjoy several lifetimes of reincarnations).

The noticeable conclusion that cyclicality is expected as a rule rather than exception emerges from the analysis of the three regimes identified earlier. Indeed, there are other models indicating similar directions. For example, Devezas and Corredine [36] present a technoeconomic model with a long-wave behavior. The evolution of the system is described discretely as a logistically growing number of "interactors" adopting an emerging set of basic innovations. By using the logistic function as the probabilistic distribution of individuals exchanging and processing information in a finite niche of available information, they demonstrate that the rate of information entropy change exhibits a wavelike regime.

In a different way, the model we propose indicates inherent conduct of cyclicality within the third regime. While the first two regimes do not characterize long-time-frame perspectives of innovations, the appearance of cyclicality was found universally within the third regime, insensitive to the parameter levels. Parenthetically, the shape shown in Figs. 2–4 was a result of a random selection of parameter levels for the purpose of illustration. The analysis implies that we probably ought to consider longer time frames following the decline of innovations, in assessing the value of ideas; otherwise we might prematurely and erroneously lay foregone successful concepts to rest.

4. Discussion and implications for practice

Overall, this research has drawn attention to a trend of "going back to the future" in which a successful product that vanished may return, just to start its PLC (Product Life Cycle) from the beginning. We offered a model that may be a stable explanation of the dynamics that govern this cyclicality. Indeed, in remote categories and domain, with different market parameters, the rebirth phenomena took place. The proposed model is not dependent on the unique cases; rather it is more general and grounded in more general principles of evolutionary modeling (for an interesting application of such principles, see Ref. [26]).

To illustrate our proposition in a simple way, imagine that each U.S. citizen will commit himself to kill one fly each day. The number of executed flies will be enormous in a couple of months. Will this cause an extinction of flies? Probably not—the winter kills almost all of them any way. It is enough for a few females to survive a sufficiently long time to lay eggs, to start the process from the beginning. Analogically, if a product survives in few islands, under certain conditions it may return. Obviously, in our model it is also necessary that innovations spreading into the population of agents A involve some kind of advantage in structure. For example, several of Da Vinci's inventions could not be implemented at their time due to lack of appropriate materials, but became known some centuries later.

Saunders and Jobber [7] claimed that companies' long-term survival depends on their replacement of existing products with new ones. They also noted that a simple qualitative research helps formulate a conceptual model of product replacement strategies. An early identification of a possible comeback of a product clearly has advantages to a firm in terms of fewer risks in R&D, and in distribution channels and even the marketing communication.

Chandy and Tellis [37] examined the willingness to cannibalize as an important determinant of firms' success in the context of radical innovation. Here, perhaps a similar yet opposite approach is required: a willingness to return previously cannibalized concepts. Such decisions may not be very easy to promote in the firm as they may evoke resistance in both levels of R&D and marketing personal (see Ref. [38] for a review and approach). Nevertheless, this is the faith of most innovations.

It might be beneficial for firms to recognize this phenomenon of rebirth, because if it happens to be relevant it offers a few opportunities. Nowadays, with the increase of competitive pressure and reduction in product life cycles, firms are trying to adjust themselves and shorten their product development process accordingly (see, e.g., Griffin [39], for methods to obtain product development cycle time and forecast its duration). Indeed, new product development time, or cycle time, has become a critical competitive variable. Even if the rebirth product is substantially different from its previous version, it is plausible to assume that its development is less complex, less risky, and probably takes a shorter time, because of the knowledge that a firm already has. Considering the findings that consumers are attracted to a combination of familiarity and newness [40], reawakened innovations may be a good gamble if first signals are traced.

McIntyre [40] argued that a radical innovation lives or dies, in part, by a company's commitment to developing its long-term potential. If correct, the rebirth model implies that this term may sometimes be even longer that its complete life cycle.

Hence, our work points to a number of implications for firms introducing new products. First, previous innovations, designs, fashions, and product usage methods may provide a large pool of ideas for "new" products. Thus, product developers and marketers should be aware of extinct innovations, learn their history, and perhaps consider reintroducing them as an option. In addition, they should be alert to the return of older innovations, viewing such a phenomenon not as a curious fad but as an expected consequence of the cyclicality discussed in this paper.

An important question is to what extent managers can forecast which innovations have a better chance to return. More empirical research on the success of reborn innovations is needed to enable a better analysis of the effect of innovation type on rebirth probability. The extent to which the innovation is radical, consumers' involvement with the product category, and past patterns of cyclicality in the specific product category may be important parameters to investigate.

A related question deals with the direct ability of marketers to affect the rebirth phenomenon. Using advertising, pricing, or distribution decisions, marketers may be able to accelerate the return of some innovations. One way may be to identify islands in which the past innovation is still in use, find the way to encourage both users of the innovations that would affect others through word of mouth, and find potential adopters that imitate the current users group.

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