Undergraduate Dissertation
DEGREE IN BUSINESS ADMINISTRATION AND MANAGEMENT

Title: Demand, Absorptive Capacity and Innovation Policy
-The debate, a model and an application to the Australian Surf Industry-

Author: Elena Ruiz Gargallo

Supervisors: Isabel Almudi and Francisco Fatás Villafranca

FACULTY OF ECONOMICS AND BUSINESS

2016/2017
03.07.2017

Author: Elena Ruiz Gargallo.

Supervisors: Isabel Almudi and Francisco Fatás Villafranca.

Title: “Demand Absorptive Capacity and Innovation Policy: The debate, a model and an application to the Australian Surf Industry”. “Capacidad de Absorción de la Demanda y Política de Innovación: El debate, un modelo y una aplicación a la Industria Australiana del Surf”.

Degree: Business Administration and Management.

Abstract

In this work, we highlight the role of the absorptive capacity of demand in innovative environments. Innovation is crucial in firms and sectors since it provides the fuel to gain competitive advantage over the rivals, and it leads the track in markets. However, as we will show, innovation can generate the phenomenon of *technological overshooting* if the absorptive capacity of demand is not enough to allow for a proper assimilation of novelties. This phenomenon can be the driver of unexpected industry stagnation phases, or it can even lead to absolute sectoral collapse. To justify our point, the case of the Australian windsurf industry is presented, and we conjecture how the lack of demand absorptive capacity could have led this industry to a breakdown some years ago. Then, we propose an industry dynamics model in the evolutionary tradition which, once adapted (in a highly stylized way) to the Australian windsurf industry, can be used to explore the interactions between demand and the innovation potential of industrial sectors. The formal analysis allows us to clarify the role of demand absorptive capacity and its links with possible innovation failures and technological overshooting episodes. We conclude with some reflections on certain policy actions that could increase the demand absorptive capacity in a given sector, so that innovations can be assimilated and the sector can progress properly. We suggest the need to “train” consumers/users in industries that might be exposed to a lack of demand absorptive capacity. This suggestions are a modest step forward in the debate on innovation policy, which has moved, in past, around supply-side factors.

En este trabajo, destacamos la importancia de la capacidad de absorción de la demanda en la evolución de sectores innovadores. La innovación es crucial en empresas y sectores dado que es una fuente crucial de ventaja competitiva sobre los rivales, y es un factor que abre camino en los mercados. Sin embargo, la innovación puede rebasar la capacidad de absorción de la demanda, lo cual puede alterar, e incluso bloquear la correcta difusión (asimilación) de las innovaciones (desbordamiento tecnológico de la capacidad de absorción de la demanda). Este fenómeno puede, incluso, dar paso a ciertos episodios de estancamiento (e incluso colapso absoluto) en la capacidad de innovación y auto-transformación de ciertas industrias. Para justificar estas afirmaciones, comenzamos presentando el caso de la industria del surf australiana, en la que la falta de capacidad de absorción por parte de la demanda pudo conducir a esta industria a una pérdida de dinamismo y a su derrumbamiento gradual (y finalmente total) hace algunos años. Seguidamente, proponemos un modelo evolutivo de dinámica industrial que, debidamente adaptado y simplificado, se aplica al estudio de los mecanismos que pudieron operar en la industria australiana del surf. El estudio de la dinámica del modelo nos ayuda a entender mejor algunas interacciones entre capacidad de absorción de la demanda y potencial de innovación sectorial así como sus efectos en el posible bloqueo de la difusión de innovaciones. A partir de estos resultados, presentamos algunas reflexiones acerca de políticas que podrían contribuir a aumentar la capacidad de absorción de las innovaciones en ciertos sectores, de forma que, así, estas industrias pudieran prosperar y tener éxito en la introducción de las innovaciones. Finalmente, planteamos unas observaciones finales que pueden ser una modesta contribución al debate de política de innovación: por lo ya dicho, creemos que sería interesante concienciar a empresas, y educar a consumidores/usuarios para evitar déficits en la capacidad de absorción de la demanda. Esta observación es original en el debate sobre política de innovación que, habitualmente, ha girado alrededor de factores de oferta.

Motivation

When the moment of choosing the topic of my final degree dissertation arrived, what I knew for sure was that it was going to be related to any of the subjects that I enjoyed the most during the whole degree. One of them, if not the most, was *Macroeconomics* and, in general, the economic theory we studied within the Macroeconomics (I,II) subjects (innovation, human capital, cycles and growth, and other topics not related to the present work -such as fiscal and monetary policy, unemployment, inflation, etc).

Even though I am a *Business Administration and Management* student, and this subjects may be more related to *Economics*, I believe that, for a future firm manager, it is especially important to have a broader view and a proper understanding of the evolution of the macroeconomic environment, which is going to shape and condition the firm behaviours, strategies, choices and results. This is the reason why, when I was taking a look at the proposals for dissertation topics, the theme called "Evolutionary Models that include the analysis of self-organization issues, innovation, and learning in specific sectors and the economy as a whole", specially caught my attention. It definitely convinced me when I realized that it was coordinated by one of my most motivating professors: Francisco Fatás Villafranca. All of the areas approached during his subjects Macroeconomics I and II, resulted really interesting to me, and I was keen to understand all the models and theories proposed quite easily. In this way, I discovered that the analytical approach to economic issues and, in particular, to problems influencing the Economy as a whole, were going to be my preferred ones. Francisco has a clear focus on the analysis of innovation and the conditions for creation of value within firms and specific sectors, and within national economies as a key factor for economic development. I share this philosophy, and thus I thought that, under these circumstances, carrying out a dissertation based on this subject and with him as Coordinator was going to be quite interesting and inspiring.

Once the topic was chosen, we arranged to have the first meeting. Given the complexity of the subject (which involves pure economic analysis instruments, the study of dynamical systems, simulation and industry-level case studies) we agreed in that an additional co-coordinator would be needed. I suggested Professor Isabel Almudi, from whom I had really good references. This extra help resulted challenging to me: I was going to address a topic that really interested me and, furthermore, it was necessary that

I put an extra effort to carry it on well, always accompanied by two professionals in the area. Those facts really motivated me to write my dissertation. After several conversations, we decided to set a specific topic, focused –at least partially- on the Australian Surf Industry, in which there is a debate on how the development of certain innovations could have damaged the industry evolution, instead of making it progress. All this completed my motivation: the Surf Industry in Australia has gone through different stages, and it would be appealing to know how innovation affected the sector, and even more, considering that innovation could (surprisingly!) have had a negative effect on the industrial path.

When I started working on my dissertation, and because of all the conditions previously explained, I had no doubt that I had correctly chosen the subject and that I could take a lot of advantage of it. With this topic, I had the possibility to widen my knowledge on absorptive capacity, the role of demand, and innovation policy -among other topics- and the application of these elements to the specific case of the Australian surf industry. Furthermore, these concepts and the analytical instruments I have learnt may be suitable to study not only the Windsurf Industry itself, and –of course, not only the Australian case- but also other sectors and activities such as the bicycle/cycling industry, culture-related industries, software, or the Smartphone industry (just to name a few). Hence, this dissertation seems to me worthwhile, since many of the analysis and results may be applicable to all those firms that are carrying out their activities in innovative sectors in which the absorptive capacity of demand is significant.

CONTENTS

List of Figures

1. Introduction

At the present time, we are living in a globalized world in which markets are continuously offering a variety of new and different products for customers. This situation provokes a fierce and increasing competition among firms, which will try to increase their competitive advantage in order to survive and succeed in the market. This competitive advantage desired by firms comes, in a great extent, from the existing degree of innovation that they are enforcing in their strategy. Nowadays, it is vital that companies innovate and offer developed and improved products and services, in order to achieve a powerful positioning and to maintain certain degree of competitiveness in the market.

As it is stated in this dissertation, innovating consists of far more than companies' endeavours on Research and Development practices (Metcalfe, 1998; Almudi et al., 2013). Innovation is influenced also by other crucial factors that will provoke its more or less costly achievement. One of them is the firm's ability to assimilate new knowledge and apply it to their processes and products. As long as firms are not capable of fulfilling this fact, innovation will not be successful.

However, the role of innovation and its correct assimilation and acceptance is not only linked to the supply side of the market. There is a tendency in the innovation literature (Metcalfe, 2007) to assess how properly new knowledge is being captured solely by the companies' side (firms-University interactions, firms absorptive capacity, property rights to foster incentives to innovate and develop dynamic capabilities, etc). The key point we want to pose is that the demand side, customers, has also been proven to be exposed to the risk of being unable to adapt to novelty that firms have imposed to their products and services.

To some extent, companies' acknowledgment of this event is crucial. As previously mentioned, even if firms allocate significant effort, capital and time on fostering innovation to offer the newest, most improved products to reach the most competitive position in the market they are able to aspire to, all this effort made by firms will be worthless whenever demand is not able to understand those new products and services and to take advantage of them. It will be crucial for firms to discover in which sectors demand might face difficulties in dealing with the product portfolio they are offering, because that will be the first step to be able to tackle the issue.

Thus, this dissertation will aim, on one side, at raising awareness of the role that the demand side actually plays in innovation. This will be achieved by proving with a real case that it must not always be the supply side the one that rules this issue, but it is also the demand side of the market that has a significant influence on the entrance and diffusion of new products.

Given the relevance of the demand side in innovation, the dissertation will consequently aim at providing with possible solutions to minimize or avoid the risk of demand's inability to assimilate new products. Possible troubleshooting will be posed from both, the demand and the supply side; we will focus, mainly, on how to increase consumers' ability to adapt to novelty. On the other hand, we will consider how to aid from the policy-side to foster innovation by firms to prevent new products offered from being unmanageable for customers.

To achieve our objective we will organize this dissertation by comprising several sections. In the first section, the role of innovation in firms and the factors that are continuously and meaningfully affecting its development will be introduced. Additionally, the significance of how the demand-side may influence innovation in a particular industry will be pointed out and contrasted with the supply side. In section three, for the purpose of illustrating how the demand's inability to adapt to innovation can actually deteriorate specific sectors, a real case based on the Australian windsurf industry will be introduced. This section shows the development of this industry from its beginnings until the point when several firms began to apply innovations in their product portfolio, which supposed a turning point for the windsurf sector.

Hence, inspired by this real case, the section four will be devoted to develop a mathematical model which aims at determining the factors that will allow for an equilibrated development between the demand and the supply side and thus, the prosperity of innovation in those industries. Afterwards, some reflections about the findings obtained are explained, and some solutions are proposed for the recurrent desired objective: thriving innovation in those industries that may have a tendency towards a lack of cognitive coordination between firms and customers (i.e. demand and supply). Finally, we highlight some concluding remarks.

2. Innovation, demand absorptive capacity and the overshooting phenomenon

Innovation is for firms one of the most important elements to gain competitive advantages in markets. But, as it is gradually recognized, innovation to be successful requires much more than just investing in R&D activities. Innovation is over all, a very risky activity which must be developed in an appropriate institutional environment. Traditionally, the debate about the role of Institutions to promote and foster innovation activities has been focussed on reaching the adequate balance between intellectual property rights and knowledge spillovers. Innovation policy has the purpose of interconnecting basic-science developments (in Universities, research labs) to private R&D discoveries. This policy seeks to amplify the range of technological opportunities for firms, maintaining active the firm's absorptive capacity and its incentives to innovate. Two interwoven concepts play an important role in the success of innovation activities: *absorptive capacity* (Cohen and Levinthal, 1990) and the overshooting phenomenon (Earl and Potts, 2015).

The *absorptive capacity* is a function of a firm's prior knowledge (Cohen and Levinthal, 1990). It consists of the ability of the firm to recognize new, external knowledge, assimilate it and apply it to its activities so that it can wider its innovative capacities. Those firms that possess their own R&D activities are more capable of extracting external information. The accumulation of prior knowledge allows the ability to allocate new knowledge and to recall it more easily. At the same time, it provides individuals with problem-solving capabilities, which create new knowledge. That is the reason why creative capacity and absorptive capacity are similar.

An organization's absorptive capacity will depend on individuals' capabilities. It will depend on transfers of knowledge across boundaries and also across sub-units. There exists a trade-off among inward and outward-looking absorptive capacities, therefore internal and external language capabilities are necessary. Diverse knowledge structures allow the sort of learning and problem solving that elicit innovation, which eventually will allow more novel linkages. The accumulation of absorptive capacity in one period will permit more efficient accumulation in subsequent periods. In the same path, owning certain expertise will allow the firm to better understand and evaluate related aspects. Research and Development is assumed not only to generate new knowledge, but also to contribute to expand a firm's *absorptive capacity*.

To show our point, we have studied the Australian windsurf industry. For this sector, we clearly identify the *demand lack of absorptive capacity* as the key cause to explain the collapse of this sector. Based on this finding and in previous results from the model and framework in Almudi et al. (2013) we explore in which sense innovation policy can be extended to avoid this knowledge miss-coordination.

3. The Australian Surf Industry

In this section, a real case which occurred in the Australian windsurf industry will be expounded to illustrate the significance of the absorptive capacity of demand. Even though this sector was successful at first and seemed to be thriving, several circumstances provoked its detriment along its last years until it reached a breakdown. This event reveals that, in spite of corporations' effort to innovate and offer novel products to the market, a particular industry can lose significant weight and can even collapse if demand does not own the full capacity to assimilate and accept those innovations proposed by firms, which were indeed originally planned to benefit and enrich consumers' experience when practicing the sport.

On the other hand, the effect that appropriability and technological opportunities may have on Research and Development will depend on the firm's ability to assimilate knowledge; it is, on its *absorptive capacity*. Hence, as absorptive capacity is diminished in environments in which learning is more difficult, lower appropriability and a lower level of technological opportunities will be the consequence, which will result in reduced Research and Development levels.

Therefore, the more technological opportunities there exist, the more provision of R&D will be given in difficult learning environments to increase absorptive capacity within a wider external environment.

With regard to appropriability, a higher spending in R&D will exploit others spillovers, which is positive. In areas in which there is large absorptive incentive and learning is difficult, spillovers may encourage and spur R&D intensity. A high appropriability will be important as the market becomes more competitive.

The implications for the innovative activity may be that firms should engage in high spillover researches so that they can exploit innovations more quickly. When

progressing, the relevant fields of the researches will become more diverse and R&D expense will increase to understand each field and augment absorptive capacity. All those firms that may be willing to obtain and use new knowledge that is not related to their ongoing activity shall develop absorptive capacity.

It is worth to point out that, traditionally, the role of innovation policy has been focussed on the supply side elements of the innovation processes (the range of technological opportunities and property rights, for example) and little attention has been paid to the demand side of the innovation process (Metcalfe, 2007). But as we show in this work, some sectorial innovative shortcomings can be explained appealing to the supply-demand side miss-coordination of newly created knowledge. That is to say, we claim in what follows that the demand can also suffer from lack of absorptive capacity, thus being unable to understand and therefore to buy, new products. If this happens, the sectorial demand, unable to absorb the novelty, will block the sector innovative process.

Nevertheless, it should be pointed out that although in theory, the most innovative firms in an industry are the ones which will capture the market and will benefit consumers by offering the cheapest, newest, best products (Thomas and Potts, 2015). In certain industries, such as equipment-based sports (for instance, the Windsurf Industry), in which uncontrolled innovation is not beneficial but harmful for both firms and consumers. This phenomenon is called *overshooting* (Earl and Potts, 2015). This phenomenon occurs when innovation speed is higher than absorptive capacity o demand, so that demand cannot absorb the novelty and firms cannot benefit from their innovation efforts. If innovation activities are not balanced with absorptive capacity of demand, the overshooting phenomenon can make the sector collapse.

In this sector, the firm itself is the actor in charge of developing new technologies, since it must try to achieve a leading position by strengthening its capabilities and competencies to survive in the industry and to achieve success. The first firms arose by the so-called user-innovators, that is, sportsmen who build up their own equipment to practice, in this case, windsurf. These latter create demand: user-purchasers in need of innovations will buy instead of build, triggering the emergence of manufacturers. Even though user-manufacturers begin with relatively high variable costs, as information is being disseminated the market grows and so does the volume. This allows lower costs, lower average prices and a consequent expansion of the market.

But, even though the practice of the sport spread successfully, it was observable that at some point, manufacturers' desire to stay ahead of the curve and to offer the fastest, most specialised (and consequently more expensive) equipment. This created a hard innovation competition among firms that ended up focusing on elite teams and professional athletes and leaving behind the standard users and aspirational participants. A collapse arose at this stage: an excess in capabilities (*overshooting)* and budget in windsurf equipment for standard sport's participants causes the dropout of the majority of them, triggering the permanent abandon of the sport and even affecting other sectors offering complementary goods and services such as clothing and tourism. The lesson was that affordable and conventional windsurfing equipment was claimed by the aspirational participants of the sport, who at the end could not engage in the upper segment of the sport, deciding to give up on it.

A Case Study as an illustration─ the rise and fall of the windsurfing industry

Windsurfing struggled at its beginnings to gain credibility is countries which already had strong water sport culture (as it is the case in the United States or Australia) but became rapidly popular during 1970-1980 in countries such as Holland, Germany or France, not having these water sports traditions and turning out to be the world's fastest growing sport and the second sport in number of participants in Europe, only after skiing.

From 1980 to 1985, the development of the windsurfing was fostered in two different paths just after the initial worldwide success of the sport.

On the one hand, European manufacturers maintained the populist way, emphasizing on simple, low cost equipment. On the other hand, Hawaii approached windsurfing as a technical, performance-based, athletic sport. This occurred, in some way, given the conditions existing in that State (strong wave and wind energy), which motivated sailors and manufacturers to try new things and innovate. When aspirational participants heard of the Hawaiian innovative equipment, demand by such equipment arose somehow in a more generalized way. Higher variable costs, higher skills and higher budget to adapt the equipment and an oversight of recreational participants were the consequence of this new emphasis on high-performance, elite athletes and aspirational users. The product was adapted to satisfy the competitive desire of these elite riders and marketing and

promotion of the sport was only focused on this top-class target, ignoring the entry-level users.

During 1985-2000 and as a consequence of the shift in the emphasis towards performance, the fact that equipment was such sophisticated and consequently expensive meant that there was more money to be made by its sale than by the teaching of the sport in the windsurfing schools previously established. The result from this turned out to be the shutdown of many schools, leading to a huge reduction of new entrants into the sport. Furthermore, the perpetual technically demanding equipment and its specialization caused that even aspirational participants lost interest and gave up on the sport.

From the year 1985, the performance market boomed and the biggest mass producers in the windsurfing industry went bankrupt. As an illustration, in the State of Victoria the number of retail outlets for sailboards was reduced from 120 in the 1980s to 12 by 2000. In 2015 there were remaining only three of them, which is consistent with the indexes that indicate that windsurfing is in a long-run decline.

This case study reflects the idea that they are not only the supply factors those ones that must be promoted with proper policies but also the demand factors. For instance, when there exists substantial lack of demand's absorptive capacity, the sector has the risk to collapse, since this fact does not allow the consumer neither to enjoy nor to buy the product.

4. An Evolutionary Model Inspired by the Surf Industry

4.1 Assumptions

In this section, we adapt the complex evolutionary model presented in Almudi et al. (2013) to the study of some of the factors we are dealing with above, and to specific features of the windsurf industry as presented in the previous section. In our model, we consider that a "new" and an "old" variety of a sectoral product, with the corresponding productive firms and market shares, exist. An innovation rate parameter and an absorptive capacity of demand parameter are fundamental to explain the dynamics of the model.

We take into account some of the key drivers of sport industries (as stated in Section 3), and we propose a simple (stylized) evolutionary model –in the tradition of Metcalfe (1998)- to analyse in detail certain aspects of the evolution of *sport industries*. For the sake of simplicity, we focus in the evolution of a single sector (sport industry -running, windsurfing, cycling, etc.) in which two varieties of the sectoral good are produced. Firstly, we distinguish what we call an "old" (or well-established, traditional) variety "Y" whose market share at t is represented by $0 < y(t) < 1$. Secondly, we also consider a "new" (emergent) variety "X" whose market share at any time is given by $0 < x(t) < 1$. We assume that both market shares are continuous and continuously differentiable functions of time (variable t). Likewise, since we just consider an "old" and a "new" sport-good variety, it is clear that $x(t) + y(t) = 1, \forall t$. Therefore, once we obtain the dynamics of $x(t)$, we can also obtain the dynamics of $y(t) = 1 - x(t)$. Let us notice that as long as we are considering that "X" is the emergent-new variety, it seems sensible to assume that, initially, $x(0) \ll y(0)$. For the sake of formal simplicity, we assume just two varieties with no appearance of new options as time goes by.

Let us assume that the "new" variety "X" represents an objective rate of improvement (in normalized performance/price terms) $\lambda, (0 < \lambda < 1)$, as compared with the normalized performance/price of the "old" variety that we assume is equal to "1" –this is a typical assumption in relative-fitness models (see Metcalfe, 1998). In general terms, we may consider λ as the *innovation rate* of the new versus the old sectoral sport-good version, and we can denote by $f_y(t) = f_y = 1$ the normalized fitness of "Y", and by $f_x(t) = f_x = 1 + \lambda > 1$, the relative (objectively improved) fitness of the new version "X"[1].

As it is typical in Metcalfe (1998) formulations (see also Almudi et al., 2013), we propose a demand-driven evolutionary model of sectoral transformation, with a constant (exogenous) rate of industry-demand growth $g \in (0,1)$. We do not enter here into the causes underlying this demand growth (new users, growing population, external forces, etc.). We do consider that firms adapt their growth rates to their demand growth rate.

[1] Notice that this assumption can be interpreted either as a unique *innovation jump* allowing for a new variety objectively superior to the old variety, or as both, the old and the new variety, improving their functionalities at a constant common rate but separated (*in favor of the new variety*) by a constant level effect λ.

We also assume that firms (let us say, a continuum of firms) may be distributed between the supply of both varieties (we do not enter in whether they are incumbents new entrants, etc); we just care about the gradual transformation of demand –as consumers/users gradually discover and understand the "new" variety-, and we consider that the continuum of firms adapt the growth rate of production of varieties "X" and "Y" according to the corresponding demand growth of both varieties.

Finally, two additional hypotheses are stated now:

(H.1) The market growth rates of both varieties "X" and "Y" of the sector sport good are given by:

$$g_x(t) = g + \left(\alpha f_x - \bar{f}(t)\right), \;\; g_y(t) = \frac{g - x(t) g_x(t)}{1 - x(t)} \qquad (1)$$

$$\bar{f}(t) = x(t) f_x + y(t) f_y = 1 + \lambda x(t)$$

in such a way that $x(t) g_x(t) + y(t) g_y(t) = g$. This assumption combines the well-known Metcalfe-type approach to sectoral order (with no equilibrium, but ongoing evolution) with our relative fitness approach to varieties-competitiveness. Note that $\bar{f}(t)$ is the average fitness (or average competitiveness level) in the market which endogenously changes as time goes by.

(H.2) The α parameter in (1) represents what we call the *absorptive capacity of demand* to understand, to use, and to acquire, the "new" variety "X".

Here we are capturing in a stylized way some of the ideas presented in Section 2. The higher the value of α, the higher the *absorptive capacity* of sectoral demand. As it is shown below, for the sake of economic meaning, we must assume that:

$$\left(\frac{1}{1+\lambda}\right) < \alpha < 1 \,, \qquad \text{with} \qquad 0 < \lambda < 1. \qquad (2)$$

Now we can start combining the previous assumptions to arrive at a tractable expression of the model dynamics. Notice that, from eq.(1) it is straightforward that the rate of change of the market share for the "new" variety "X" is:

$$\frac{\dot{x}}{x} = g_x(t) - g = \alpha f_x - \bar{f}(t) \qquad (3)$$

with the expression $\dot{x}$ denoting $\dot{x} \equiv \frac{dx}{dt}$.

Once we have in (3) the dynamics of the "new" variety market share, it follows that the dynamics of the "old" variety share, is $y(t) = 1 - x(t)$. Therefore, we focus on studying the dynamics of $x(t)$. Given the general configuration of our framework and the specific hypothesis and assumptions already formulated, the model is completely specified. Therefore, we can obtain the fundamental differential equation of the model and, later on, in Section 4, the dynamic properties and results.

Let us obtain, first, the fundamental equation of the model. If we combine (1) and (3), and taking into account the previous definitions of the main variables, it is straightforward to conclude that the dynamics of the model can be analysed through the following first-order (non-linear) ordinary differential equation:

$$\dot{x} = \Phi(x(t)) = x(t)[(\alpha(1+\lambda) - 1) - \lambda x(t)] \qquad (4)$$

This is the fundamental equation of the model which –keeping in mind the economic meaning of $x(t)$ (it is a market share), and considering the constraints on the parameters stated in (2)- drives the model dynamics that we explore in sub-Section 4.2.

4.2 Dynamic Analysis

We are going to analyse the dynamics arising from eq. (4) by exploring in global-general terms -see propositions 1 and 2 (below)- the existence and number of rest points (stationary states) in the dynamics, and the stability properties of each stationary state (see Gandolfo, 2009). These results will allow us to characterize some properties of the stationary states in terms of the parametric values and initial conditions in the sector; we will obtain interesting multiplier effects around the relevant stationary state, and we will propose a measure of the speed of convergence to the post-innovation structure of the sector. As we will see, all these results have interesting economic interpretations related to what we have seen in Sections 1, 2 and 3 regarding certain innovative sport industries.

Let us say that, since propositions 1 and 2 provide us with a full and general closed-form analysis of the model, the simulations that we show (below) are just for illustrative purposes. All the aforementioned is clearly stated and proved in the following propositions:

Proposition 1: *There exist two stationary states (resting points) in the model* (*eq.*(4)) *which are* $x_1^* = 0$ *and* $x_2^* = \frac{\alpha(1+\lambda)-1}{\lambda}$ *. The first one,* $x_1^* = 0$*, is unstable under the assumptions adopted, and the second one,* $x_2^* = \frac{\alpha(1+\lambda)-1}{\lambda}$*, is globally asymptotically stable.* ▪

Proof: Applying the definition of stationary state, we consider in eq.(4) $\dot{x} = 0$. Then, we obtain: $x(t)[(\alpha(1+\lambda)-1) - \lambda x(t)] = 0$; there are two roots for these second order equation which are the two stationary states: $x_1^* = 0$ and $x_2^* = \frac{\alpha(1+\lambda)-1}{\lambda}$.

Let us notice that, if we do not impose the condition (established in the conditions (2) above) $\left(\frac{1}{1+\lambda}\right) < \alpha < 1$, the second state $x_2^* = \frac{\alpha(1+\lambda)-1}{\lambda}$ does not have economic meaning as a market share. Then we assume that the condition hold.

Now, let us analyse the stability characteristics of both stationary states. Regarding $x_1^* = 0$, considering equation (4) and the parametric constraints, since we obtain that $\frac{\mathrm{d}\Phi}{\mathrm{dx}}(x_1^* = 0) = \alpha(1+\lambda) - 1 > 0$, x_1^* is unstable and, therefore, irrelevant for our analysis.

On the other side, regarding x_2^*, since $\frac{\mathrm{d}\Phi}{\mathrm{dx}}(x_2^*) = 1 - \alpha(1+\lambda) < 0$, x_2^* is locally stable. Additionally, it is easy to see that $\Phi(x) > 0, \forall x \in (x_1^*, x_2^*)$, and $\Phi(x)$ is strictly concave $\forall x \in (0,1)$; therefore, we can assure that $x_2^* = \frac{\alpha(1+\lambda)-1}{\lambda}$ is globally stable. ▪

Thus, we have proved that the stationary state x_2^* is the point towards which, for any initial condition given, the market trajectory will always tend asymptotically. That is to say, for any $x(0) = x_0$, as closer to "0" as we want from the right-side, the system tends towards a "new" variety market share $x_2^* = \frac{\alpha(1+\lambda)-1}{\lambda}$. Let us note that the value of x_2^* , (which is always positive and lower than 1 in the model), defines the "old" variety

market share as: $y_2^* = 1 - x_2^*$. Let us notice that both shares and, therefore, the limit-market structure depend crucially on the main parameters (α, λ). Once we have obtained these fundamental results on the model dynamics, let us analyse in the following proposition the role of the two fundamental parameters.

Proposition 2: *From equation* (4)*, and from the results obtained in Proposition 1, we can state that:*

1) *The stable state x_2^* depends positively on both, the absorptive capacity of demand, "α", and on the rate of sectoral innovation "λ".*
2) *The parameters (α, λ) not only determine the limit-structure of the sector in the stable state x_2^*, but they also determine the speed at which the sector evolves towards its limit-structure. More precisely, they affect positively to the speed at which the new variety gains market share, and to the speed at which the sector converges to its steady state.*
3) *There exist compensatory effects between α and λ regarding, both x_2^* , and the speed of convergence to this stationary state. This result suggests that there may be alternative ways (even policies) to transform a sport sector.*▪

Proof:

1) From the results obtained in Proposition 1 and the assumptions of the model, it is easy to proof that: $\frac{\partial x_2^*}{\partial \alpha} = \frac{(1+\lambda)}{\lambda} > 1$, and $\frac{\partial x_2^*}{\partial \lambda} = \frac{1-\alpha}{\lambda^2} > 0$. Therefore, the higher the value of both parameters, the higher the limit-market share for the "new" variety within the sport industry.
2) We prove point 3 in Proposition 2 by obtaining, and solving, the Taylor first-order series expansion of (4) in a neighbourhood of x_2^*, which leads to:

$$x(t) \approx (x_0 - x_2^*)e^{-(\alpha(1+\lambda)-1)t} + x_2^*$$

with$(\alpha(1+\lambda)-1) > 0$ being the speed of convergence to x_2^*. Thus, this value is our indicator of the speed at which the "new" variety gains market share. Let us note that, by estimating the value of $(\alpha(1+\lambda)-1)$ in a specific industry, since $\frac{x_t - x_2^*}{x_0 - x_2^*} \approx e^{-(\alpha(1+\lambda)-1)t}$, this would allow us to calculate (e.g.) the time t^c

that would take the market to cover half-way of the distance from x_0 to the limit market share of the new variety x_2^*.

More precisely:

$$t^c \approx 0.7/(\alpha(1+\lambda)-1).$$

3) From Proposition 1 and part 1) of this proof, it is easy to show the expression of the second partial derivative of x_2^*, first respect to λ, and then, respect to α, That is: $\frac{\partial \partial x_2^*}{\partial \lambda \partial \alpha} = \frac{\partial}{\partial \lambda}\left(\frac{1-\alpha}{\lambda^2}\right) = \frac{-1}{\lambda^2} < 0$.

Additionally, if we consider $x_2^* = \bar{x}$ -with $\bar{x}$ being a fixed value for the stationary state that we fix exogenously, from the expression of x_2^* and being $x_2^* = \bar{x}$, we can obtain that: $\alpha = \frac{1+\lambda\bar{x}}{1+\lambda}$. If we derivate this expression with respect to λ, we obtain: $\frac{\partial \alpha}{\partial \lambda} = \frac{\bar{x}-1}{(1+\lambda)^2} < 0$. These two latest results prove the existence of a certain compensatory relationship between both parameters. ▪

The interpretation of this result is interesting. In a sport industry which were characterized by a relatively low level of λ, the existence (or promotion) of a high level of absorptive capacity (α) would lead to a speed and scope of industry transformation in favor of the "new" variety which could be analogous to the one obtained with a much higher innovation rate.

On the other side, a sport industry showing a very high innovative potential can turn out to be almost stagnant, if absorptive capacity is not enough.

Now, as an illustration, we are going to perform simulations to present three possible patterns of industry evolution emerging from our model in Figures 1, 2 and 3 below. We will consider in the three simulation runs that x_0 is initially rather low (x_0=0.03), and we also consider the existence of a high innovation potential in the industry (λ =0.9). I run the model for alternative α –values. We run the model in the computer (we used excel for simplicity; but more complex software packages could have been used -such as Mathematica, Matlab, Python, etc). Programming is not the goal of my work here, so I used the simulation mode that was easier for me while, still, reproducing in a rigorous way the model dynamics. We present the trajectories generated for the model for the specific parameter settings and initial conditions, and we fix a time-span T=50 which is enough in our settings for the dynamics to reach the stationary state.

Thus, fixing the values (x_0=0.03), and (λ =0.9), we show in Figure 1 the case of a level of absorptive capacity ($\alpha = 0.7$) which is not enough for the "new" variety to conquer the market. The "new" variety reaches a niche, provoking a decrease in the market share of the "old" variety, and remains there, but still below the "old" variety.

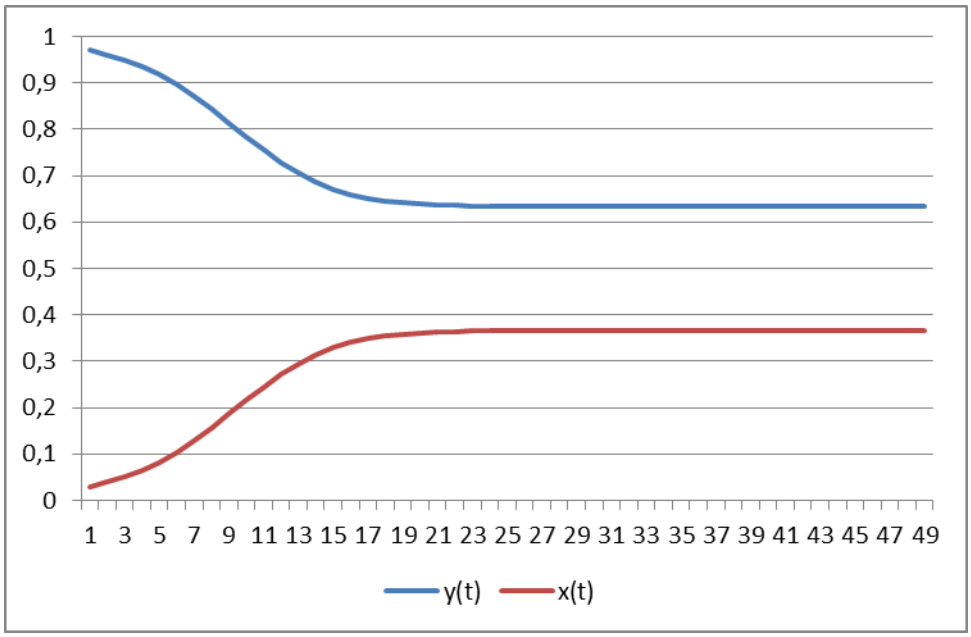

Figure 1.- Industry Evolution for $\alpha = 0.7$.

In Figure 2, we maintain the initial conditions and the value of λ, but we increase absorptive capacity. We show the resulting paths and the industry evolution in the Figure and we see how, in this case, the "new" variety surpasses the "old" one and ends up being the dominant option.

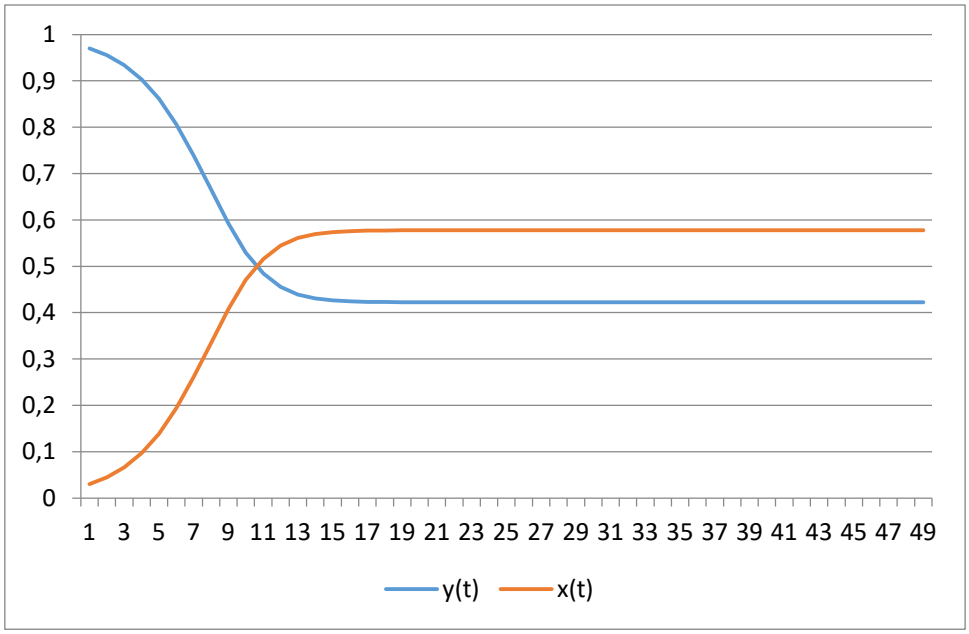

Figure 2.- Industry Evolution for $\alpha = 0.8$.

If we increase even further the absorptive capacity of demand, we obtain the result in Figure 3, where the "new" variety practically dominates the sport industry, and, as a consequence, the "old" variety almost reaches the minimum.

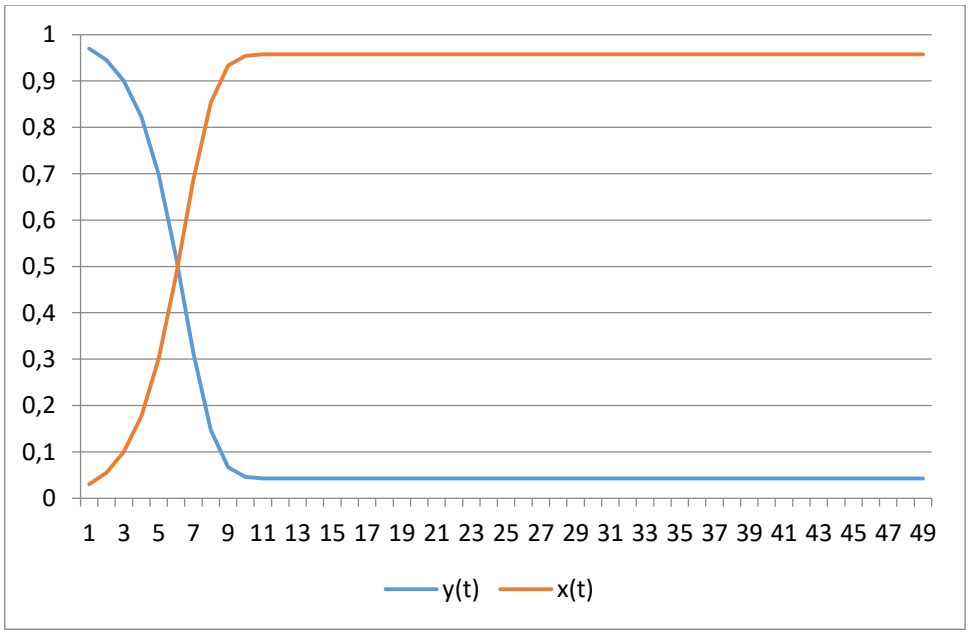

Figure 3.- Industry Evolution for $\alpha = 0.98$.

As it is shown in the previous graphs, for a high level of innovation rate, only "new" variety will prevail and will be successful in establishing if the absorptive capacity of the demand is high enough. The higher the absorptive capacity (α) from the demand side for a given innovation rate in the supply side, the greater will be the assimilation and the success in the market of the new variety, with a consecutive fall down of the old variety, which will make the sector get ahead and progress with the innovations introduced.

To sum up, we can conclude that absorptive capacity of demand plays a crucial role in explaining sectorial development. In the next section we will make a reflection about this fact.

5. Reflections on demand absorptive capacity and innovation

In this section there will be introduced some of the solutions that could avoid the damage of industries in which the existence of absorptive capacity of demand is significant. To this end, there will be solutions proposed from both the demand side and the supply side, either increasing the absorptive capacity of demand or controlling the level and the way of innovating that firms implement in their products. Some of them imply offering consumers the possibility to be taught how to use those novelty products, or approaching innovations in such way that they are accessible in use for standard consumers.

To allow the most profitable entrance of innovations of products and services for both the demand and supply side in a certain industry, some solutions are proposed.

If the *absorptive capacity* is not developed by itself in the demand side, its fostering will be necessary. Since the absorptive capacity of the demand is the ability of the demand to understand and consume products that include novelty, its increase can be achieved by the promotion of its use among the public. Whenever the activity implied in a certain product or service surpasses the standard use and it is complex or not possible to be exercised by oneself, it is advisable that the brand behind that product or service offers a specialized training or demonstration to make the most of the purchase experience.

In the case of the windsurf industry, the companies behind the most innovative equipment are advised to offer and carry out intensive promotions of training activities

for the aspirational and standard users to be able to adapt to the innovations applied to that equipment and to take the maximum advantage of their use. The most effective way for the absorptive capacity of the demand to increase is the provision of training courses where the potential customer can learn how to use the product expounded. In this way, the customer is not only going to adapt to the increasing level of use of the equipment by learning how to use them when practising the sport, but they are also going to see their capacities expanded and they are going to enjoy a much richer experience when windsurfing. This can be achieved by offering a training service at the moment of the purchase of the equipment, with its previous advertisement so that the potential customer is aware of this opportunity and can feel more secure to buy the product. In this training service, a professional user can provide the buyer with face-to-face classes until they can use it properly. This might seem as an extra cost because it implies a payment to the expert user, but in the long term it will develop the engagement of the population to the sport, which will increase sales and revenues in the companies operating in the windsurf sector and will enliven the industry.

Another way to increase the absorptive capacity could be innovating in such a way that the proper innovation can ease the customer's use. That is to say, that the innovation applied to the windsurf equipment is included in the most convenient and intuitive way for the user, so that they can learn how to use it by themselves and not with a significant effort. In this case, the innovation might be lower (as it must fit the customer's abilities more easily) but it may be worth it. An example for this could be that the components of the windsurf equipment were made of other materials to make them lighter, faster and more resistant, but their functions did not change in such proportion that users did not know how to use them.

Another approach in line with the kind of innovation that does not imply a disadvantage for the customer's use would be the introduction of innovations in evolutionary steps that can allow the demand to adapt to it progressively. In our case, new models of Windsurf equipment should not make a substantial change in-between them that provoke the sudden inability in their use. An illustrative example for this could be the smartphones industry. Companies supplying smartphones may have the necessary knowledge and techniques to launch in the market a revolutionary device that could give them a huge competitive advantage; however, their interest is to introduce several models which little by little include innovations. The aim of this is accustoming the

client to innovation changes progressively, introducing intuitive steps so that they can learn by their own and adapt without difficulties. The proposal for this could be the design of very innovative windsurf equipment to be launched in a certain period of time, but with the introduction of several models before that would go presenting the innovations in progression. This would ease the absorptive capacity of the demand and could be even positive in profitable terms since there would be more models to be purchased.

On the other hand, another solution to avoid the collapse of the Windsurf industry under these circumstances would come from the innovation rate side. If the demand is not able to assimilate new, innovative products, then innovation rate should be directed. With that end, there exist supporting institutions that regulate innovation in certain industries so that the product itself is maintained similar and there is not much difference with the previous models and with the ones offered by other firms.

One example would be in the cycling industry. The "Union Cycliste Internationale" (see Webgraphy) (UCI) regulates the equipment that bicycle riders take to their route or track tests. Except for the "mountain bike" type, all the technical innovations related to any kind of device that participants take with them when competing (bicycles, accessories, helmets, mediums of communication…), will only be allowed to be used if the UCI has previously approved them.

Bicycles are highly controlled by this institution, which aims at equal footing for all riders. Regulations define a variety of factors that must be taken into account with regard to the use of bicycles, such as the structure, driving, position when riding, propulsion, or technical specifications: measures, weight and shape. Hence, although presenting some variations, all of them must have basic characteristics in common and technical innovations are restricted to certain extent, which clearly demonstrates that innovation is being oriented. Cycling participants will not purchase novelty bicycles or related devices because they are not to be allowed at competitions. This way, firms' incentives to innovate "outside the technical rules" are restricted.

Another example is the swimming industry. During races in competitions, swimmers are allowed neither to wear nor to use any kind of device or swimsuits that, due to technical innovations applied, is able to enhance the swimmer's speed, buoyancy or resistance during competition (see Webgraphy). Items such as "Power" bracelets,

adhesive substances or swimsuits that are manufactured with no textile materials so that they are more elastic and light are not allowed. Any other kind of innovation implemented in the swimming equipment must be approved by the "Fédération Internationale de Natation" (FINA).

Once again, firms that perform in the swimming sector will be limited by this type of regulation, which provokes that participants of the sport are not interested in consuming cutting edge, innovative swimming products because they are not to be allowed during competitions.

6. Concluding Remarks

Innovation for firms can be a key aspect in their strategy that might ensure a competitive advantage against rivals and provide them with success in their performance. However, if the supply side is applying innovations in their products and services but the demand side is not able to respond to them, the consequence can be the collapse of those firms and even of the sector.

It can be concluded from the Windsurf case study that a high innovation rate in this determined industry is not going to be a competitive advantage for firms whenever there is not a parallel absorptive capacity from the demand side that can assimilate the innovation and adjust to it. From the year 1985, the fact that Windsurf schools shut down, because of the lack of interest in training of consumers, provoked that the absorptive capacity of demand (consumers) decreased even more, creating a continuous loop that lead to the failure of this sport industry. Since the absorptive capacity of demand was not sufficiently big for the given innovation rate and the industry concentrated in the high-skilled segment of consumers, who were not sufficient to maintain the sector alive, the new variety tended to disappear.

We also make some suggestions about how to increase absorptive capacity of demand and how to orient the rate and direction of innovation. Finally, it is worth to point out that this dissertation illustrates that knowledge incoordination can make a sector collapse. Therefore, sector's failure is not only a matter of competition, marketing or income but also a matter of knowledge coordination.

Bibliographical References

- ALMUDI, I., FATAS-VILLAFRANCA, F. and IZQUIERDO, L.R. (2013). "Industry Dynamics, Technological Regimes and the Role of Demand". *Journal of Evolutionary Economics*, 23 (5), pp. 1073-1098.
- CHIANG, A. and WAINWRIGHT, K. (2005). *Fundamental Methods of Mathematical Economics*. McGraw-Hill. New York.
- COHEN, W. M. and LEVINTHAL, D.A. (1990). "Absorptive Capacity: A New Perspective on Learning and Innovation". *Administrative Science Quarterly*, 35 (1), Special Issue: Technology, Organizations and Innovation, pp. 128-152.
- EARL, P. and POTTS, J. (2015). "The management of creative vision and the economics of creative cycles". *Managerial and Decision Economics*, 37(7), pp. 474-484.
- GANDOLFO, G. (2009). *Economic Dynamics*. Springer. Berlin.
- METCALFE, J.S. (1998). *Evolutionary Economics and Creative Destruction.* Routledge. London.
- METCALFE, J.S. (2007). "Policy for innovation". *Elgar Companion to Neo-Schumpeterian Economics.* Hanusch, H. and Pyka, A. (Eds). Edward Elgar. Northampton, Mass. US.
- THOMAS, S. and POTTS, J. (2015). "Industry Sustainability under technological evolution: A case study of the overshooting hypothesis in sports". *Procedia Engineering*, 112, pp. 562-567.

Webgraphy

- http://www.rfec.com/ckfinder/userfiles/files/Docs/Legislacion_Normativa/UCI/01_org_gral_act_20170501.pdf
- http://www.rfen.es/publicacion/userfiles/Reglamento%20tecnico%20Natacion%202013-2017%20-%20ESPANOL-INGLES-%20Enero%202015(2).pdf.