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**‘Capital Intensive Sports: preliminary research on the sources of  
innovation in Scuba Diving and Golf’**

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## **Abstract**

This paper will analyse two Capital Intensive Sports: scuba diving and golf. The paper proposes an exploratory analytical framework for the analysis of Capital Intensive Sports. It also examines the characteristics of scuba diving and golf, broad patterns in their patenting activity and aspects of their related infrastructure. Evidence from literature on leisure sports points to significant informal participation of users in early innovation, particularly among new sports. Based on this evidence, the study identifies hypotheses for the study of the innovation sources in both sports.

## Introduction

The objective of this paper is to report results of preliminary research on two Capital Intensive Sports: scuba diving and golf. The paper identifies hypotheses for the analysis of their sources of innovation. The hypotheses build on evidence from the literature on user innovation, which shows that a high degree of user-centric innovation is present in the early stages of leisure sports such as skateboard and windsurf. This might be the case of scuba diving.

Our literature searches on the specialist journal 'Journal of Sports Economics' indicated that many studies analyzing sports use analytical frameworks based on orthodox economics in the subfield of *sporteometrics*. Such studies usually employ a simple production function combining financial resources (i.e. capital) and human resources (Sloane, 2005). We build upon this approach, to consider that the requirements for capital resources may vary in any one given sport.

This paper defines Capital Intensive Sports from a two-fold perspective. Capital requirements in sports have to do with: 1) the consumer side, for the purchase of sports equipment; and 2) the firm side, for expenditures in Research and Technological Development. From the perspective of the consumer (sportswomen and men), when the requirement for equipment purchase is above the spending capacity of the average consumer, a sport can be defined as Capital Intensive. For instance, Tcha and Persin (2003:220) exemplify that yachting<sup>1</sup> is a Capital Intensive Sport, for its financial requirements are quite substantial. The authors suggest that sports such as marathon running or boxing are not capital intensive, because their financial requirements are comparatively modest. From the perspective of the firm, when the capital requirements for the Research and Technological Development as a proportion of the firm revenue are substantial, and, say, on par with at least a 'medium-tech' sector, a sport can also be defined as Capital Intensive.

## Background

As the process of innovation has developed towards a more open and participative model users (e.g. customers) increasingly participate as active contributors to innovation processes (von Hippel 2005; Chesbrough 2006b; Flowers 2007).

It is possible to identify different levels of users in this context. These could be: individual users, communities of individual users, firm users and communities of firm users. Both concepts of user innovation and user-centric innovation are closely related to the concept of open innovation (von Hippel 1988; Flowers 2007; Chesbrough 2006a) in that innovative ideas come from inside as well as from outside firms, and can be commercialized beyond the traditional market of these firms. Therefore, open innovation seems to be particularly relevant to Capital Intensive Sports, as ideas for equipment improvement might flow freely among communities. This can be a value-creation strategy that is an alternative to vertical integration (Sinard and West 2006).

Although the literature on user-led innovation is now extensive, there is little which focuses specially on leisure sports. Research on mountain bikes (Luthje, Herstatt et al. 2002) indicates

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<sup>1</sup> For example, the cost of the Brazilian sailing boat 'Brasil1' for the Volvo Ocean Race was estimated in US\$ 20 million (<http://esporte.uol.com.br/vela/ultimas/2007/05/14/ult820u1228.jhtm> last accessed 27 June, 2007).

that some users operate in what the authors called a “low-cost innovation zone” to develop their innovation activities. Research on kayak rodeo identified that users have adopted shorter boats with sharper edges in order to obtain better performance (Hienerth 2006). Studies on newer sports such as skateboarding, windsurfing and snowboarding (Shah 2006) and also on more mature sports such as basketball (Füller, Jawecki et al. 2007) all show that social activity in innovation communities influence both firm level behavior and market formation.

In these circumstances users have at least two alternatives. First, they may request solutions from manufactures. Companies would then improve their products, possibly based on their internal R&D, before launching them on the market. Or second, consumers may choose to build their own prototype solution, and in some instances, start there own companies based upon their innovations.

While the studies referred to above make important contributions to the user-led innovation literature, none have analysed important elements such as the development of skills and services in relation to changes in market and innovation. Furthermore, sports such as scuba diving and golf, which in principle are capital-intensive, have yet to be analysed. It was with this in mind that these two sports were selected for study.

### **Research Method and Analytical Framework**

The methodology encompassed data collection from the following four sources: 1) primary data on patents from the United States Patent and Trade Office, 2) secondary data from the following web sites; Divers Alert Network, British Sub-Aqua Club and PADI (Professional Association of Diving Instructors), 3) review of specialized magazines such as Dive (to have an overview of this sport) and 4) review of government reports from the following bodies Sport England (Participation Survey) and HEFCE (Higher Education Funding Council for England, Research Assessment Exercise).

The empirical part of the study will compare scuba diving with golf. This is because the latter can be considered a mature sport and scuba diving can be considered a relatively newer sport, at least in comparison to golf.

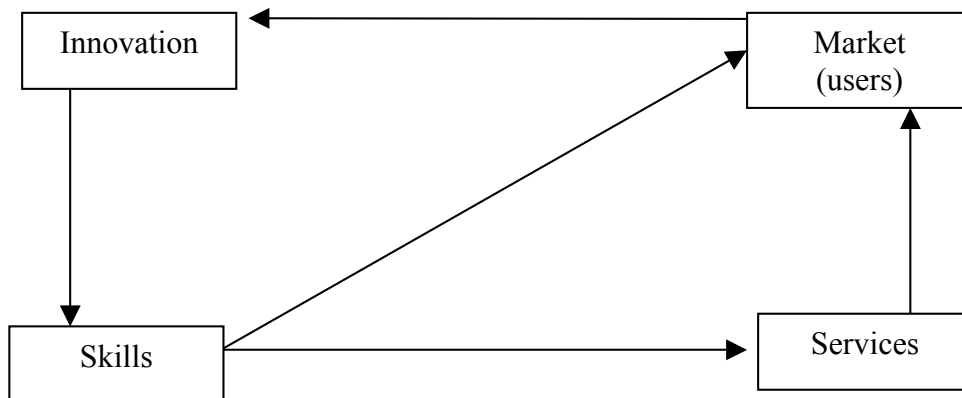
Figure 1 introduces an analytical framework which hypothesizes the relationship between innovation, market, skills and services in Capital Intensive Sports. According to the theory in innovation studies, the **market** (i.e. the demand side represented by the changes in the amount of users) influences the process of innovation by signalling firms with user requirements (Pavitt 2004). In addition, **innovation** may be influenced by other factors such as the need of non-consumer users to improve the operational performance of the equipment (Shah 2006) or the ability of firms to target niches and alter consumer preference (Pavitt 2004) for instance by creating products to elderly or handicapped users.

Part of these innovative efforts may ultimately be patented by the companies or by their inventors. But this outcome is not guaranteed, patenting may not occur in an open innovation environment in which pecuniary incentives are not always central (von Hippel 2007).

The focus of this paper is on the innovations that actually decrease the **skills** levels that are needed to practice sports.<sup>2</sup> For instance, in golf Titleist created solid core balls (Pro V1) that permit recreational players to reach longer driving distances. In similar fashion, Nakashima have created drivers that improve the stroke distance of recreational golf players.<sup>3</sup> In scuba diving, Suunto developed tri-dimensional under-water computational-based navigation systems. Suunto claims that the development of such devices was accompanied by a reduction in diving accidents.<sup>4</sup> The reason for this focus is that such innovations enable a larger number of users to practice the sport, increasing the **market** scale.<sup>5</sup> **Skills** may also be changed by means of individual training.

Changes in skills may influence the **market** in relation to the development of the **services'** infra-structure related to the sports. This includes, for instance, the related publicly available research and education and other forms of media. Other aspects are the facilities related to tourism infra-structure (e.g. golf courses, dive boats, etc), networks of equipment maintenance work-shops and selling-points for sports equipment. Finally, the change in the **market** scale reinforces the incentives for **innovations**.

Figure 1 - Basic analytical framework



## Empirical Evidence

Tables 1 and 2 show some socio-economic dimensions of both sports, in addition to their characteristics as well as regulatory and historical issues. Table 1 shows that there is a larger preference for golf in the UK, ranked in the 7<sup>th</sup> position in practitioners preference, when compared to scuba diving in the 53<sup>rd</sup> position. This is not surprising; the UK has a substantial infrastructure of golf courses and clubs within easy travelling distance, creating incentives for the practice of golf. Scuba diving contrasts with golf, in as much as it requires substantial training and trustworthy equipment and travel to dive sites can be costly.

<sup>2</sup> Part of the innovations may actually increase the **skills** that are needed to practice the sports. For instance, radically shorter surfboards introduced in the 1970s made it more difficult for surfers to ride waves.

<sup>3</sup> Sources: USA Today, various editions; Technology and Tradition – Preserving the Balance <http://www.titleist.com/technology/indefense.asp#> (last accessed 10.10.2007) and <http://www.nakashimagolf.com/technology.php> (last accessed 19.06.2007).

<sup>4</sup> Source: <http://www.suunto.com> (last accessed 10.10.2007).

<sup>5</sup> At the very least, such innovations may keep the amount of practitioners stable.

Table 1 Preference among English practitioners: Golf<sup>1</sup> and Scuba, 2006 (%)

Sports	Rank <sup>2</sup>	% among adults	Number of adults <sup>3</sup>
Golf	7 <sup>th</sup>	3.6	1.46
Scuba	53 <sup>rd</sup>	0.1	0.05

Notes: 1 Golf includes pitch and putt and putting.  
 2 Among 230 sports.  
 3 Per million.

Although both sports are in the collective category (table 2), the risk involved in scuba diving is much higher when compared to golf. Golf emerged in the 15<sup>th</sup> century (English Golf Union) and is a more mature sport. Modern scuba diving only appeared in the first half of the 20<sup>th</sup> century (with the creation of the British Sub-Aqua Club).

Table 2 Features of Scuba Diving and Golf

Variables	Socio-economic dimensions		Features of sport			Historical aspects <sup>2</sup>	
Sports	UK <sup>1</sup> Preference	Social Issues	Risk	Location	Olympic	Period of Emergence	National Board Creation
Golf	7 <sup>th</sup>	Collective	Low	Mostly Outdoor	No	15 <sup>th</sup> Century*	English Golf Union 1924
Scuba Diving	53 <sup>rd</sup>	Collective	High	Mostly Outdoor	No	20 <sup>th</sup> Century (1 <sup>st</sup> half)	British Sub- Aqua Club 1953

Notes: 1. Active People Survey Headline Results, Sport England.  
 2. Dimensions suggested by Steve Flowers, based on Flowers (2007).

Legend \* = First recorded match.

As shown in table 3, the degree of patenting is much higher in golf. This might be related to the maturity of this sport. It may also be related to the origin of scuba diving, which was closely related to military activities and, therefore, belonged to an environment that relied intensively on secrecy and, arguably, less relevant levels of patenting. Golf patents started from a far larger base and doubled in every decade. Scuba diving patents only doubled from 1986 to 1995, maintaining almost the same level of growth in the following decade.

We identify three hypotheses on the role of users in innovation based on these results. First, scuba diving innovation may be organized in a less formal fashion. And this might result in a more open and user intensive participation. Second, an alternative hypothesis in line with its military origins is that its R&D is actually formalised, but the results from such activities are kept secret and not patented, and the role of users in innovation is not central. Third, golf is considered in this study a relatively more mature sport; therefore, its R&D activities are expected to be more formal. This may be reflected in the level of patenting and the role of users may be more secondary, arguably related to testing and feed-back on innovations.

Table 3 Key words in patent's abstract: number and growth rate/decade, 1976 to 2005

Key word	1976 to 1985	1986 to 1995	1996 to 2005
Golf	1,117 (100)	2,943 (263.47)	6,058 (542.35)
Scuba	47 (100)	103 (219.14)	111 (236.17)

Note: growth rates in brackets, 1976 to 1985 base = 100.  
Sources: USPTO.

Source: Active People Survey Headline Results, Sport England.

Our final set of evidence aims at testing the relationship between innovation in emerging Capital Intensive Sports and increases in the related services infrastructure. Tables 4 and 5 show trends in the popularization of scuba diving and related structuring of service infrastructure. The evolution of incidents and memberships in the UK from 1965 to 2006 is based on data from the British Sub-aqua Club. It becomes evident that with the popularization of scuba diving, there is an increase in the number of incidents.

Table 4 Scuba Diving Certifications / BSAC: Evolution in amount of members, 1965 to 2006

Year	1965	1975	1980	1990	1995	2000	2006
Members (a)	6,813	23,204	24,900	36,434	52,364	41,692	35,422
Incidents (a)	N/a	N/a	N/a	100*	351	439	437
Incidents** (a/b)	N/a	N/a	N/a	2.7	6.7	10.52	12.33

Note: \* Data for 1992, nearest year with data available.

\*\* Per 1000 members

Source: Adapted from (Cumming 2005)

Table 5 presents data about insurances provided by the US based Divers Alert Network (DAN – which provides services such as health insurance, emergency treatment and research related to scuba diving) related to scuba diving. This indicates the continuous and substantial increase in members affiliated to DAN. The growth in affiliation underpinned the increase in revenue from over US\$ 2 million in 1992 to over US\$ 9 million in 2004.

Table 5 DAN: membership data, 1987, 1995 and 2002

Data	1987	1995	2002
Members - US	14,000	113,000	143,783
Members - International	N/A	N/A	65,510
Instructors	N/A	N/A	18,955

Legend: N/A = Not available.

Source: Adapted from Annual Report, 2001 and 2002.

Our research also identified, that along with increases in patenting activities, and in the number of participants, other types of services related to golf and scuba diving became substantial. For instance, in the UK written media we identified 13 specialist golf magazines and four specialist scuba diving magazines. We also identified a substantial higher education infrastructure related to golf. The 2001 Research Assessment Exercise (RAE) reported 33 centres performing research in sports in the UK. The topics covered by these centres included both the hard-sciences (e.g. in medicine and materials) and social sciences related to sports. According to the English Golf Union, in the UK there are six universities that offer courses specifically designed for golf and nine universities offering leisure or sports studies.

### **Concluding remarks**

A relationship between patenting, market and, to a certain extent, services has been showed in this study. Patenting levels are relatively lower in scuba diving, but its presence in the market is increasingly higher as the number of certifications and insured practitioners demonstrates. Golf, in contrast, is a mature sport which innovation processes appears to be centred on companies and more traditional internalized R&D, confirmed by its high levels of patenting. An increase in services related to scuba diving demonstrates a strict relation between market and service sector in this industry, mainly due to its high risk reflected in insurance and certification levels.

We also identified three hypotheses on the role of users that can be derived from the patenting profile of firms trading in these sports. Further research is needed to test them, and also their relation to the 'skills' dimension, which is expected to change as it is related to the other elements. A change in skills might determine a new demand in the service and/or in the market segments.



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