1 Introduction

1.1 Purpose of the study

In the last ten years the academic interest on natural and artificial networks has enormously increased. The first article that ignited this explosion appeared on the 4th of June 1998 in *Nature* and its title is *Collective dynamics of ‘small-world’ networks* (Watts and Strogatz, 1998). In this paper, Watts and Strogatz show that many different networks, both natural (e.g. the neural network of the worm Caenorhabditis elegans) and artificial (e.g. the power grid of the western United States and the collaboration graph of film actors), display two characteristics: the nodes of the networks are highly clustered (if node A is connected to node B and node A is connected to node C, then it is very likely that also B and C are connected) and the average shortest path between two nodes is very low (going from node A to node B passing by other nodes takes just a few steps). The authors propose a very simple model in order to formalize a continuum between a regular network and a random network, they define the small-world area as that area of the network that displays those two characteristics and they identify it in the networks mentioned above.

The literature about network structures was already quite developed, especially in social science (Burt, 1992; Milgram, 1967; Wasserman and Faust, 1995; for a useful overview the reader can visit the International Network of Social Network Analysis (INSNA) web page: http://www.insna.org). But the great merit of Watts and Strogatz’s paper was that, besides attracting many other scholars from different fields of the academic world (Amaral et al. 2000; Barabasi and Albert, 1999; Newman, 2002; Pastor-Satorras and Vespignani, 2002; Young, 2002), it also created the basis for a huge interest from a general public (Barabasi, 2002; Watts, 2004). In our opinion, this new big wave of interest on networks had two main causes. First, network structures explain complex phenomena with very simple models and test them with interesting data sets.
Second, but equally important, it allows researchers to formalize very large networks. While the previous existing literature focused on the interesting dynamics of social networks that formalized small groups of friends and/or small organizations, this new network fashion of the academic world makes use of large networks with several thousands of nodes. Consequently, the number of phenomena to which these new network models can be applied dramatically increases. In less than ten years the number of publications about network structures literally exploded. These works flourished in the field of statistical physics (e.g. Amaral et al. 2000; Barrat et al. 2004) but almost immediately they invaded other fields such as computer science (e.g. Albert et al. 2000), biology (e.g. Dodds and Watts, 2005), epidemiology (e.g. Newman, 2002) and again social science (e.g. Deffuant et al. 2005).

In economics there is no large stream of research on this topic though some interesting and authoritative publications appeared also in the field of economics using these new network models (Gaber et al. 2004; Janssen and Jager, 2001; Young, 2002). The main goal of this thesis is: to adapt network models to a marketing framework that includes consumers’ preferences and social influences among consumers and to apply these models to study their effects on innovation diffusion and market dynamics.

First, we study how the penetration and the speed of the diffusion of a new product that enters different markets are affected by different global network structures (scale-free network and small world network) and by local network specifications (cost constraints for number of links, weighted links, directed links and small versus large personal networks). Second, we focus on the effects of local network characteristics: simulating different levels of consumers’ heterogeneity concerning the individual susceptibility to the others’ behaviours and different specifications of the influence that the hubs of the network have on other consumers, we test the variations on the speed, the degree and the uncertainty of the market penetration. Finally, we direct our study towards marketing strategies (i.e. different targeting and different timing of promotional campaigns) and we show how some of these strategies result in an enhancement of the final penetrations for different categories of new products.
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1.2 Innovation diffusion

In Western societies the concepts of development and innovation are closely related and the recent acceleration of technological change of the modern societies has further strengthened this link. It is possible to define development as consisting of a change and the diffusion of this change (Adner and Levinthal, 2001; Utterback and Abernathy, 1975). The field of marketing has mainly focused on the latter and it has acquired a substantial body of knowledge about it. Here, the diffusion process has often been associated with the diffusion of new products, it has been addressed as innovation diffusion and it has been widely studied using field data (for a review, see Arts et al. 2006; Mahajan et al. 2000; Ruiz, 2005; Meade and Islam, 2006).

The roots of this stream of research reside in the works of Bass (1969) and Rogers (1995). The Bass model formalizes the innovation diffusion process by means of a simple differential equation (3.1). The parameters of this model refer to two different kinds of adoption: adoption caused by external influence (e.g. advertising) and adoption caused by internal influence (e.g. word-of-mouth (WOM) and imitation). After the work of Bass, many new product diffusion models have appeared in the marketing field trying to include the effects of other relevant variables that affect the innovation diffusion process. Ruiz (2005) presents a complete review of the new product diffusion models that followed the original work of Bass. For example, many studies have advanced the sophistication of this kind of models including multi-stage diffusion models that allow considering heterogeneous populations (Jain et al. 1991; Hahn et al. 1994), dynamic potential market (Bass et al. 1994; Jain and Rao, 1990), dynamic internal and external influences (Jain et al. 1995; Lilien et al. 1981; Parker, 1993; Hahn et al. 1994; Parker and Gatignon, 1994), repeated purchases (Lilien et al. 1981), competition (Krishnan et al. 2000; Parker and Gatignon, 1994), and so forth.

These models formalize the diffusion at the aggregate level, which basically means that the sales of a new product are described, explained and forecasted according to macro variables (such as advertising, WOM, price, competition) that describe the market as a single entity. However, they exclude the micro level variables that affect the individual adoption of the consumers. In the marketing literature the studies about micro-level drivers of adoption have formed an independent and separated line of research. This research focused on how consumers’ attitudes and behaviour are affected
by product characteristics such as relative advantage, compatibility, complexity, trailability and observability (for a review see Arts et al. 2006).

Besides the particular results described in the chapters that deal with innovation diffusion (chapters 2, 3 and 4), our main contribution to the literature of innovation diffusion is building a bridge between these two streams of research.

1.3 The cinema market

The idea that the global and local structures of the consumers’ relations affect the way consumers behave and consequently the aggregate dynamics of the market is based on the fact that the human decision making highly depends on what other people do (Granovetter, 1978; Veblen, 1899). In marketing and micro economics this idea has a long tradition (Granovetter and Soong, 1986; Katz and Lazarsfeld, 1955) and it has been referred to as social influence (Batra et al. 2001; Bearden et al. 1989; Jager, 2000; Mangleburg et al. 2004; Terry and Hogg, 1996). The effects of social influence usually cause a convergence of the decisions of the consumers (Banerjee, 1992; Bikhehandani et al. 1998; Rosen, 2000). Take the cinema market, for example. Here, the decision making of the movie goers is highly interdependent and often this market is considered as a typical example of a winner-take-all market (De Vany, 2004). In this kind of markets a few successful products usually obtain high market shares and the rest of the products have to make up with very low shares (Frank and Cook, 1995). Social influences can determine the convergence of consumers. Salganik et al. (2006) showed that the inequalities of the market outcomes are significantly higher in the social influence condition compared to the independent condition.

Chapter 5 deals explicitly with the issue of social influence. It focuses on the cinema market, it proposes an agent based model that formalizes the decision making of the movie goers and it explains why the box offices of the movies are very unequally distributed and why the typical life cycles of the most successful movies almost always display the same fast decay.

The motion picture industry has recently attracted the attention of many scholars in the field of marketing (for a complete review see Eliashberg et al. 2006).
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Basically this is due to the high visibility that such a market has on a large audience and because the data about the characteristics of this market are very easy to obtain. The revenues that movies gain at the box office are published every week and are available from different sources (see for example http://www.variety.com, http://www.the-numbers.com, http://www.imdb.com). Also the production and the marketing budgets that the large studio producers or the independent producers spend in order to produce, advertise and distribute the movies are often public, especially for the most visited movies. Finally, this industry displays some specific characteristics that call for explanation. One of these resembles a paradox: a large majority of the movies produced result in a loss. Why do movie makers keep on producing movies if they know that it is quite likely that their movies will encounter a loss? Such incongruence reflects the well known uncertainty that governs this market. At the moment of the opening weekend, when a new movie enters the cinema theatres, it is very difficult to predict how many visitors the movie will have attracted to the cinema theatres at the end of its life cycle (De Vany, 2004; De Vany and Walls, 1999). This characteristic of the market is partially explained when considering the high inequalities observed at the box office. The cinema market is a typical example of a winner-take-all market where a few movies become big hits and obtain a great part of the market shares while the remaining movies have to be content with small market shares (Elberse and Oberholzer-Gee, 2006; Frank and Cook, 1995). If we sum up all the profits of the cinema market we will certainly obtain a large positive number. This is due to the facts that the biggest hits of the market are just a few movies which generate large profits, whereas a majority of movies generate financial losses.

Our decision of focusing on the motion picture industry was certainly facilitated by all the reasons mentioned above, but the main reason is that the cinema represents a market where social influences are dominant, and we believe that a significant part of the described odd characteristics are caused by them. In chapters 5 we present a simulation model that is based on the demand of the market and that is aimed at explaining how the social influences, that affect the decision making of the movie goers, cause the large differences in the market shares that we observe in this industry.
1.4 The methodology: computational models and simulations

In economics, the idea that market outcomes can be explained as a result of many individual decisions is widely accepted. However, the micro studies on the individual behaviour of economic agents and the macro studies on aggregate market variables resulting from the individual behaviour have almost always been separated. In the marketing field, for example, the works on the effects of marketing efforts on aggregate variables like sales and the works on consumer behaviour are quite distant to each other and are often considered as two separated fields. Traditionally in economics the micro and macro levels have maintained a certain distance because often, almost always, the summation or the extrapolation of the aggregate from the individual behaviours is not trivial. In order to make a connection between micro and macro it is necessary to understand the influences that people exert on each other, and this is usually not easy. (Coleman, 1987; Schelling, 1978; Young, 2001). To have an idea of how unexpected the aggregate outcomes may be we may mention several examples. It can happen that different individuals become completely segregated in similar groups although their preferences are not particularly in favour of similar individuals (Schelling, 1978). It can happen that every week the large majority of movie goers direct their visits to two or three movies even if their individual preferences are widely spread to the dozens of movies that enter the cinema theatres (De Vany, 2004).

In economics, computational models may furnish a great help in studying and explaining the connections between the micro and the macro levels. Computational models are models expressed as algorithms and implemented as software. They simulate a set of processes observed in the world in order to understand better these processes. They aim at studying, explaining and predicting the outcomes of these processes given a specific set of input parameters. The accelerating growth rate of computational power of the last decades has permitted the flourishing of different kind of computational models (Simon, 2001). In particular, in the last 20 years the agent based computational economics has become a widely recognized methodology that contributes to the classical topics investigated in different fields of economics. Agent based models are computational models consisting of independent interacting agents (Shoham, 1993). In economics, they simulate economic entities such as consumers, producers, families,
firms, institutions, etc. For a complete and detailed overview of how this methodology has been applied in economics, the reader is refereed to Tesfatsion and Judd (2006).

Considering the recent tremendous growth of the use of computational models, it is very likely that in the future their use will still grow considerably. We maintain the idea that academic research in economics may find a new enhancement if it makes a profitable use of the opportunities that computational models offer (Flache and Macy, 2005; Hegselmann and Flache, 1998; Garcia, 2005; Gilbert and Troitzsch, 1999; Goldenberg et al. 2004; Lusch and Tay, 2004; Tesfatsion and Judd, 2006). In particular, we believe that the use of computational models may contribute in filling the gap between micro and macro levels. The work presented in this thesis is thoroughly grounded on the methodology of agent based models. In fact each chapter addresses a different marketing question and it proposes a different agent based model to answer it. However, this work of this thesis embarks also on an attempt to integrate these agent based models with empirical support. In chapter 5 we test the simulation outcomes of the agent based model against empirical data at the macro level of the market.

Figure 1.1 illustrates a methodological process in order to guarantee empirical support to computational models and it represents the relation between the agent based models proposed in the chapters of this thesis and the empirical phenomena they try to explain. It is a cycle that involves two levels of analysis: micro and macro. It suggests computational models like our agent based models, that aim at explaining economic phenomena, to conduct two empirical tests: one, called calibration, for the assumptions made at the micro level (agent decision making, relations among agents and relations between the agents and the environment) and an other one, called validation, for the simulation results obtained (market outcomes like penetration of a new product, market inequalities, etc.).
1.5 Contributions and outline of the dissertation

The work of this thesis contributes to the marketing literature enhancing theoretical and practical knowledge about how social processes affect the micro decision making of the consumers and what the resulting effects on the macro dynamics of the market are. It proposes models that are inspired by the consumat approach (Jager, 2000; Jager and Janssen, 2003). This approach revisits the needs that drive the consumer behaviour at the micro level and it suggests to use social simulation models (Gilbert and Troitzsch, 1999) in order to derive the resulting marketing outcomes at the macro levels. Examples of implementing the consumat approach for explaining different economic phenomena are Janssen and Jager (1999); Janssen and Jager (2001); Janssen and Jager (2002); Janssen and Jager (2003). As mentioned in section 1.2 and section 1.3, the proposed models of this thesis are directed towards two well known marketing topics. The first one is a traditional transversal topic that involves many industries: innovation diffusion; the second one is a particular industry that recently has become the object of analysis in the field of marketing studies: the motion picture industry.
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About the former, chapter 2 and chapter 3 show how market dynamics can vary for different network structures that represent the relations of the consumers. Here we show which network structures help the diffusion of a new product and which ones do not; we show how social influence dampens the diffusion at the beginning of the life cycle and enhances it at the end of the life cycle. In chapter 4 we show how optimal targeting and timing strategies of promotions result in higher market penetrations for different product categories. About the latter, chapter 5 presents a model that simulates the USA motion picture market. It generates movie life cycles that are highly similar to the real ones and it shows how social influences create market inequalities at the box office. Finally, in chapter 6 we summarize the main conclusions of this work and we discuss further venues of research.