The Echoes of Bandwagon Through a Complex System of Innovation and Development

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Abstract

In this paper we seek to contribute to the innovation literature analysing how preferences guided by bandwagon behaviour may affect innovation decisions. More specifically, the decision of a firm to choose between process and product innovation given the state of the market. Due to the degree of complexity involved in the matter, we choose to build an agent-based model where agents have bounded rationality and sequentially make non maximizing decisions based on the amount of information they have about the market. The rationality degree can be exogenously adjusted setting the awareness capability of consumers. As a core of bandwagon behaviour, each consumer is affected by the decision of others and the resulting cascade effect yields different impacts on the economy depending on the inclination of each agent towards new products. There are in total five types of consumers: techies, visionaries, pragmatists, conservatives and skeptics, in decreasing order of bandwagon behaviour degree. We find that the greater the number of techies, or the rationality degree of agents, the shorter are the product life cycles in the market, generating a faster market saturation and thus more product than process innovations, with firms charging higher prices and obtaining larger profit-rates.

Resumo

Neste trabalho pretende-se contribuir com a literatura sobre inovação analisando como preferências guiadas por comportamento *bandwagon* podem afetar a escolha de uma firma entre inovação de processo e de produto dadas as condições de mercado. Dado o grau de complexidade do assunto, faz-se a escolha pela construção de um modelo baseado em agentes no qual indivíduos e firmas possuem racionalidade limitada e tomam decisões sequenciais não maximizadoras com base na quantidade de informações obtidas sobre o mercado. O grau de racionalidade - e portanto a quantidade de informações obtidas a cada ponto no tempo - pode ser exogenamente controlado através da capacidade de percepção dos consumidores, a qual chamamos de *awareness*. Cada consumidor pode ser afetado pela decisão de outros e o efeito castata resultante gera diferentes impactos na economia de acordo com a preferência de cada agente em relação à adoção de novos produtos. Assume-se que existam, no total, cinco tipos de consumidores: tecnológicos, visionários, pragmatistas, conservadores e céticos, em ordem decrescente referente ao grau de comportamento *bandwagon*. Os resultados obtidos sugerem que quanto maior a quantidade de consumidores tecnológicos e o grau de racionalidade dos agentes, mais curtos são os ciclos de produto no mercado, gerando uma saturação mais veloz e, consequentemente, uma maior frequência de inovação de produto do que de processo, com firmas escolhendo maiores preços e obtendo maior lucratividade.

Keywords: Innovation, Bandwagon Behaviour, Demand Saturation, Product Life Cycle, Complexity
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1. Introduction: The Echoes of Bandwagon

Dating back from Schumpeter (1934), literature on innovation has evolved to the point of leading its object of study to the status of one of the main forces driving economic growth and development. The fact that Sollow's TFP[1] black box might not be so black anymore has certainly something to do with understanding how the engine of innovation is greased. In this paper, we suggest that one of the cogwheels of this engine is the bandwagon behaviour of consumers, its impact on innovation diffusion and, ultimately, on the firm's decision to engage on a certain type of innovative process.

Bandwagon effect was first introduced by Leibenstein (1950) based on previous contributions of past economists, psychologist and sociologists, such as Veblen (1899), Rae (1905) and Morgenstern (1948), in the phenomena of fashion and conspicuous consumption. Developments of this field in innovation literature yielded sophisticated formal threshold models of innovation diffusion through social networks from both the supply and demand points of view, especially Granoveter (1978) and, more recently, Rosenkopf and Abrahamson (1999), Young (2002) and Acemoglu et al. (2011).

The recent increase in computational capacities and its popularization in economics are key factors to understand why these subjects are back on the spotlight. Demand heterogeneity suits itself much better in complex environments and models that cannot yield useful solutions other than through simulation. It is also very hard to fit consumer interaction into equilibrium models which only reinforces the need of proper agent-based models to capture all the nuances behind it. Malerba et al. (2007) and Valente (2013) are good examples of agent-based models where demand factors are important to understand innovation.

With all this information at hand, it is perfectly arguable that the product cycle theory ruled by the triad Vernon (1966) - Utherback and Abernathy (1978) - Kotler (2005) might be outdated or in need of some re-discussion. A lot has changed since VHS and innovation is now viewed more as a survivability necessity than a profit maximization luxury. New high-tech products such as smartphones, TV's and computers presents a much higher rate of creative destruction. Product innovation does not seem to slow down as predicted by PLC[2] theory yielding great differentiation that creates changes ranging from small, to ones big enough to challenge the dominant design. The fact is that these industries cannot rely on market expansion, already saturated, and even less on repeated purchases given how durable the products are.

The only solution is then to engage heavily on R&D[3] to be able to sustain a constant de-maturity process (see Higuchi and Trout (2008)) in which consumer bandwagon behaviour plays a key role to success. The bandwagon behaviour was described by Moore (2005) and its details will be stretched further.

We propose to take the next step in bandwagon theory regarding innovation and investigate how the emergent pattern of diffusion from consumers bandwagon effect shapes the market and influences the firm decision between process and product innovation. This interactive behaviour is determinant to understand how the speed of technological change shape societies and promotes economic development and welfare.

In order to do so, we build an agent-based model where consumers have bounded rationality and sequentially make non maximizing decisions about buying only one product from the available firms. Consumers are heterogeneous in respect to what we call *profile* towards new products and follow the distribution proposed by Moore (2005) as a baseline. Since our consumers do not have information about global demand or preferences, the probability to change consumption choices plays the role of thresholds. Consumers can only get information about quality and prices by interacting with each other when they are inside each other's awareness radius (similar to Chugh and Bazerman (2007)). Consumers then evaluate how many others are using a given product or technology and decide to change their product of choice or not. Firms on the other hand cannot see individual preferences, but analyse market saturation and concentration to decide on the amount of R&D investment and between process and product innovation.

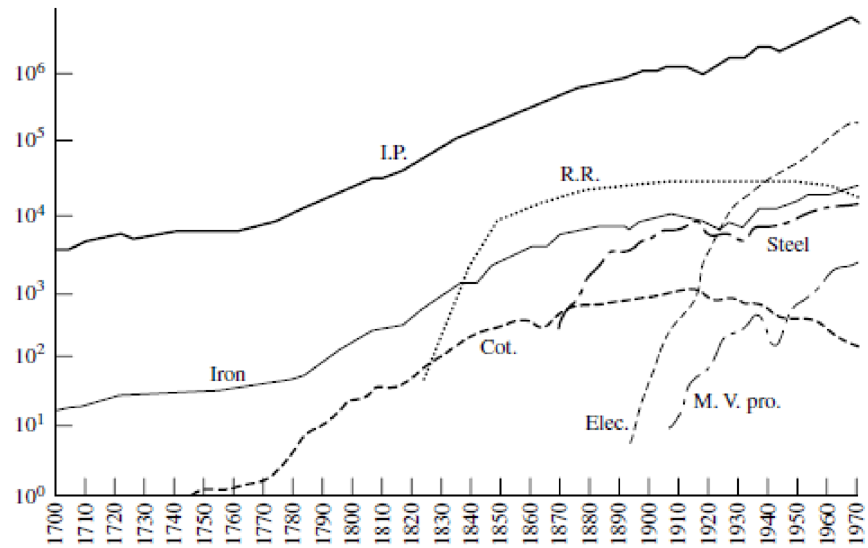
The chapter is organized as follows: the section 2 discusses the literature on life cycles and bandwagon preferences. Section 3 presents a formal agent-based model in which consumers have bandwagon behaviour and influences process and product innovation decision by firms. Section 4 presents and discusses the results and, finally, section 5 brings the conclusions.

[1] Total Factor Productivity.
[2] Product Life Cycle.
[3] Research and Development.

2. Life Cycle Theory and Bandwagon Behaviour

A Life cycle is not by any margin an exclusive economic phenomena. From natural to social sciences, from bacteria to sales, the majority of growth processes follow the same pattern of birth, acceleration, dis-acceleration and decline, generating a S-shaped curve. It is no different in economic regimes. Using the words of Aoki and Yoshikawa (2002), "plot a time series of production of any representative product such as steel and auto-mobiles, or production in any industry, against year, and, with few exceptions, one obtains an S-shaped curve"(see figure 1).

Figura 1: Demographic Transition and the Impact on Growth: the case of Japan



Notes: Industrial production (I.P.); railroad mileage (R.R.); raw cotton consumption (Cot.); production of iron (Iron); steel (Steel); electricity (Elec.); and motor vehicles (M.V. Pro.).

Source: Rostow (1978).

It is not difficult to understand the mechanism behind a S-shaped curve. In fact the key words here is also one that motivates economic science: scarcity and saturation. In the beginning there are almost no constraints for growth, be it space, food, knowledge, demand: they are usually abundant at first so the process can grow exponentially with no boundaries. But when it reaches a certain stage scarcity begins to take its toll and the agents involved start to feel the lack of resources, preventing them from freely "reproduce". The growth then begins to slow down until it reaches a maximum possible equilibrium or to decline, if it can not maintain itself at a given level for internal or external reasons. Scarcity restricts the growth by the lack of resource by supply side. Saturation, on the other hand, accrue from behaviour of consumers subject to the forces of satiation. The amount of product a consumer or society is able to consume is limited, even when it could be abundant in the lack of resources restrictions. For example, a given product can never surpass a certain level of sales even if its price tends to 0, because there is a maximum amount of people in the market. Sales will never grow to infinity.

There are three life cycle theories in economics in the present day focusing on slightly different aspects of the theory: industry location, technology and sales/marketing.

Locational Life Cycle (LLC), introduced by Vernon (1966) as a criticism and alternative to the theory of comparative advantage, discusses that it is not only the cost of resources that defines the arrival of new sectors and product innovations, but the proximity to knowledge sources i.e. the ability to understand the needs of the market, from both firms and consumers. However, after the creation of a new product, demand effects are forgotten in LLC theory and the locational decision of firms is based solely on the want to reduce production costs.

Utherback and Abernathy (1978) follow the work of Vernon but focus on explaining the life cycle through the dynamics of product and process innovation. They divide what they call Technology Life Cycle (TLC) theory into two main stages based on the arrival of the dominant design. The first stage, pre dominant design, is subdivided into two periods: embryonic and prenatal, but they are, in fact, very similar to the new product stage of Vernon because understanding and being able to adapt to the needs of the consumers before the dominant design arrival is key. The second stage takes place after the arrival of the dominant design and is characterized by a change in the firms focus from product to process innovation until the product reaches maturity and demand starts to drop. Neither of those stages, however, is influenced by demand or behavioural factors.

Still according to the TLC theory product innovation should decrease after the earlier stages and eventually come to a full stop, what is also not confirmed in the literature (Klepper, 1996). In addition to these critiques, TLC pays little attention to technology diffusion, mainly guided by the interaction of agents in the form of social interactions[4].

Finally, we have the Product Life Cycle (PLC), brought to economists attention by Kotler (2005). Despite being considered a marketing theory, it brings important insights about how the diffusion of technology takes place through a consumer interaction perspective. Since it is the only life cycle theory that disaggregates industry behaviour into single products and series of products sales evolution, it is key for those like us who wish to study the microeconomic drivers of innovation from consumer networks. Take the smartphone industry for instance. To be able to understand how the whole industry develops we would need to examine the processes behind each one of the individual products released. In the case of product life cycle, an Ipad 6 for example would be a single product while the family Iphone 6, Iphone 6s and Iphone 6c would be the series of products. The aggregation of life cycle of these products will then yield a pattern for Apple's market evolution.

A new product diffusion in the PLC takes place mainly through a word of mouth process[5] that closely resembles bandwagon behaviour. Consumers interact with each other and spread the rumour of the brand new product accelerating the diffusion process. The only difference between the concept of word of mouth and bandwagon is that in the latter there is no need to interact with others to be influenced by them. The mere fact the individuals are able to see what kind of behaviour, costumes and products society is taking or consuming is a sufficient condition for bandwagon contagion. As the saturation of a given product approaches its limit, the firm becomes more and more inclined to try and perform a product innovation with the aim of igniting a re-buying process leading to a new S-shaped cycle of saturation and maturity. This process is described by Higuchi and Trout (2008) as *De-maturity*, in which the firm prevents the arrival of the maturity phase of the PLC by creating a new product version.

Bandwagon behaviour was first modelled by Leibenstein (1950) based on previous contributions of past economists, psychologist and sociologists, such as Veblen, Rae and Morgenstern, in the phenomena of fashion and conspicuous consumption. It is a special case of non-additivity in utility functions such as the Snob and Veblen effects. The use of bandwagon preferences in innovation literature is usually associated with threshold models of innovation diffusion such as Granoveter (1978), Rosenkopf and Abrahamson (1999), Acemoglu et al. (2011) and many others. In these models agents only adopts a new product influenced by society when a certain amount of others have done it already. However, as pointed out by Valente (1996),"individuals vary in their willingness to take risks in adopting a new idea, product or behaviour before everyone else", and so diffusion of a product might be unpredictable if information about the distribution of individuals profiles towards innovation is scarce. In this case the figure of representative consumer fail to describe or predict the aggregate dynamic transformation of a society.

There are several authors[6] that contributes to diffusion literature by performing a categorization of adopters based on their innovativeness profile i.e. the point in time they decide to adopt the new product or technology. One of the first was Rogers (1995) that defines four categories: early adopters, early majority, late majority and laggards.

A recent empirical study performed by Moore (2005) finds percentages for each one of the consumer profiles in the market. Have you ever seen those hundreds of kids camping outside malls to be the firsts to put their hands on new Iphones? According to the author they are called *techies* and correspond to about 2.5% of the consumers. The following profiles are similar to Rogers and are presented in decreasing order of

[4]See Granoveter (1978), Young (2002) and Acemoglu et al. (2011).
[5]See Czepiel (1974) for more details on word of mouth and technology diffusion.
[6]See Rogers (1995) and Moore (2005)

appreciation towards new technology or products: *visionaries* (12.5%) may not buy the product at the time of the release but they have a high probability to buy it soon. *Pragmatists* (35%) and *conservatives* (35%) correspond to the bulk of population and are similar to early majority and late majority profiles. Finally, *skeptical* (15%) rarely care for new products even when the majority of the population owns it.

Nevertheless if one considers that both consumers and firms have bounded rationality and awareness, simulation of traditional threshold models of bandwagon starts to become infeasible since individuals cannot see the total amount of consumers that adopted a certain product, only people they randomly meet or that are part of their social networks. Blume (1993) and Ellison (1993) developed a stochastic feedback process in which the probability that a given individual adopts the behaviour of his neighbours at a given time is an increasing function of the number of his neighbours who have adopted it and thus shifting the threshold values from deterministic to stochastic and allowing a more suited way to treat the contagion process of agents with bounded awareness[7].

We combine the stochastic threshold idea with consumer profiles to create a model in which the consumers probability to adopt a new product depends both on his profile towards new technology and on the amount of neighbours who already adopted. Similar approach is used by Young (2002) but in his case individual preferences are not related to technology but to the choice over a set of predefined product types.

3. The Model

In this section we present a formal agent-based model where consumers have bounded awareness and sequentially make non maximizing decisions about buying only one product from the spectrum of available firms. Consumers are heterogeneous in respect to what we call *profile* towards new products and follow the distribution proposed by Moore (2005) as a baseline. Since our consumers do not have information about global demand or preferences, the probability to change consumption choices plays a stochastic role of traditional deterministic thresholds. Consumers can only get information about quality and prices by interacting with each other when they are inside each other's awareness radius[8]. Consumers then evaluate how many others are using a given product or technology and decide to change their product of choice or not with probability ϕ. Firms on the other hand cannot see individual preferences, but analyse market saturation and concentration to decide on the amount of R&D investment on each period t and between process and product innovation. There is strong interactions between consumers and consumers, and consumers and firms which produce complex dynamics of innovations, cycles and economic development.

3.1. Consumer Interaction and Bandwagon Behaviour

Consider a constant length set of consumers given by $\Omega = \{1, ..., N\}$ with heterogeneous profiles (propensity to assimilate new technologies or products) that follows a quasi-normal distribution in respect to their probability of incidence in the population described in table 1 below. Each consumer ω_i carries an intrinsic propensity to adopt new products according to their profile, which we call stochastic bandwagon threshold (β). Consumers are randomly spread and randomly move across a bi-dimensional wrapped plain Γ characterizing our economic space.

Tabela 1: Bandwagon Population

Type	% of population	β
Techies	2.5	1
Visionaries	12.5	0.8
Pragmatists	35	0.6
Conservatives	35	0.4
Skeptics	15	0.2

[7] See additionally Chugh and Bazerman (2007)
[8] Similar to Chugh and Bazerman (2007) and Ellison (1993).

Consumers have the same bounded awareness represented in the model by a circle of radius $\Lambda = \{1, ...\Gamma/2\} \subseteq \Gamma$ around them[9].

Consumers can also die with the probability $k_4 = [0, 1]$, but they immediately give birth to another agent with the same profile, the only difference being that new consumers enter into the space Γ with no supplier[10]. This mechanism is introduced in order to capture the effects of new agents constantly entering the market. since they have no information whatsoever about products prices and quality they are important to contribute to smaller firms demand and thus prevent monopoly situations. The set of consumers at time t, $\Omega = \{1, ..., N\}$ as well as its distribution is, nevertheless, always kept constant[11]

At any point in time t, consumers may own only one product z of quality q, supplied by firm $x \in \{0, ..., X\}$ for which they pay the price ρ.[12]. However, they can be influenced to change their adopted product if they are inside each others awareness radius i.e., if they are neighbours with relative position between $(\omega_i, \omega_j) = (0, 0...\Lambda)$ in the plain. In this coordinate 0 means the reference point where the consumer stand, from which he or she can see by a distance of radius Λ. The neighbouring set of individuals who can potentially influence consumer $i \in \Omega$ in time t can then be described as $\Theta_i(t) = \{j \mid (j, i) \in \Lambda_i\}$, where j comprises all of the individuals in range of consumer i awareness (Λ_i). The consumers j inside the view radius of consumer i carry some information which can convince or not he or she buy the new product. For example, it can happen that a consumer j be a *skeptic* who not bought a new technology yet, therefore, do not carry information about quality q and price ρ of a new product.

We assume that at the initial state of the model $t(0)$ there is only one incumbent firm that invents a brand new type of high-tech product and immediately engages in marketing activities capturing all consumers with a *techies* profile. These "crazy for technology" consumers will also instantly buy any new better quality versions of the product provided they are clients of the innovating firm at the time of product innovation[13]. At time t the subset of consumers who adopted a given product z in the market is given by $\Phi_z(t) \subseteq \Omega$.

A consumer $i \notin \Phi_z(t)$ may be influenced[14] by his neighbours to change his product in two distinct situations: when faced with one or more neighbours j who have adopted: a) a better quality product[15]; or b) a product of the same quality from a firm with a lower price.[16]

3.1.1. Adoption by quality

We will start by addressing the first case. A consumer $i \notin \Phi_z(t)$, walking randomly through our plain, meets in his awareness radius Λ at least one neighbour who owns a better quality product $z_j > z_i$. The probability that consumer i will be influenced to buy the better-quality product he saw will be affected by three factors: the amount and percentage of the neighbours owning that product at time t and consumers i bandwagon profile. The decision process is detailed below. Note that the bars delimiting the terms in the numerator and denominator of the first term of the equation denotes cardinality i.e. the number of agents on each of the sets. The decision is:

$$k_1\beta_i\frac{|\Phi z(t) \cap \Theta i(t)|}{|\Theta i(t)|} + (1 - k_1)\, |\Phi z(t) \cap \Theta i(t)| > \epsilon \Rightarrow i \in \Phi z(t + 1) \tag{1}$$

where ϵ is a random number following a continuous uniform distribution over the range $\epsilon = U[0, 1]$ and

[9] Note that this is not the same radius suggested by Young (2002) in his model where agents are distributed along the edges of a radius.

[10] And consequently without a product, quality, price paid and so on.

[11] This is a necessary condition to analyse how changes in the distribution (more precisely the number of *techies*) affects the evolution and final stage of the model during simulation.

[12] We choose to make two distinctions about notation: between the price paid by a consumer ρ and the price charged by a firm p; and between the consumer product provider χ and the firm per se x.

[13] Techies will always act as seeders of the new versions of the product.

[14] Consumers may only be influenced once per time t.

[15] If there is more than one different product quality perceivable from Λ, Consumer i will only consider to change for the best one.

[16] Pay close attention to the fact that consumers will always prefer a quality change over a price change in the form: $q \succ \rho \Leftrightarrow (q \succ \rho \bigwedge q \not\prec \rho)$. i.e., there is no utility function in the model in the form of a trade-off between quality and price because consumers are assumed to have enough income to buy any product they want. We shall discuss income inequality later in this thesis.

$\{0 \leq k_1 \leq 1\}$ is a constant measuring the impact of each type of influence[17].

Now consumer i is left with the decision of where to buy the product, i.e. from which one of the available firms. If there is only one candidate $j \in \Lambda_i(t)$ for potential influencer in consumer i awareness radius Λ_i, the decision is straightforward and he will buy from his neighbour's supplier so that $\chi_i(t+1) = \chi_j(t)$. However, in cases where the subset $\Phi z(t) \cap \Theta i(t)$ is non-unitary, it may be possible that there will be two or more neighbours who are clients of different firms. How will consumer i choose between the available firms? He will choose to buy the selected product from the firm that incurs him the lowest effort e_i. The effort of a given consumer i to buy a product z from a provider firm χ is given by:

$$e_i = \rho_{i,\chi} + k_2 d_{i,\chi} \tag{2}$$

where ρ_i is the price paid by agent i for product z_i of firm χ_i at time t, d_i is the distance between the consumer i and his supplier χ_i and $0 \leq k_2 \leq 1$ is a constant measuring the impact of distance on a consumers effort.

But consumer i does not have information about the prices of all firms in Γ, therefore he will need to choose based on the effort information gathered from his neighbours $j \in \Lambda_i(t)$. The firm χ choose by consumer i will depends on the interacting process given by:

$$\chi_i = \arg\min_{\chi}\{e_j(\chi_j) \mid \chi_j \in \{1, ..., X\}; j \in \Lambda_i(t)\} \tag{3}$$

where $e_j(\chi_j)$ is the effort the consumer i must incur to reach a firm (χ_j) into its view radius (Λ_i).

3.1.2. Adoption by price

Now consider the second setting of interaction between consumers in which $\Phi z(t) \cap \Theta i(t) = \emptyset$. In this case, consumers bandwagon behaviour neither the amount and percentage of neighbours who owns a product with a lower price matters because they are not analysing a change in product quality/technology. However, we assume that there is an associated cost in changing the firm providing products for consumer i and thus changing is not guaranteed, but depends positively on the difference between the price paid by him ρ_i and by consumer ρ_j[18]. Consumer i will ultimately change his supplier χ_i if his new effort $e_i(\rho_j, \chi_j)$ is lower than the current one $e_i(\rho_i, \chi_i)$. The interaction results in:

$$\chi_i(t+1) = \chi_j(t) \quad \text{if} \quad (1 - \frac{\rho_j}{\rho_i}) > \epsilon \quad \text{and} \quad e_i(\rho_j, \chi_j) < e_i(\rho_i, \chi_i) \tag{4}$$

Besides being influenced by neighbours, consumers can also be influenced by firms inside Λ_i. The set of firms that can influence consumer i at time t is given by $\Xi_i(t) = \{x \mid (x, i) \in \Lambda_i\}$[19]. Similarly to the pure consumer interaction there are two ways in which a firm may influence a given consumer i to change his product: a) there is at least one firm x in Λ selling a product with a better quality than z_i; and b) there is at least one firm offering a product with the same quality as z_i but for a lower price.

In the first scenario, consumer i finds a firm x with a better quality product $z_x > z_i$ than he has and is influenced to buy it. The decision whether to adopt or not adopt this product and supplier will depend solely on consumer i bandwagon profile according to:

$$\beta_i k_3 > \epsilon \Rightarrow z_i(t+1) = z_x \quad \text{and} \quad \chi_i(t+1) = x \tag{5}$$

where $0 \leq k_3 \leq 1$ is a constant.

If the set $\Xi_i(t) = \{x \mid (x, i) \in \Lambda_i\}$ is non unitary, there might be two or more firms charging different prices p_x for products with the same quality. In this case consumers will always prefer the firm offering product with the lowest price:

$$\chi_i = \arg\min_{x}\{p(x) \mid x \in \{1, ..., X\}\} \tag{6}$$

[17] From here on we will drop the time notation when it is not necessary.

[18] As in the previous case consumers will only consider to be influenced by his neighbour with the lowest price.

[19] Note, though, that individuals cannot interact with buildings so we assume that the interaction occurs between a consumer and a salesman trying to convince him to buy the latest best-quality product of the firm.

The second setting presents the case in which a consumer owning a product with quality q_i finds a firm x selling the same product for less money i.e., $p_x < \rho_i$. Analogously to the pure consumer interaction consumer i will decide between changing his supplier or not based on the difference between the price he is paying for the product and how much the firm is selling it for:

$$\chi_i(t+1) = x \quad \text{if} \quad (1 - \frac{p_x}{\rho_i}) > \epsilon \tag{7}$$

3.2. Firm Behaviour

As mentioned in the previous section, at time $t(0)$ only one incumbent firm[20] creates a new economic sector or market[21] by inventing a product and immediately captures the demand of *techies*. From this point on new firms can enter and exit the market if they find it profitable, considering the option of investing in bonds paying the constant interest rate r. Thus at a given time $t \neq 0$ there will be a set $\Xi = \{1, ..., X\}$ of firms in the market. Firms produce goods on-demand and thus doesn't accumulate stocks. There is also no kind of economies of scale or scope i.e., cost reduction arises only from successful process innovations.

There are two pivotal decisions a firm has to make in the model: how much to spend in research and development activities and what type of innovation to pursue given the market situation at any point in time. Based on the literature, we assume that market saturation and competition play a key role on a firm innovative decisions.

3.2.1. R&D expenditures decision

Despite Schumpeter's claim that monopoly power provides incentives for innovation by raising the firm's capabilities, recent literature on the subject[22] shows that it is usually competition that fuels innovation. The argument is that competition raises the intrinsic costs of falling behind in competitiveness by failing to successfully engage on R&D activities. Aghion et al. (2002) finds that these two effects combined generates an inverted-U relationship between the variables. Up to a certain level, competition creates incentives for innovation because firms try to become more competitive reducing costs or differentiating products, but if competition gets to fierce, profits tend to fall along with resources available for R&D. In our model we assume that investment in R&D is a positive function of competition but since the amount invested is given by a percentage of profits, competition might hinder innovation if it heavily impacts profit.

Pasinetti (1981) has long ago stated that saturation is a natural bottleneck for economic growth and development. Even in the case of a high and sustainable productivity growth, population would have to grow accordingly for saturation not to happen, which does not seem to be the case for most developed and developing countries. The way firms deal with saturation is through a life cycle de-maturity process of product innovation, specially in durable goods industry where re-buying takes time to occur. McMeekin et al. (2002) provides a great overview of the literature relating aspects of demand with innovation. We use Saviotti and Pyka (2012) equation that relates search activities with market saturation[23] and a similar function to competition impact on innovation to define the percentage of profits a firm will secure for R&D at any point in time:

$$\theta_x = k_4(1 - e^{(-k_5 S_x)}) + k_6(1 - e^{(-k_7 \text{HHI})}) \tag{8}$$

where θ_x is the chosen percentage of profits secured for R&D, $0 < k_{4,...,7} < 1$ are constants, HHI is the Herfindahl Hirschman Index and S_x is the market saturation for the best-product of firm x. HHI and S_x are given by:

$$S_x = \frac{\sum_{i=1}^{N} [C_i \mid z_i = z_x]}{\sum_{i=1}^{N} [C_i \mid z_i \neq 0]} \tag{9}$$

[20] Adding more incumbent firms does not change the outcome of the model except for the initial HHI concentration index.

[21] The new sector can be view both as industry or service.

[22] For more details about the relationship between competition and innovation see Aghion et al. (2002), Aghion et al. (2006) and Tomohiko et al. (2008)

[23] It is important to note that firms will always consider the saturation of their best-quality product for innovation decisions and not the global saturation level

$$\text{HHI} = \sum_{x=1}^{X} ms_x^2 \tag{10}$$

where ms_x is the market-share of firm x. Thus the investment in R&D of firm x at time t is given by:

$$I_x^{R\&D} = \theta_x \pi_x \tag{11}$$

with

$$\pi_x = \sum_{z=1}^{Z} (D_x(p_x - c_x) \tag{12}$$

where π_x is the profit, D_x, p_x and c_x the demand, price and cost for each product of firm x.

3.2.2. Innovation type decision

After deciding on the amount of R&D resources, firms have to decide in what type of innovation they are going to invest these resources. It is reasonable to assume[24]that market saturation has a bigger impact on product innovation than process innovation because a firm can only overcome saturation with process innovation while there is still a potential demand to be conquered. However, it is a little more complicated to infer the contrary for market competition, since both product and process innovation can help a firm to gain a competitive advantage[25]. Nevertheless, we assume that firms will prefer to invest in product innovation only when market saturation is higher than market competition and saturation is above a certain threshold S_{min}. This is due to the fact that product innovation is considered to be more difficult to successfully implement than process innovation, since it requires consumers approval.

$$\text{Type} = \begin{cases} \text{Product} \Rightarrow I_x^{R\&D}(t) = I_x^{PD}(t) & \text{if} \quad S_x(t) > H(t) \quad \& \quad S_x(t) > S_{min} \\ \text{Process} \Rightarrow I_x^{R\&D}(t) = I_x^{PC}(t) & \text{otherwise} \end{cases} \tag{13}$$

where PD means product innovation and PC process innovation. The probability of arrival of an innovation type is a linear function of the total amount of investment in one of them. It follows that:

$$\phi_x^{PD,PC} = k_8^{PD,PC} I_x^{PD,PC} \tag{14}$$

where $0 < k_8^{PD,PC} < 1$ are constants.

3.2.3. Effects of successful innovations

We now turn our attention to how a successful innovation changes the innovating firm status. Consider first the case of product innovation. When a firm manages to succeed in product innovation in time t, it uses all it's R&D resources of that type[26] to start producing, at $t+1$, a new product of better quality than its previous best $(Q_{z,x}(t+1) > Q_{z,x}(t))$, at a higher cost $(c_{Z,x}(Q, t+1) > c_{Z,x}(Q, t))$ that will be added to the set $\Psi_x(q,t) = \{1, ..., Z_Q\}$ of all products, ordered by their quality, being demanded to firm x. The new product is immediately adopted by the firm x set of "'techies"' clients[27]. We can summarize the impact of a product innovation as:

$$\phi_x^{PD} > \epsilon \Rightarrow \begin{cases} Z_{Q,x}(t+1) \in \psi_x(t+1) \\ Q_{Z,x}(t+1) = Q_{z,x}(t) + (\Delta_q) \\ c_Z(Q, t+1) = (\Delta_c^{PD}) c_Z(Q,t) \end{cases} \tag{15}$$

[24]This is a subject yet to be better explored by the literature since results are still inconclusive. Some examples of papers in this area are Bonanno and Harworth (1998) and Rosenkrantz (2005).

[25]See Porter (1999).

[26]In this case I_x^{PD}.

[27]If a firm does not possess any costumer with techies profile the only way it can diffuse the new innovation is through consumer/firm interaction.

where it is assumed that Δq[28] and Δ_c^{PD}[29] are constant in time parameters measuring the impact of product innovation on Q_Z and c_Z respectively.

Process innovation, on the other hand, has the sole effect of reducing the cost of production of all of a firms products:

$$\phi_x^{PC} > \epsilon \Rightarrow c_{z=\{1,...,Z\}}(t+1) = \Delta_c^{PC}[c_{z=\{1,...,Z\}}(t)] \tag{16}$$

3.2.4. Price setting behaviour

Firms are engaged in Bertrand competition defining their prices primarily by a mark-up rule, but also considering the mean price of firms in the market when $|\Xi| > 2$. We assume that prices are somewhat sticky, meaning that firms will wait a certain threshold number of periods (τ) before reacting to market-share (MS_x) alterations in order to assay if the tendency is persistent or seasonal.[30]. The price $p_{z,x}$ charged for product z of quality q by a firm x at time t is given by:

$$p_{z,x}(t) = \begin{cases} \mu_x(t)c_{z,x}(t) & \text{if} \quad |\Xi| \leq 2 \\ k_9\mu c_{z(q),x}(t) + (1-k_9)\frac{\sum_{x=1}^{X} p_{z,x}}{|\Xi|} & \text{if} \quad |\Xi| > 2 \end{cases} \tag{17}$$

where $\mu_x(t)$ is the mark-up of firm x at time t and $0 < k_9 \leq 1$ is the impact of mark-up on a firms price decision[31]

Firms alter their mark-up according to:

$$\mu_x(t) = \begin{cases} \mu_x(t-1) + k_{10}\mu_x(t-1) & \text{if} \quad MS_x(t-\tau) < MS_x(t-\tau+1).... < MS_x(t) \\ \mu_x(t-1) - k_{10}\mu_x(t-1) & \text{if} \quad MS_x(t-\tau) > MS_x(t-\tau+1).... > MS_x(t) \end{cases} \tag{18}$$

where $0 < k_{10} < 1$ is the mark-up changing reaction.

3.2.5. Entry/exit mechanism

At any point in time a prospective firm faces the decision of entering given the market situation. In order to make the decision, it is assumed that possible entrants observe the mean profit rate of currently operating firms, the saturation of the best-quality product and the concentration of the market. The higher the market profits and concentration and the lower the saturation, higher the probability to enter[32]. Entrants will only be willing to produce the best-quality product in the market at time of possible entry. Additionally, the saturation of the chosen product cannot be higher than 50%[33]. Best-quality product saturation is given by:

$$S_Z(t) = \frac{\sum_{i=1}^{N}[\omega_i \mid z_i(t) = Z(t)]}{N} \tag{19}$$

where z_i is the product being consumed by consumer i.

The mean profit rate of firms is:

$$\overline{\varpi} = \frac{\sum_{x=1}^{X} \frac{\sum_{z=1}^{Z} \varpi_{z,x}}{Z}}{X} \tag{20}$$

where $\varpi_{z,x} = \pi_{z,x}/I_x$ is the profit rate of product z of firm x.

And thus the decision of a given firm to enter the market is given by:

[28] We assume $\Delta q = 10$ although it may take any positive value without changing the outcome of the model.

[29] We follow Adner and Levinthal (2001) and assume $\Delta c = 0.2$.

[30] Due to managerial costs such as menu, customer negotiation and information gathering costs. See Zbaracki et al. (2003) and Dias et al. (2011) for a detailed discussion.

[31] Simulating the model we will assume that $k_9 = 0.6$ based on studies of Keney et al. (2010) who finds that the share of firms that set their prices by mark-up is about 60% while 40% of firms set their prices by looking at the other firms prices.

[32] See Dixit (1989) and Chang (2009) for studies about firm entry/exit decision.

[33] We assume a firm will never be willing to enter the market producing a good that is close to maximum saturation because the entrant won't have time to accumulate R&D investment for product and process innovation and will most likely fall behind on technology and product quality.

$$\text{Entry} = \begin{cases} \text{Yes} & \text{if} \quad S_Z < 0.5; \quad \varpi > r; \quad \varpi S_Z H > \epsilon \\ \text{No} & \text{Otherwise} \end{cases} \tag{21}$$

Firms will exit the market if their mean profit-rate over a range T of periods is smaller than the interest rate r, which means firms fight to remain in the market even when profit-rates are smaller than the other possible investment option[34]. At any point in time a firm will check the mean of its last T profit-rates and compare it to the interest rate:

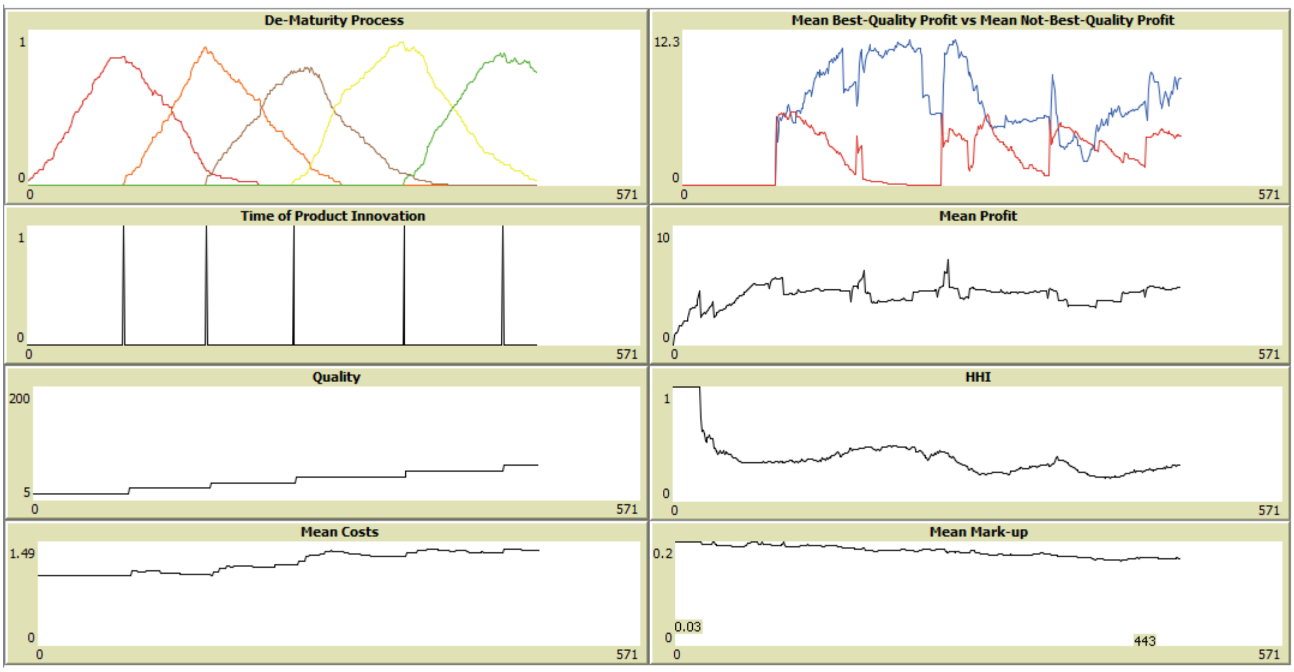
$$\text{Exit} = \begin{cases} \text{Yes} & \text{if} \quad \frac{\sum_{t=t-T}^{t} \varpi_x(t)}{T} < r \\ \text{No} & \text{Otherwise} \end{cases} \tag{22}$$

3.3. From micro behaviour to aggregated results

Before we go into the results of the model using a series of different simulation runs for each condition of interest, it is important that we analyse interesting macro patterns only observable when we consider a single simulation run, which means the resultant behaviour of variables is not a mean from several simulation runs. We are then able to shed some light in the "black box" that many consider agent-based models to be.

The figure 2 shows how the de-maturity process takes place in our economy and how some key variables such as quality and costs react to it. Note that saturation of a product of given quality - represented by the colourful lines[35] in the de-maturity graphic - follows a S-shaped curve as expected from empirical observations. Each time a new product is released demand saturation enters a new cycle as consumers are instigated by bandwagon behaviour to update the quality of their product. This creates degrees of product quality and costs, since each product innovation raises the mean cost of production by a small margin. We can also see the evolution of the mean profit between firms with the best quality in time t and the others as well as the mean mark-up and the Herfindahl-Hirschman concentration index.

Figura 2: The Pattern of Variables on a Single Simulation Run



4. Results

In this section the simulation results of the model are presented in six different scenarios in which different values for two key variables are assumed: consumers awareness radius ($\Lambda = \{1.5, 2, 2.5\}$) and the percentage

[34] Is is assumed that there is no depreciation in the model which implies that a firm would be able to fully recover its initial investment I_x if they decided to sell their infrastructure.

[35] Only the first five product qualities are visible.

of techies amongst the population (techies = $\{3\%, 9\%, 15\%\}$). In order to ensure robustness, 100 simulation runs are performed for each scenario, for a total of 600 runs over a time period of $t = 2000$. Results are presented for every variable in the model, but the analysis focus lies on the evolution of market saturation, concentration, and the pattern of product and process innovation adopted by firms given market conditions. Similar to Adner and Levinthal (2001), it is possible to use the firms cost curve to evaluate the incidence of process and product innovation on each scenario given that firms cost is only affected by process (negative impact) and product innovation (positive impact). A positive relationship between cost and time indicates that firms have prioritized product over process innovation and vice versa. The models baseline is considered to be the case of techies = 3% and $\Lambda = 2$.

It will be shown that the impact of awareness radius and the percentage of techies in the proposed economy are quite similar, except for some few important peculiarities. However, it is fundamental to stress the complete difference between the logic and meaning associated with these two variables.

In this model, the awareness of an individual is a direct measure of rationality. If awareness radius is set to the maximum possible ($\Gamma/2$), that means consumers can perceive the consumption behaviour of every single agent in the economy at any point in time, which is rather unrealistic. But note though, that even so, it would not be possible to assume perfect rationality since the agents in this model cannot predict the future and foresee the decisions of consumers and firms alike. What can be safely argued is that awareness is a variable that probably does not change much from market to market. Of course, individuals have different interests and thus pay attention to different patterns of fashion but rationality is not expected to change that much and is probably not expected to be perfect.

The percentage of techies, on the other hand, simply refers to the amount of people in the economy that are willing to buy new products as soon as they are released and thus it is a variable strongly related to the degree of technology of the given market. It would be at least odd to watch people lining up early in the morning in front of the supermarket just to buy the new type of frozen lasagne a certain brand announced.

Table 2 below shows information about the values taken by constants in our model, which remains unchanged between scenarios:

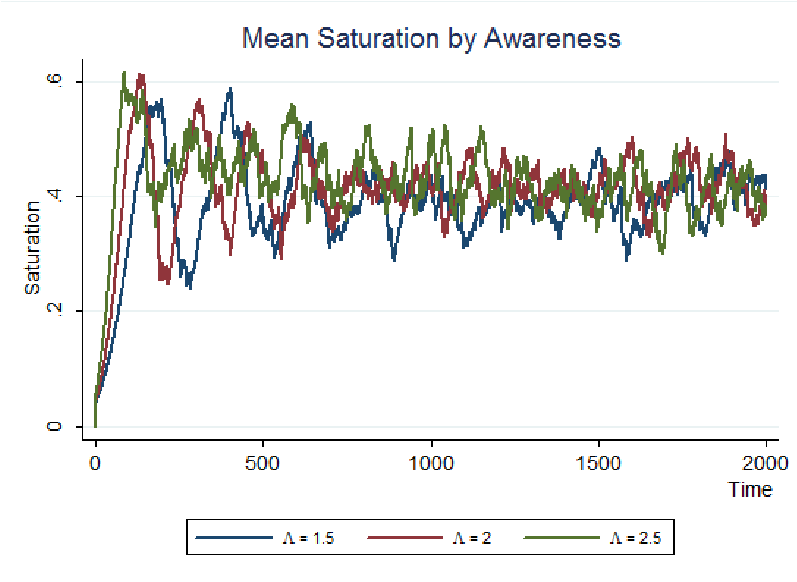
Tabela 2: Model Constants

Constant	Value	Constant	Value
Incumbents	1	Population	100
k_1	0.5	k_2	0.03
k_3	0.05	$k_{\{4,..,7\}}$	0.2
k_8^{PD}	0.01	k_8^{PC}	0.08
k_9	0.6	k_{10}	0.05
r	0.05	Δ_c^{PD}	0.2
Δ_c^{PC}	0.044	$c_{z,x}(0)$	1
$\mu_x(0)$	0.2	$Q_Z(0)$	15

4.1. Varying Awareness

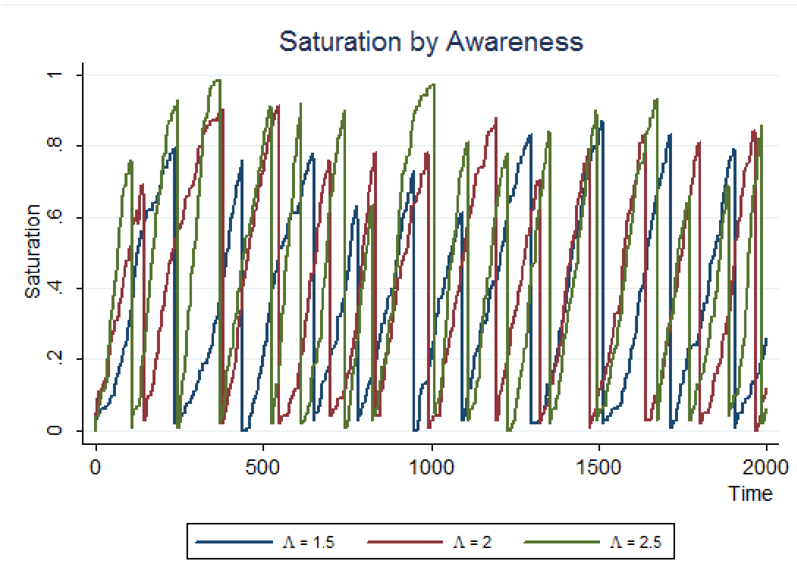
Changing the value of awareness radius has clear impacts over all variables of interest in the model. Lets start with the impact of awareness on market saturation. As mentioned in the previous section, there are certain variable patterns that are better observable when considering only one simulation run. Take saturation for example. Figure 3 below shows the mean best-quality product market saturation (S_Z(t)) of 100 simulations each point in time.

Figura 3: The Impact of Different Awareness Radius on Market Saturation (100 runs)



Since in every simulation the exact time of innovations arrival vary, it is difficult to observe product cycle and de-maturity patterns on aggregate simulations results. Nevertheless we can still observe that higher values of awareness yields saturation curves of higher frequency and higher spikes, indicating that awareness positively affects saturation speed and the maximum saturation achieved just before a new product innovation arrives. It is much easier to see this looking at just one simulation run[36] on figure 4:

Figura 4: The Impact of Different Awareness Radius on Market Saturation (1 run)

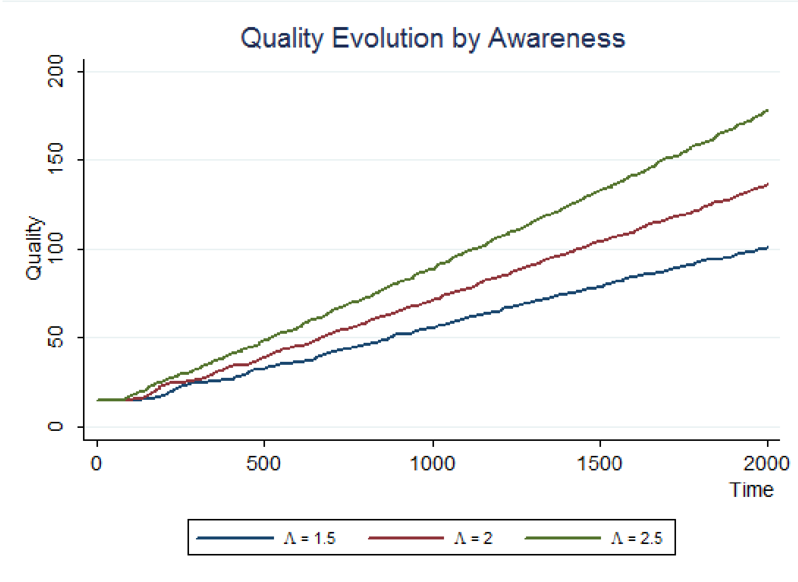


With a bigger awareness radius Λ, or rationality, consumers are able to observe more individuals and therefore the probability to be influenced rises. Thus, a new product is diffused faster in the market raising the speed of saturation and consequently yielding more innovations along the observed period of time.

Figure 5 below that shows the evolution of quality in our economy for each Λ also confirms that.

[36] Thus, we use simulations 1, 101 and 201 to create figure 4 from each awareness value on figure 3

Figura 5: The Impact of Different Awareness Radius on the Evolution of Product Quality

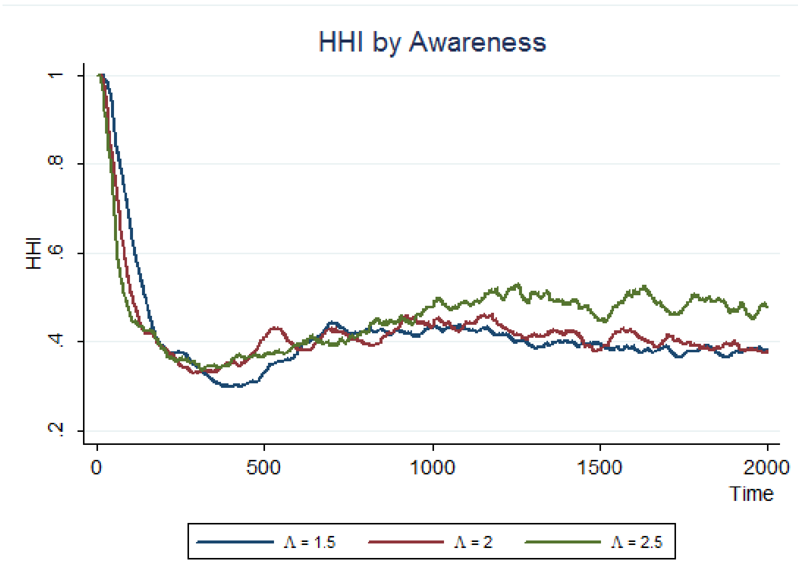


The higher the awareness the more frequent is the arrival of product innovations led by faster market saturation. Thus, the economy reaches higher product qualities. It can then be implied that growth and development are also higher, taking into consideration the important fact that there are no restrictions to technology, nor budget restrictions in our model.

The impact of awareness radius on market concentration is, however, not so straightforward because of the endogenous nature of the model. A higher awareness not only leaves consumers more susceptible to adopt new products, but also to pursue better prices. That means consumers will be changing suppliers more frequently which can be good for competition[37]. Additionally, since awareness affects saturation speed and maximum saturation before product innovation, it may leave a smaller time gap for firms to enter the market and start investing in innovation, providing some advantage to incumbent firms and even more to the firm that manages to be the first to create a new best-quality product. This also pressures firms to invest a bigger part of their profits on R&D, driving weaker firms out of the market.

Figure 6 below shows the effect of changing awareness on HHI.

Figura 6: The Impact of Different Awareness Radius on HHI

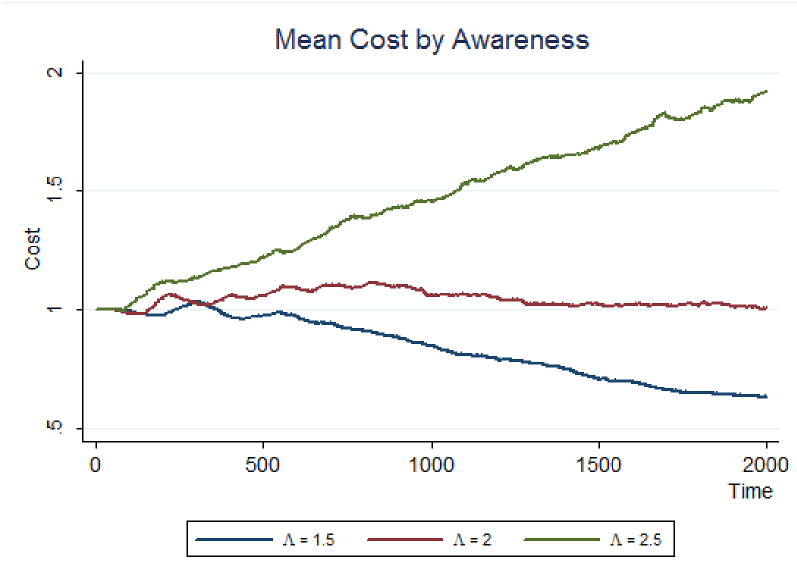


[37]Mark-up adjustments will be more frequent raising price competition but not necessarily market competition because firms that fail to reduce their costs through process innovation will be punished harder.

A considerable difference is only observable when $\Lambda = 2.5$. It may suggest that before a certain threshold, Λ has an ambiguous effect on HHI, but after the threshold is surpassed consumer awareness begins to become negatively correlated with competition.

Now consider the impact of awareness on cost shown in the figure X below. In the models baseline scenario it can be seen that the cost initially rises, about $t = 200$ and then slowly falls from $t = 750$, until it stabilizes at initial value $c = 1$ from $t = 1250$ on. This suggests a predominance of product innovation at the beginning of the time frame which is slowly traded for process innovation at later stages of the market. This finding is consistent with Life Cycle Theory that theoretically predicts this pattern. Results are also comparable to Adner and Levinthal (2001), except that they consider a smaller time lapse which might explain why the initial parts of his baseline cost curve has a more distinguishable hump-shape.

Figura 7: The Impact of Different Awareness Radius on the Mean Cost of Firms



Awareness has clearly a powerful effect over the cost of firms and thus the pattern of product and process innovation. When awareness is bigger (smaller) than the baseline, market achieves saturation faster (slower) and thus R&D investments on product development grows (decreases) in proportion to process innovation driving the costs up (down).

Finally, figures 8 and 9 below show results for the impact of awareness on profit related variables: the mean mark-up and product innovation profitability of firms, this last one measured as the difference between the mean profit of firms selling the best-quality product at each point in t and the mean profit of the rest of the firms.

Figura 8: The Impact of Different Awareness Radius on Mean Mark-Up of Firms

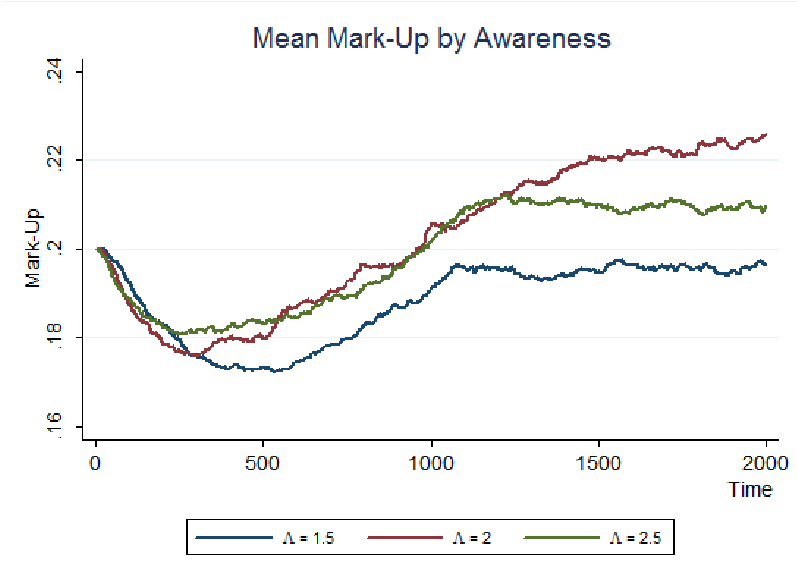
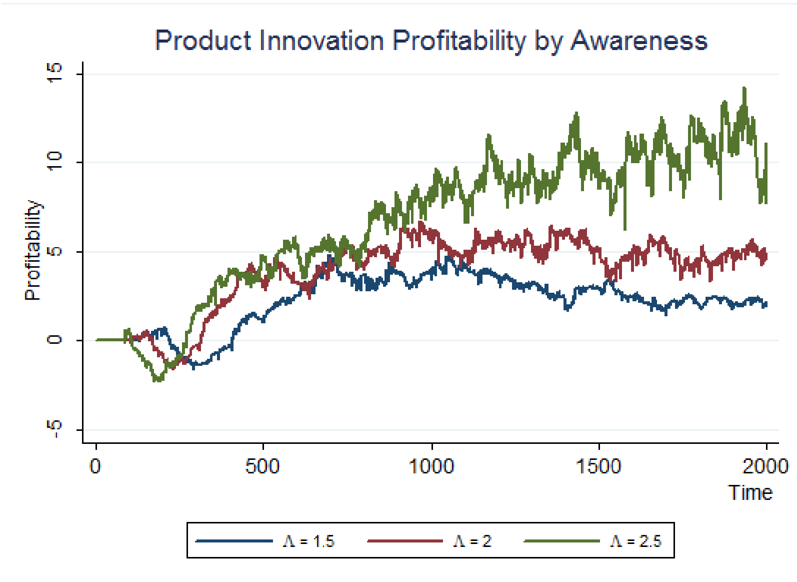


Figura 9: The Impact of Different Awareness Radius on Product Innovation Profitability



Product innovation profitability evolution behaves as expected. A larger awareness increases diffusion speed and thus raises profitability of new product. On the other hand, mean mark-up of firms seems to achieve its maximum with $\Lambda = 2$ which, at least in the spectrum of the economy modelled here, contradicts the claim that a greater market concentration directly implies higher mark-ups.

In the first stages of the market, the fast drop on concentration caused by the entry of the first non incumbent firms drives mark-ups down mainly because the incumbent has to adjust its prices to respond to entrants competitiveness. However, as mentioned before, fast technological advances makes more difficult for new firms to succeed, causing the entry/exit process to be more unstable and thus also mark=up adjustments. Additionally, the fact that the ratio product/process innovation is greater with larger awareness make the impacts of cost reductions smaller preventing large firms to have big cost advantages over other firms and thus making it more susceptible to price wars.

4.2. Varying Techies

The effects of varying the percentage of techies in the market are similar to those obtained changing awareness but with a few important peculiarities.

First, although it is observable that a higher techies percentage in the market also accelerates the speed of diffusion, it is not possible to infer that it raises maximum saturation achieved during each cycle. This is expected, since, unlike awareness shifts, differences in the number of techies does not affect the acceleration[38] of innovation diffusion, only its speed. Figures 10 and 11 bellow show saturation curves for the cases of 1 and 100 runs.

Figura 10: The Impact of Different Percentages of Techies in the Population on Market Saturation (100 runs)

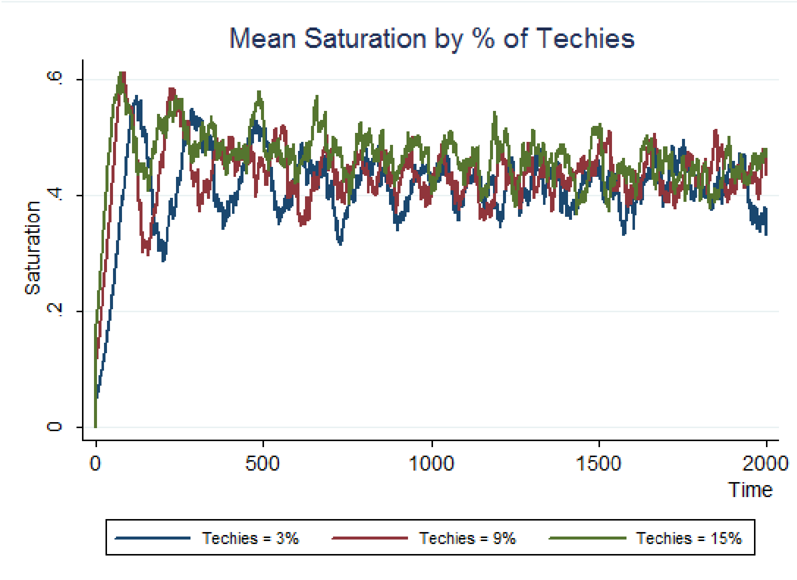
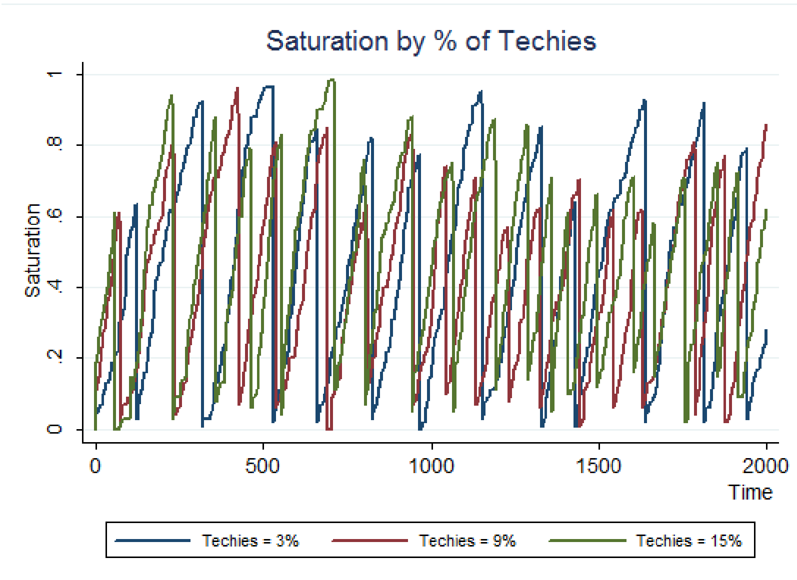


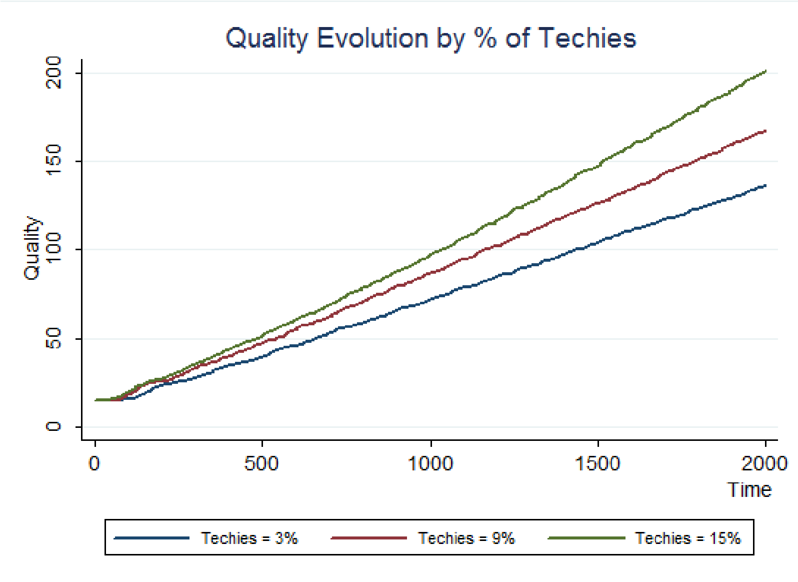
Figura 11: The Impact of Different Percentages of Techies in the Population on Market Saturation (1 run)



The evolution of product quality over time yielded the expected results. The higher the number of techies in the market, faster is the market saturation, leading firms to heavily invest on product innovation. It is interesting to note that, as can be seen in the figure 12 below, in the case in which techies correspond to 15% of consumers, results show that the curve can behave exponentially, indicating that the time between product innovations is getting shorter as time passes, albeit product quality is assumed in the model to present linear growth.

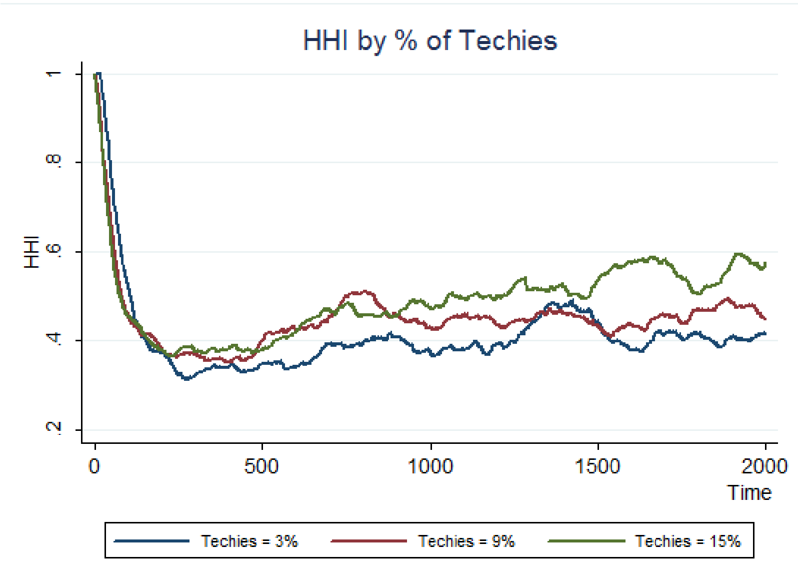
[38] Acceleration can be viewed as the second derivative of the life cycle (saturation) function.

Figura 12: The Impact of Different Percentages of Techies in the Population on the Evolution of Product Quality



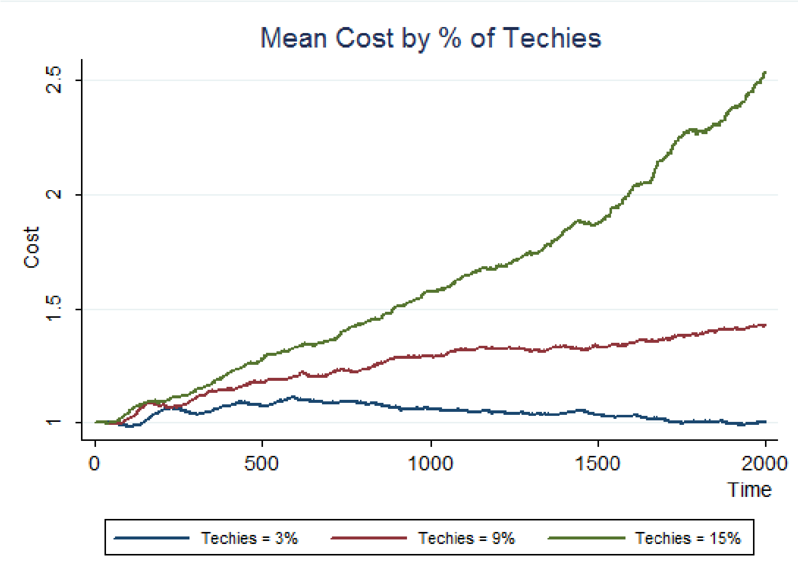
Results on market concentration also follow the same pattern as the awareness analysis, except this time the positive relationship between number of techies and HHI holds in the three scenarios analysed, in contrast to awareness effects in which only the maximum awareness level tested yielded significantly different results.

Figura 13: The Impact of Different Percentages of Techies in the Population on HHI



Raising the number of techies in the market also raises mean cost of firms, an indicative that firms are engaging more heavily on product innovation than process innovation. Again, we can see an explosive tendency on the curve related to the maximum percentage of techies tested. Figure 14 below shows the results.

Figura 14: The Impact of Different Percentages of Techies in the Population on the Mean Cost of Firms



Finally, mean profits and profitability also rise with the increase in the percentage of techies. The once again present explosive tendency, this time of profits, may indicate that raising the percentage of techies above a given threshold may cause a certain degree of disequilibrium in the model. Nevertheless, it is hard to imagine a society where so many consumers are of "crazy-for-innovation" profile.

Figura 15: The Impact of Different Percentages of Techies in the Population on Mean Profits of Firms

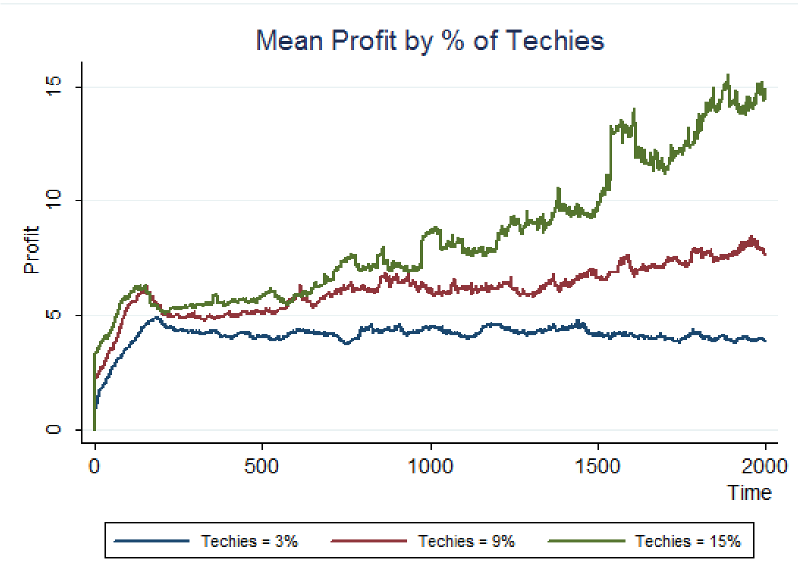
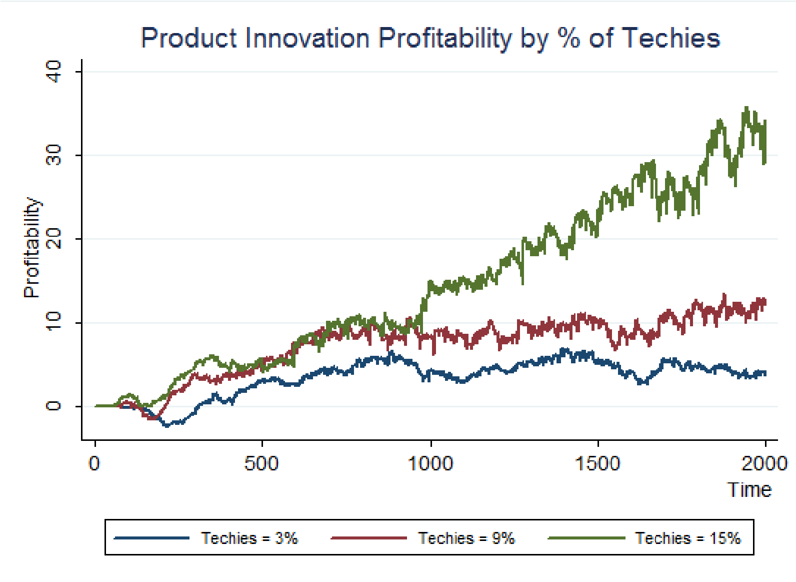


Figura 16: The Impact of Different Percentages of Techies in the Population on Product Innovation Profitability



5. Conclusion

In this paper an agent-based model was presented with the goal to formalize and test the effects of bandwagon behaviour on the firms decision between process and product innovation. The chosen strategy was to test different values of consumer awareness - which in this model are closely related to the degree of agents rationality - and percentage of techies in the market, a type of consumer that immediately buys new products at the exact time they are released and thus are considered the initial seeds for innovation diffusion through a products life cycle.

Since the paper does not cover empirical confirmation for the model, results should be viewed with precaution and considered mostly theoretical. That being sad, they are very interesting and show that both awareness and percentage of techies have a positive effect on the ration between product and process innovation i.e. firms tend to value more product innovation over process innovation when rationality and percentage of techies increases. We also find that increasing awareness has a positive effect on the profitability and price charged by the firms, while the percentage of techies also affects mean profits of firms in the market and the Herfindahl Hirschman Index of market concentration.

There are several ways in which this model could be upgraded in future researches. A formal process of production decision could be incorporated, as well as labour market and consumer income inequality. The assumption of homogeneous awareness among consumers can be relaxed to capture the idea that some consumers are better informed than others.

6. References

Acemoglu, D., Ozdaglar, A., Yildiz, E., 2011. Diffusion of innovations in social networks. MIT Working Papers .

Adner, R., Levinthal, D., 2001. Demand heterogeneity and technology evolution: Implications for product and process innovation. Management Science 47, 611–628.

Aghion, P., Bloom, N., Blundel, R., Griffith, R., Howitt, P., 2002. Competition and innovation: An inverted u relationship. NBER Working Papers .

Aghion, P., Blundel, R., Griffith, R., Howitt, P., Plantl, S., 2006. The effects of entry on incumbent innovation and productivity,. NBER Working Papers .

Aoki, M., Yoshikawa, H., 2002. Demand saturation-creation and economic growth. Journal of Economic Behaviour and Organization 48, 127–154.

Blume, L., 1993. The statistical mechanics of strategic interaction. Games and Economic Behaviour 4, 387–424.

Bonanno, G., Harworth, B., 1998. Intensity of competition and the choice between product and process innovation. International Journal of Industrial Organization 16, 495–510.

Chang, M., 2009. Entry, exit, and the endogenous market structure in technologically turbulent industries. Cleveland State University Working Papers .

Chugh, D., Bazerman, M.H., 2007. Bounded awareness: what you fail to see cant hurt you. Mind & Society 6, 1–18.

Czepiel, J.A., 1974. Word of mouth process in the diffusion process of a major technological innovation. Journal of Marketing Research 11, 172–180.

Dias, D., Marques, C., Martins, F., Silva, J., 2011. Why are some prices stickier than others? European Central Bank Working Paper .

Dixit, A., 1989. Entry and exit decisions under uncertainty. Journal of Political Economy 97, 620–638.

Ellison, G., 1993. Learning, social interaction, and coordination. Econometrica , 1047–1071.

Granoveter, M., 1978. Threshold models of collective behabiour. The American Journal of Sociology 83, 1420–1443.

Higuchi, T., Trout, M., 2008. Life Cycle Management in Supply Chains. IGI Publishing, Hersheys, NY.

Keney, M., Lawless, M., Murphy, A., 2010. How do firms set prices? evidence from ireland. Central Bank and Financial Services Authority of Ireland Research Papers .

Klepper, S., 1996. Entry, exit, growth and innovation over the product life cycle. American Economic Review 86, 562–583.

Kotler, P., 2005. Marketing Management. 12 ed., Prentice Hall, Upple Saddle River, NJ.

Leibenstein, H., 1950. Bandwagon, snob, and veblen effects in the theory of consumers' demand. The Quarterly journal of Economics 64, 183–207.

Malerba, F., Nelson, R., Orsenigo, L., Winter, S., 2007. Demand, innovation, and the dynamics of market structure: The role of experimental users and diverse preferences. Journal of Evolutionary Economics 17, 371–399.

McMeekin, A., Green, K., Walsh, V., 2002. Innovation by Demand. Manchester University Press, Manchester, UK.

Moore, G., 2005. Dealing with Darwing. Portfolio, New York.

Morgenstern, O., 1948. Demand theory reconsidered. The Quarterly Journal of Economics 62, 165–201.

Pasinetti, L.L., 1981. Structural change and economic growth. Cambridge University Press, Cambridge.

Porter, M., 1999. Clusters e competitividade. Revista Management July.

Rae, J., 1905. The Sociological Theory of Capital. The macmillan Co., United States.

Rogers, E.M., 1995. Diffusion of Innovations. 4 ed., The Free Press, New York.

Rosenkopf, L., Abrahamson, E., 1999. Modeling reputational and informational influences in threshold models of bandwagon innovation diffusion. Computational & Mathematical Organization Theory 5, 361–384.

Rosenkrantz, S., 2005. Simultaneous choice of process and product innovation. Mimeo, Wissenschaftszentrum, Berlin.

Saviotti, P.P., Pyka, A., 2012. On the co-evolution of innovation and demand: Some policy implications. Revue de l'OFCE 124, 347–388.

Schumpeter, J.A., 1934. A Theory of Economic Development. Harvard University Press, Cambridge, Massachusetts.

Tomohiko, I., Atsushi, K., Tsutomu, M., 2008. Do competitive markets stimulate innovation? The Research Institute Of Economy, Trade and Industry Working Papers .

Utherback, J., Abernathy, W., 1978. A dynamic model of process and product innovation. The International Journal of Management Science 3, 40–47.

Valente, M., 2013. An nk-like model of complexity. Journal of Evolutionary Economics doi:DOI10.1007/s00191-013-0334-4. published on line: 26 october 2013.

Valente, T., 1996. Social network thresholds in the diffusion of innovations. Social Networks 18, 69–89.

Veblen, T., 1899. The Theory of the Leisure Class: An Economic Study in the Evolution of Institutions. Macmillan, United States.

Vernon, R., 1966. International investment and international trade in the product cycle. The Quarterly Journal of Economics .

Young, P., 2002. The diffusion of innovations in social networks. Santa Fe Institute Working Papers , 13–54.

Zbaracki, M., Ritson, M., Levy, D., Dutta, S., Bergen, M., 2003. Managerial and customer costs of price adjustment: direct evidence from industrial markets. The review of Economics and Statistics 86, 514–533.