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HOUSEHOLDS AND THEIR EXPENDITURES AS AN EVOLVING COMPLEX SOCIAL SYSTEM

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Contents

List of Acronyms

BSE: Bovine Spongiform Encephalopathy

CCDF: Complementary Cumulative Distribution Function

CDF: Cumulative Distribution Function

CLCA: Complete Linkage Clustering Algorithm

COICOP: Classification of Individual COnsumption by Purpose

COLDIRETTI: Confederazione Nazionale Coltivatori Diretti (*tr. En.* National Confederation of Farmers)

ER: Erdős-Rényi

ERFC: Complementary Error Function

EUROSTAT: Statistical Office of the European Communities

FAFH: Food Away From Home

FDR: False Discovery Rate

FWER: Family-Wise Error Rate

GPS: Global Positioning System

GST: General Systems Theory

HIV: Human Immunodeficiency Virus Infection

IETI: Influenced by Economic and Technological Innovation

ISTAT: Istituto Nazionale di Statistica (*tr. En.* Italian National Institute of Statistics)

KS: Kolmogorov-Smirnov

MCC: Matthews correlation coefficient

NEET: Neither in Employment nor in Education or Training

PDF: Probability Density Function

SMI: Standardised Mutual Information

SVN: Statistically Validated Network

WHO: World Health Organization

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Introduction

The aim of the present thesis is to adopt the Complex Systems theory (Simon 1996; Sawyer 2005; Johnson 2009) as a new theoretical framework for the analysis of consumption. Indeed, until now, sociological scholars never treated individuals and their consumptions in terms of a Complex System, although such a theoretical approach has been already adopted in other scientific domains (as economics, biology, physics, finance etc.), giving relevant insights.

A complex system is defined as a system composed of multiple elements that interact among them at lower level of the system, generating emergent phenomena at higher level, that modify its overall behaviour. Typically, systems' elements are very heterogeneous (e.g. social agents, molecules, companies etc.) and their connections are non-linear, making hard to predict the evolution of the system and the emergent phenomena that can rise. It implies that the classical reductionist approach reveals not appropriate for studying the system's properties and its patterns of evolution. On the contrary, scholars interested in the analysis of complex systems have to adopt a holistic approach that consider the system as a unit, whose overall behaviour cannot be explained through the analysis of its single elements.

The complex social system considered in the present work consists of Italian households and their consumptions (intended as the expenditures for specific goods and services), in a time-window from 2001 to 2013. We may argue that the different purchasing patterns of families are the result of multiple dimensions that interact among them, such as the tastes, needs and interests of members, the household structure, the negotiation processes within the family, some external events that have an impact on expenditure decisions and so on. To apply the theoretical framework of complex systems for analysing households' consumptions allows us to take into account these multiple dimensions, by means of a set of new working concepts and innovative methods (Castellani and Hafferty 2009), specifically conceived for dealing with the specificities of complex systems.

The present work is divided in four main chapters:

- Chapter 1. In the first part, we introduce an overall description of complex systems (with a focus on complex social systems) highlighting their main features and their properties that give rise to different patterns of evolution. In particular, some specific characteristics that allows one to consider a system as "complex" are presented, such as 1) the self-organization rules of system's elements; 2) the mutual influence among systems, and between the system and the environment; 3) the elements' capability of adaptation to system's changes; 4) the mechanisms of feedback; 5) the community structure, that allows one to observe (and to aggregate) groups of elements similar within them and different among them; 6) the homophily and selection processes in elements' interactions; 7) the cascade of information, herd behaviour and so on. These characterizing features are presented together with specific examples in real systems. In the second part of the chapter, we introduce the network analysis as an appropriate method for dealing with the complexity of the systems by adopting a holistic approach. In this regard, complex system is modelled in the shape of a complex network, in which nodes represent system's elements and links that connect nodes indicate the interaction among the elements. The leading measures for detecting relevant insights from the system modelled in the shape of a graph are presented, together with the main network models conceived for representing some properties that can be observed in real systems (Watts and Strogatz 1998; Barabási and Albert 1999). Finally, we describe the method of Statistically Validated Networks, introduced by Tumminello et al. (2011) in order to filter meaningful information from a complex and heterogeneous network. Starting from a bipartite graph, consisting in two sets of qualitatively different nodes, the method allows to create a projected network composed of the elements of one set (Newman 2010), in which the

connections between nodes have been statistically validated under the null hypothesis of random connectivity. A generalization of the method will be applied in the third chapter for dealing with tripartite graphs.

- Chapter 2. The first part of the chapter focuses on the main sociological theories for the study of consumption. In this regard, we introduce a brief excursus on classical, modern and contemporary sociological approaches, in order to highlight the limits of such perspectives and their points of connection with the theory of complex systems. Moreover, we discuss the main approaches through which family consumptions have been analysed in scientific research over time, distinguishing among the influence of different family members and different stages in family life-cycle (Solomon et al. 2006) in purchasing patterns. In the second part, the characterizing features of households and their consumptions that allow us to consider them as a complex social system are introduced. In particular, we discuss 1) why we may observe properties of complex system in the evolution of family structure, and to what extent such evolution and the technological progress can have an impact on households' consumption; 2) the heterogeneity of system's elements, both qualitative and quantitative, that has to be taken into account in the empirical analysis of the system; 3) the dimensions outside the family system that may affect households' purchasing choices; 4) the different behaviour of families in terms of consumption, according to the macro-regions in which they live; and 5) the mechanisms that modify purchasing attitudes (such as herd behaviour, information cascade, adaptation).
- Chapter 3. In this chapter, an empirical study of Italian households and their expenditures is presented. We use secondary data collected by the Italian Institute of Statistics (ISTAT), from 2001 to 2013, on family purchasing choices of a wide range of heterogeneous goods and services. The aim of the study is to detect if and to what extent some dimensions may affect households' consumption patterns. In this regard, the sample has been stratified, in two phases, in order to take into account the family structure, the stage of family-life cycle in which the households are, and the generation of children. The concentration of expenditure of each family type, over time, is analysed through concentration indices (Gini 1912, Theil 1967) and the trend of the mean number of expenses in which households allocate part of their income. Thereafter, for each year of the survey, we construct a Statistically Validated Bipartite Network, generalising the method (Tumminello et al. 2011) to the case of a tripartite system, in which the nodes belong to three different sets: 1) family types (according to two classifications in line with the scientific purposes); 2) households; 3) expenditure categories expressed in quintiles after a pre-processing of raw data. The analysis reveals that family purchasing habits are manly influenced by the stage of family life-cycle in which the households are and by the family structure (in terms of presence or absence of offspring). Moreover, other dimensions within and outside the family system appear as prominent to interpret consumer choices, such as the number of working parents, the level of education of parents and the socio-economic changes occurred in the observed time-window.
- Chapter 4. This empirical work aims at detecting the impact of children belonging to Y- and Z-generation to the purchasing choices of families related to leisure time. According to the generationalist approach (Mannheim 1928; tr. En. 1952), we argue that the different lifestyles, attitudes, tastes, views of the world shared by people belonging to different generation (the children, in this case) can be reflected on consumption choices. For such a reason, we consider families with Y-generation children (sampled in 2001 and 2007), and families with Z-generation children (sampled in 2012), stratified according to the number of working parents and their highest level of education. The different years of survey allow us to compare adolescents aged between 13 and 17, but belonging to different generations. We then perform a hierarchical cluster analysis and a logistic regression on the shares of expenditure that considered households allocate for some purchases related to leisure time activities (such as sport, books, eat away from home,

concerts etc.). The analysis highlights some differences in leisure consumption of families with Y- and Z-generation offspring. Such differences may be explained through the mutual influence of children generation and the changes occurred within a time window wide enough (about a decade) to include social, political, economic and technological changes, that are internalized by family members and influence their consumption styles.

Finally, the present thesis ends with some overall conclusions that summarize the main findings of the empirical works, interpreted within the complex systems' theoretical framework. Therefore, this work aims at supporting the idea that the complex system approach represents a unifying theoretical framework that should be adopted by scholars of consumption, by considering the intrinsic complexity of social system as an opportunity of knowledge, rather than a limit.

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CHAPTER 1

Complex Social Systems

1. Complex Systems

The common definition of complex system describes it as a system composed by different elements that interact between them in the lower level of the system. Such interactions generate emergent phenomena in the higher level that modify the overall system behaviour. The connections between the elements of a complex system are typically non-linear, it implies that there is not a linear sequence of causes and effects in complex system's behaviour (Simon 1996). As a consequence, the emergent phenomena that rise in complex systems are difficult to predict, since they may reveal in multiple ways. For such reason, Page suggests to adopt the definition of "systems capable of complexity" (Page 2005, 25) instead of "complex systems", since they have the attitude to show their complexity in very different scenarios, generating multiple and difficult to predict outcomes. In light of this, let's introduce some outcomes or emergent phenomena (among all the possible scenarios that the evolution of complex systems can reveal) that rise within social and biological systems:

- *Traffic congestion* (Johnson 2009). In this case, the elements of the system are the drivers and the connections between them depend on the choice of the most convenient route to take by car. Such a decision can be conditioned by a wide range of feedbacks, e.g. the will to follow the shorter route or the radio news about an accident along the usual road. The traffic congestion can be considered as an emergent phenomenon rising from many drivers that decide to take the same route for a wide range of different reasons. It apparently has not a specific cause since it is the result of individual decisions that coincide.
- *Crowd phenomenon and its consequences* (Johnson 2009). Generally, crowd raises from the interactions between social agents that compete for limited resources (e.g. the most convenient route for avoiding traffic congestion, a usually expensive product on sale, or a single emergency exit in a burning building). The emergent behaviour of a crowd reveals fundamental for the different scenarios that a system can show: for example, the spread of panic throughout a crowd may have very dangerous consequences for people safety. In this sense, crowd formation and its dynamics have been investigated in relation to critical situations, in order to detect patterns of evolution of the system under stress conditions (Challenger and Clegg 2011; Bellomo et al. 2016; Johansson and Helbing 2018).
- *Global warming*. The issue of climate change can be attributed to the interplay of different natural changes, mostly caused by the human actions, such as gases generated from industrial processes, deforestation, pollution, intensive farming and so on. All these factors together lead to a dangerous rise of temperatures that may have strong consequences both natural and social.
- *Revolutions*. According to Simon (1996), some systems may exhibit a sort of quite stable behaviour "followed by a sudden shift to disequilibrium or to another, quite different equilibrium" (Simon 1996, 175). The outbreak of human revolutions rises from similar mechanisms. For example, social inequalities and poor living conditions may progressively increase lower classes' discontent, that may erupt in violent riots that suddenly alter the system's behaviour.

- *Spread of epidemics* (Barabási 2002). Before the eighties, the Human Immunodeficiency Virus Infection (HIV) was not known by scientific community. When the first cases were diagnosed, it was not yet clear how the disease was transmitted, and the lack of information facilitated the spread of contagion between the gay community and drug addicts. Sexual promiscuity and lack of sexual protections strongly increased the exposure to the infection and risk of getting HIV. These factors contributed to the emergence of the epidemic both with medical and social consequences (e.g. HIV infected have been stigmatized for a long time).
- *Tumour*. Considering the human body as a complex system allows one to assume that the behaviour and the interactions between the elements that compose it (e.g. cells, tissues, organs etc.) can generate emerging phenomena that may alter the human physical conditions and having consequences on human health. The growth of a tumour, for example, is an emergent phenomenon within human body that results from an excessive and uncontrolled growth of cancer cells that reproduce.

These examples describe emergent phenomena that may rise from the connections between the elements of several different systems, and that are very difficult to forecast in a long-run period. Moreover, the examples show how complex systems are part of everyday life: we are surrounded by them and we are part of them. Finally, the examples highlight that many heterogeneous systems reveal different possible outcomes deriving from their complex structure (social, biological, economic, physical etc.): that is the reason why the study of complexity interests so many disciplines and the interdisciplinary approach is the key feature to better understand the rise of complexity.
The main assumption behind the idea of complex systems, that has its roots in chaos theory[1] (Gleick 1987), is that although their behaviours may seem random, they actually are governed by laws that determine specific patterns of evolution. Indeed, the chaotic behaviour does not lead to a total absence of order, but it mainly refers to an *ordered disorder* (Miller and Page 2007): it means that behind the apparently random behaviour of the systems, some distinctive schemes of evolution may emerge and can be detected by the observer. Moreover, the complex system evolution exhibits a strong dependence on initial conditions. It means that also very small perturbations within the system's structure (e.g. between the interactions of its elements) can drastically alter the overall system's behaviour. In chaos theory, such assumption was demonstrated through the discovery of Edward Lorenz, known as "butterfly effect" (Lorenz 1963), according to which small changes in the parameter values of the initial settings can have strong effects on the weather conditions simulated by the scientist (such as the flapping of a butterfly's wings may have an impact on the formation of a tornado). Such phenomenon is resumed by the sociologists of late nineties, that interpret main social changes of modern age (e.g. globalization processes) as the result of aggregated social effects generating from local interactions between individuals. In this regard, the butterfly effect detected in the emergence of social phenomena is clearly highlighted by Urry's words:

> "Most people most of the time act iteratively in terms of local information, knowing almost nothing about the global connections or implications of what they are doing. However, these local actions do not remain simply local since they are captured, represented, marketed, circulated and generalized elsewhere. […] The consequences for the global level are non-linear, large-scale, unpredictable and

[1] Although many assumptions of complexity theory are inherited from chaos studies, there are some differences between chaotic and complex systems. First of all, chaos theory assumes that the system is deterministic, it means that by knowing the initial conditions, it is possible to infer the final state of the system (in the short-run). Moreover, in chaos theory few parameters are used to model the system's dynamics, that are generated by the iteration of simple rules. On the contrary, to model a complex system, a huge amount of variables has to be taken into account, and the dynamics of the system are the result of the interaction between multiple elements (Rickles et al. 2007).

partially ungovernable. Small causes at certain places produce massive consequences elsewhere."
(Urry 2000, 197)

It means that, on one hand, the emergent phenomena in society are driven by the interactions between the individuals and, on the other hand, it highlights that perturbations at local-level connections may have drastic and irreversible impacts on the global structure. Such a sensitivity to initial conditions, which leads to a ripple effect, is at the root of the sociological analysis of the transformations occurred in modern society, concerning (among all) the new global perception of risk and vulnerability–e.g. the consequences of the disaster of Chernobyl, the spread of AIDS and the terroristic attacks on September 11, 2001–(Beck 2006), the "glocalization" concept–which summarizes, in a single word, the interplay between local interactions and global effects–(Robertson 1995), or climate change perception and collective action (Lubell et al. 2007; Stoutenborough et al. 2015). All of these examples represent (and are analysed as) long-term observable consequences of human actions.

In the last decades, the main goal of complexity scientists has been to understand how emergent phenomena rise from the connected parts of the system. In this view, it is worth to note that not necessarily the elements are complex as the system they belong to, in fact, complexity typically arises from the interconnections between system's components that can be either very simple or complex. Let's think about the constructions made by the Lego (Johnson 2009) and consider which level of complexity they can reach. The starting point is a set of simple and small pieces of Lego, the final outputs can be buildings, castles, life-size characters and so on. At the same time, the traffic congestion is generated by elements that we can consider more complicated, such as traffic lights, and others that are definitely complex, such as the drivers of cars, trucks, coaches, and buses.

It is worth to note that the elements of a system can often be considered complicated according to the huge amount of internal mechanisms that compose them and allow them to operate properly, nevertheless, not necessarily they are complex. Just think that, in the case of car malfunctioning, it is possible to detect which internal component generates the problem, in order to isolate it and fix it, restoring the correct car functioning. Such a specification leads us to the difference between complicated and complex system. A complicated system can be composed by many parts that interact between them in order to accomplish a specific goal, such as the internal mechanisms that compose a car or a clock. Nevertheless, such components are not strictly dependent between them, or, rather, they are *functional dependent*. It means that by removing a car tyre, only the vehicle movement is compromised, while the other functions–as radio, air conditioner, motor etc.–are preserved. At the same time, by removing a malfunctioning car battery, the other parts are affected, since their functioning depends on it. Nevertheless, if the battery is replaced by a functioning one, all the related mechanisms correctly work again. On the contrary, the dependence between the elements of a complex system is deeper and the malfunctioning of one component may have catastrophic consequences all over the system. Let's consider the human body as a complex system: it is composed by a organs and tissues that "collaborate" to the correct functioning of the entire system. Although each component has its own task, it is the interdependency between the parts that generates all the physical activities, like breathing, digesting, walking, speaking, and so on. If one of the components that allow the correct functioning of the human body, for example the liver, "breaks down", we may assist in a cascading collapse of the other organs, eventually resulting in the individual's death. At this stage, to replace the liver with a working one does not fix the problem, since the other organs have been compromised. It is more than a functional dependence between the elements: indeed, the connections between them maintain the complex system alive, and the malfunctioning of one component modifies the overall state of the system that, despite the replacement of the broken element, may not return to its initial state, since the evolution of a complex

system is typically irreversible. One may argue that, thanks to the scientific and technological progress, the problem of an element of a complex system as the human body can be solved by adopting the same approach used to deal with a complicated system: selecting the broken part, fixing it and waiting that the entire system re-adopts the correct functioning. Nevertheless, in complex systems, the interconnections between the elements–and the emergent phenomena that they generate–make this process more difficult to be carried out through a reductionist approach. Indeed, a specific problem can be generated by multiple factors and by fixing the problem does not guarantee the imminent correct functioning of the entire body. In light of this, the main feature that differentiates complex systems from complicated ones is the impossibility to reduce the former in the elements that compose them. In fact, as Watts argues "What makes the problem hard, and what makes complex systems complex, is that the parts making up the whole don't sum up in any simple fashion. Rather they interact with each other, and in interacting, even quite simple components can generate bewildering behavior" (Watts 2003, 42). Such an assumption requires the adoption of new theoretical and methodological approaches for dealing with complexity and studying the different and hard-to-predict behaviours of complex systems: the new paradigm shared by complexity thinkers leaves the classic reductionist approach in favour of the holistic one, which implies an abrupt change of point of view for complexity scientists. Indeed, by adopting a holistic approach, the complex system is considered as a unit whose overall comportments cannot be explained through the separate analysis of the behaviour of its single elements. It is worth to note that many complex systems are naturally partitioned in sub-parts at different levels of aggregation, just like a country is divided in macro-regions, regions, cities, neighbourhoods and so on. In such intrinsic hierarchical structure, the laws that regulate the emergent phenomena at different levels of aggregation cannot be inferred from either upper or lower scales (in this sense, it is not possible to guess the behaviour of a specific region from the behaviour of the cities). This property of complex systems requires the researcher to focus on a specific aggregation level, not considering the micro- or macro-levels. In light of this, probably it is more appropriate to define the holism embraced by complexity scientists as a "meso-approach" (Trobia 2001), or to consider a "weak holism" approach, by adopting a weaker interpretation of the concept of emergence that rises from different structural levels (Simon 1996): "in this pragmatic way, we can build nearly independent theories for each successive level of complexity, but at the same time, build bridging theories that show how each higher level can be accounted for in terms of the elements and relations of the next level below" (Simon 1996, 172).

To better understand the difference between mechanistic thinking and system thinking–that can be considered, by analogy, the difference between reductionist approach versus weak holistic approach–let's present an example introduced by Dekker (2011), in order to explain how these two paradigms offer very different solutions to the same simple question: "How does a cell phone work?". A reductionist (mechanistic) thinker, analysing the single components of the telephone's hardware, will reply that the device functioning is due to its internal mechanisms that give the possibility to make phone calls, take pictures, browse the internet, listen to music and so on. Each functionality of the mobile phone corresponds to single components designed to make the device suitable for a specific activity. The reply of a system thinker will be radically different and it will concern the multiple emergent phenomena related to mobile phone production at many different levels. Starting from Coltan–a mineral used to improve the cell phone battery performances–, Dekker explains how the system thinker will analyse the social, economic and environmental implications of Coltan extraction in Congo: such as the exploitation of miners that manually extract the mineral, the civil war to control the territories of extractions, the killing of gorillas in order to sell their meat to miners and rebels etc. Such an example highlights how a complex system is part of a larger network of systems in which different emergent phenomena rise from the same components. In light of this, it is worth to note that although the interactions among components' system are local–miners that manually extract Coltan

have no idea about the consequences of their actions, as the mineral selling process, the fight for the control of territories, the gorilla extinction etc.–, they have an impact on other systems at different levels. As Dekker argues,

> "In a complex system, each component is ignorant of the behavior of the system as a whole. This is a very important point. If each component "knew" what effects its actions had on the entire rest of the system, then all of the system's complexity would have to be present in that component. It isn't. This is the whole point of complexity and systems theory. Single elements do not contain all the complexity of the system. If they did, then reductionism could work as an analytic strategy: we could explain the whole simply by looking at the part." (Dekker 2011, 140).

In light of this, the main goals of complexity scientists are to understand the nature of rising events, their implications for the system behaviour, their connections to other systems, and how such emergent phenomena lead to an evolution of the system that, as said, is very difficult to forecast in a long-time run. Indeed, complex systems' evolution leads to multiple possible scenarios: the examples presented in the first part of this session are just some of the possible behaviours that the systems may reveal. This is the reason why the study of emergent phenomena is a domain strongly investigated by complexity scientists, who adopt new analytical and computational models to predict the possible "scenarios" that the evolution of a complex system may determine.

2. Complex Social Systems

Studying society is, by definition, studying complexity. The concept of complexity already appeared in the sociological discourse at the beginning of the past century (Bain 1929), although with a different (maybe opposite) meaning with respect to the idea of complexity embedded in the contemporary complex systems' theory. In fact, what Bain (1929) pointed out was the difficulty of social scientists to apply rigorous scientific methods to deal with intangible social phenomena: such an idea, on one hand neglects the presence of laws that generate emergent phenomena and that can be inferred by adopting the correct approach; on the other hand, it considers the intrinsic complexity of social systems as a limit to knowledge, rather than an opportunity. Also the concept of emergence is not a new topic in the sociological discourse (Sawyer 2005): indeed, Comte, Marx, Durkheim and Weber, prominent figures that studied society, already adopted a systemic approach to analyse emergent phenomena in modern societies. Although such thinkers never directly spoke about complexity, they already reasoned in terms of *social complexity*, focusing on the consequences that industrialization had in Western societies: division of labour, middle-class growth, technological and medical developments, class struggles, civil rights, and welfare reform (Castellani and Hafferty 2009). Despite the fact that complexity theory may be considered as a new theoretical framework to analyse social processes, it is still a debated issue (Davis 2019). Nonetheless, it is evident that society is full of complexity and emergent phenomena that rise in many different forms, and may be generated from simple or more sophisticated interactions between the individuals (such as, for example, the connections between family members or between investors in financial markets, respectively).

A complex social system is a complex system whose behaviours and emergent proprieties are the result of the lower-level dynamics between the social agents that are part of the system. What is relevant in complex social systems and differentiates them from other kinds of systems (such as, for example, the physical and the biological ones) is that social agents act by *making sense* to their actions. It means that, in the individuals' interactions, a huge amount of different social dimensions come into play, for example peer's influence, past experience, needs, expectations, social pressure and so on. Such dimensions can occur simultaneously in the interactions between the individuals,

have an impact on their choices, modify their behaviours and the consequent overall behaviour of the social system. Moreover, during the interaction, the social actor is aware that the actions of its counterpart can be affected by desires, pressures and influences different from his and that, as a consequence, the result of the interaction depends on the actions and expectations of both the participants. In light of this, the interest of social scientists that study society within the theoretical framework of complexity is not merely on the aggregate outcome of people's interactions, but also on the specific sense of individuals' actions that generate the emergent phenomena.

Then, social complex systems are *agent-based systems*, since their building blocks are composed by individuals and their interactions. As we know, every single person is a complicated mixture of attitudes, desires, ambitions, expectations and so on. Nevertheless, in the aggregate form, so when we consider social agents as a *group*, such individual differences do not count in view of the collective behaviour that the social system may reveal: the emergent phenomena rise at the group level, not of individual units.

Although people are complex agents, even their very simple interactions can generate complexity. The difficulty to model collective behaviour has been clearly highlighted by Miller and Page (2007), who introduce the simple emergent social phenomenon of standing ovation as the result of an aggregate group behaviour that does not depend on the properties of single individuals. The authors demonstrate that it is not possible to create a mathematical model through which they can predict when many people simultaneously stand and the standing ovation rises. In fact, even if the model takes into account many different variables (such as the quality of performance, how such performance is received from the individual and the different thresholds beyond which the supporters decide to stand up and applaud), it does not consider other dimensions that are fundamental for the rise of the standing ovation phenomenon, such as the fact that people react in different way if they are surrounded by friends or strangers, or that the comportment of a group can generate cascades of behaviour, which result in the typical waves of standing ovation. The highlighted collective behaviour of standing ovation is the result of the individual responses to stimuli coming from personal experience (that is the emotional involvement) and external influences (such as the social contagion of surrounding people). Nevertheless, other forms of collective behaviour typically emerge in society in spontaneous way (such as mass panic): also in these cases, although the people's interactions seem quite simple, the emergent phenomena generated are very difficult to model and to forecast.

As well as the overall behaviour of every complex system cannot be merely explained through the sum of its parts, also the emergent phenomena in society cannot be inferred through the study of individual decisions, attitudes and behaviours. Nevertheless, it is worth to note that although complex social systems share the main properties of complexity, they also show some peculiarities that distinguish them from other types of complex systems. The General Systems Theory (GST), that has been introduced in the early fifties (Boulding 1956; von Bertalanffy 1968), already highlighted the need of a holistic and multidisciplinary approach and some key features of systems that will be later taken into account by complexity scientists in the contemporary age of the *complexity turn* (Urry 2005)[2]. Nevertheless, as Sawyer points out (2005), the GST was not adequate to study societies. Indeed, under the misleading GST's assumption that the complex systems are qualitatively identical, the models adopted to analyse systems were originally developed for investigating the emergent phenomena of natural systems, with the aim to generalize such formalisms in order to interpret very

[2] As Chaos theory, also the General System Theory contributed to highlight some systems' properties that will be the key points for the subsequent study of complex systems. Indeed, already in Boulding's manuscript (1956), it is possible to trace the main features that will be used to describe the complex systems behaviour (e.g. dynamicity, interaction between elements and environment, hierarchy of complexity within systems, and systems' properties as self-maintenance and self-reproduction).

different kind of systems, including social systems. Nevertheless, the GST's purpose to develop universal laws for studying of every system did not take into account some unique properties of human society that differentiate it from other kind of systems (Sawyer 2005):

- In many complex systems the boundaries that surround the system are physically observable, so that the observer is able to limit the space in which the interactions between the elements occur. In complex social system, such boundaries are difficult to distinguish. For example, let's suppose to study the connections between people that live in the same neighbourhood: which are the boundaries that divide our specific district from another one? They are not naturally set, but they are the result of artificial decisions. Moreover, people can have connections with individuals that do not live in their neighbourhood, we need to narrow the relationships in the studied space and such process is not so obvious. The difficulty to set physical boundaries within social systems leads society to be more open compared to the other complex systems. In light of this, the solution adopted by complex theory is to trace boundaries according to the features of a society that the researcher wants to investigate (Dekker 2011).
- Along with boundaries, also the connections between the elements of the complex social systems are difficult to be observed. We can observe two or more social agents that interact because they are friends, colleagues or relatives, but we do not know the content of their interaction, the nature of the communication and how the individuals receive and interpret the information. On the other hand, in some complex systems among those who belong to the physical and the biological world, it is possible to clearly view the connections between the elements, e.g. the interactions between neurons or between molecules.
- Finally, a peculiarity of social systems lies in the nature of the elements that compose them, that are the social agents. Human beings are complex systems themselves and their actions (and interactions) are driven by endogenous factors–attitudes, needs and tastes–, conditioned by the possible actions that other social agents can make, and dependent from the representation of the situations they have and from the information they process. As Miller and Page point out (2007), what differentiates social agents from physical ones is the *mindfulness*, that affects their behaviours: "Social agents often have mental models that they use to inform their behaviour. Moreover, unlike physical agents, there is a plasticity in social agents who can change how they behave if outcomes are not their liking" (Miller and Page 2007, 100).

The above specifications highlight how society differs from other complex systems in many aspects that, probably, make the study of complex social systems a new challenge for social scientists and, in general, for all the complexity thinkers. Such challenge mainly attracted the interest of researchers with the purpose of studying specific social systems, as the economic and financial ones, by adopting a complex systems approach. The complexity framework for the study of economic system, introduced by the Santa Fe Institute in the Eighties (Anderson et al. 1988), allows to adopt new ways and perspectives of thinking economic issues: the interest is on the strategies that economic agents (such as banks, firms, consumers etc.) implement in order to deal with the emergent phenomena they create through their interactions in economy (such as economic growth, inflation, price increase etc.). Such interest (and the possibility to study economy as a complex system) relies upon the fact that economy constantly evolves, since the social agents that compose it continuously change their actions in relation to the outcomes that themselves created and to the expectations that they have:

"one of the earliest insights of economics […] is that these aggregated patterns form from individual behaviour, and individual behaviour in turn responds to these aggregate patterns: there is a recursive

loop. Complexity is not a theory but a movement in the sciences that studies how the interacting elements in a system create overall patterns, and how these overall patterns in turn cause the interacting elements to change or adapt." (Arthur 2014, 3).

Arthur et al. (1997), pioneers of the introduction of complex-systems thinking in economy, point out some typical features of economic system that are difficult to model through classical mathematic models and require the adoption of complexity approach:

- Dispersed interaction: the economic agents are dispersed throughout the system (decentralized economy) and their actions and interactions are a consequence of changes in economic patterns.
- No global controller: there is not a global entity that controls the interactions, that are mediated by different roles and specific tasks of social agents.
- Cross-cutting hierarchical organization: the economy has different level of organization. The hierarchical structure implies that, although agents, products and strategies can be partitioned in different units, there are interactions across the levels.
- Continual adaptation: economic agents constantly adapt to the new outcomes of economic system generated by their interactions. It is a continuous learning process.
- Perpetual novelty: the evolution of the economic system leads to the continuous emergence of new phenomena within the market.
- Out-of-equilibrium dynamics: according to the feature mentioned above, it is evident that non-equilibrium is the natural state of the economy. Indeed, the economy is always in a state of flux, constantly evolving and changing.

These features reveal that economy is an adaptive non-linear complex system: such an assumption has deep implications for the new way in which the economic structure and agents' interactions are conceived, and for the way in which the economy issues and emergent phenomena are faced. Indeed, to adopt a complexity framework for economic thought opens to new frontiers of knowledge of market's dynamics. This point is clearly highlighted in the theoretical and empirical studies of last two decades that approach economy as a complex system in order to: 1) deal with different emergent phenomena that alter the economic structure (Archer 2009, Harper and Endres 2012); 2) understand the behaviour and management of specific areas of economy by adopting dynamic modelling (Costanza and Ruth 1998); 3) adopt quantitative measures to evaluate the evolution of economic system (Wood and Lenzen 2009); 4) study economic systems fluctuations and properties (Stanley et al. 1999); 5) adopt complex systems concepts and multidisciplinary approach of physics and economics in order to deal with a specific field of the economic system, the financial market (Mantegna and Stanley 1999).

Together with the economic system, the financial market is another sub-system among the social complex systems that has been strongly investigated by adopting a complexity framework (Kwapień and Drożdż 2012)[3]. As outlined above, the complexity of social systems relies upon the nature of the elements that compose them, that are *mindful agents*. In the case of financial market, such social agents are buyers and sellers endowed with intelligence that act according to personal expectations and information that have about the system (in extreme cases, they also adopt an irrational herd

[3] Mandelbrot is the first to leave the classical economic theories to study markets' behaviour (Mandelbrot 1997). He rejects the idea that financial market trends are essentially random and therefore unpredictable. According to chaos theory, Mandelbrot introduces the assumption that financial markets may reveal order and predictability and that, in some cases, events that are considered highly unlikely (i.e. whose probability of success is extremely low) are realized, having disastrous consequences on the entire system.

behaviour): “Each individual participant in the market arrives with certain beliefs and expectations–about the value of assets or products, and about the likelihood of events that may affect these values” (Easley and Kleinberg 2010, 691). Moreover, what makes the financial markets even more difficult to analyse is that investors are very heterogeneous in terms of assets, risk aversion, roles (e.g. they may be households, companies, banks etc.) and so on. The financial market attracted the interest of complexity scientists since it reveals the characterizing features of complex systems that will be deeply outlined in the next section: such as sensitiveness to environmental conditions (Lillo et al. 2014), non-stationarity and fluctuations (Gabaix et al. 2003; Munnix et al. 2012), risk of systemic failure–tipping points–(Scheffer et al. 2012), and so on. Finally, nowadays, the huge amount of available financial data (for example, type of transactions, type of investors, capitals etc.), deeply attracts the scientific community, which find in such big data an opportunity to describe and model the evolution of financial markets (Farmer et al. 2012).

2.1. Characterizing features of Complex Social Systems

In the previous sections, we briefly introduced some of the key concepts that characterize complex systems, such as emergence, interactions, openness, feedbacks and so on. In this section, we present more in detail the characterizing features of complex social systems.

The fact that element’s interactions may be non-linear and generate emergent phenomena that are difficult to predict does not mean that, within a complex system, there are not general laws that determine the behaviour of the components. Indeed, the elements interact between them under decentralized and specific rules of interaction, generating the *self-organization* of the system (Klüver 2000): it means that, through the rules that regulate elements’ interactions, complex systems can spontaneously exhibit a high degree of order. This property clearly emerges when endogenous or exogenous factors alter the behaviour of the system–such as in the event of a catastrophe or emergency–and multiple actors are involved to face the same problem, in order to achieve larger goals. The process of self-organization that regulates people’s actions for coping with a disaster is well described by Comfort (1994) through his detailed analysis of system’s reaction to Pittsburgh oil spill on January 2, 1988 (Comfort 1994). The study points out the conditions that facilitate or inhibit the self-organization of many different social agents (public, private and no-profit) interacting between them to face the threat of a natural disaster. Comfort’s analysis shows how the self-organizing rules between social agents’ interactions are oriented to preserve the system from inputs that can alter its internal order. Such inputs come from the interconnections between different systems or between the system and its environment. Indeed, complex systems–and complex social systems in particular–tend to be *open*, it means that they can interact with and be influenced by the *environment* that surrounds them, like the selling price of a specific good might be affected by a sudden increase in production costs. The impact that environment has on complex systems implies that it is not possible to fully understand the systems’ structure without considering the external inputs that can alter their behaviour, since they are mutually dependent. In this regard, Morin (2007) highlights the limits of the classical experimental science, that takes the object of the study off its natural environment, places it in an artificial environment and modifies its structure and its behaviour through different experiments in order to know its emergent patterns (Bocchi and Ceruti 2007). This procedure has been adopted to study the behaviour of chimpanzees in laboratory. According to the idea of a mutual influence between system and environment, it is quite clear that the behaviour of animals in an isolated condition cannot be representative of the normal comportments and relationships that they adopt within their natural environment. The interplay between the laws that regulate the system and the environment’s influence has been already faced by social sciences in the analysis of some emergent social phenomena, such as the globalization process. Robertson, for example, adopts the term

"glocalization" in order to describes the interwoven effects of local conditions on global pressures (Robertson 1995).

As outlined in the previous section, the openness of complex social systems implies a difficulty to clearly trace defined boundaries between system and environment. Nevertheless, the advantage to distinguish the system from the environment that surrounds it allows one to infer how the system responds to the external inputs–its adaptation behaviour–without knowing all its internal self-organizing rules. In light of this, Herbert Simon (1996) introduces a simple but clear example through which he demonstrates that, by adopting a functional explanation of the interactions and influences between system and environment, it may be possible to predict system's behaviour. Moreover, Simon's example reveals that everyone is able to do unintentionally such inferring process, also without knowing the clear difference between system and outer environment. Let's think about the elements that compose animal systems that live in polar regions. Many of them have a white fur, such as bears, foxes, wolves and so on. Even if we do not know the laws that govern the animal kingdom, and we do not have a scientific knowledge of animals that live in Artic, but just some basic assumptions, we can suppose that their white fur is a response to the environment that surround them: that is, a way that the animal system found to survive in extreme conditions.

Such consideration leads us to introduce an essential feature that characterizes complex systems, which is their capability of *adaptation*. In brief, the adaptation is the ability of the system to modify its internal rules (that is the self-organization process) in order to deal with the internal (inside the system) or the external (inside the environment) requirements. System's dynamics are then a response to interfering conditions: the greater the system's ability to adapt to the perturbations–if necessary by strongly changing its rules–, the greater the possibility of surviving to changes both inside it and in the environment in which it performs. Complex systems show different mechanisms of adaptation. Let's consider, for example, the case where people rise and give applause after a performance. Such behaviour may be due to both emotional involvement (an individual stands up for applauding since he appreciated the performance) and social contagion (e.g. the individual emulates the overall behaviour for avoiding negative social sanctions) (Davis 2019). In the latter case, the mechanism of adaptation is driven by the fitness[4] within the system, that is, the will to be in accordance with the behaviour of the other social agents. The fitness process can be also detected in the adaptation's strategies that the system adopts for dealing with the environment. Physical evolution is a clear example of how the living system adapts to the environment conditions in order to self-preserve: for example, the different skin pigmentations between Scandinavian and South Saharan populations depend on the different needs to protect human body from exposure to ultraviolet rays (in this case, fitness mechanism reveals how human system adapts to environmental conditions to survive). Moreover, also the processes of selection play a decisive role in the adaptation of complex systems. Selection mechanisms may be identified, for example, in the housing preferences of individuals, depending on specific socio-demographics or socio-economic characteristics of the neighbourhood. The social tendency to prefer a neighbourhood composed by people with similar attributes (e.g. income, ethnicity, social position etc.) leads to a homogeneous adaptation of the system (Miller and Page 2007), since the result of such selection process is the formation of different areas of segregation within the city[5]. Finally, we can look at the adaptive behaviour of the systems in terms of *feedbacks* or

[4] The concept of fitness, introduced in biology, has attracted the interest of social scientists in order to explain the mechanisms of adaptation in complex systems. For a detailed literature review on the interpretation and use of fitness mechanisms in social sciences, we suggest the work of Gerrits and Marks (2014).

[5] The residential segregation, as result of selection mechanisms, will be further explained in the next section by introducing the Schelling model of urban segregation (Schelling 1971).

memory. Indeed, complex systems have a history that influence their actual behaviour since the elements that compose them adapt their strategies and interactions according to what they learned from the past (temporal feedbacks or memory[6]) and to the information they receive in the present (spatial feedbacks). For example, let's consider the choice to take a specific route to come home after work. Our decision can be influenced by a previous negative experience, such as the last time that we took that route and we found traffic congestion, or by instantaneous information about the traffic condition of the route coming from different channels, such as a colleague or the radio news that inform us that it could be better to take another way. In light of this, "Feedback control shows how a system can work toward goals and adapt to a changing environment" (Simon 1996, 172). Therefore, feedbacks and history are key components of complexity, since they influence elements behaviours, generating the evolution of the systems and emergent phenomena. Let's consider an emergency situation in which people go out from a building in after an earthquake alarm, and let's suppose that some individuals, instead of staying calm, start to panic. The feedback introduced in the system might cause a spread of panic between people with consequences that may jeopardize individuals' security. That is a case of positive feedback: an input introduced within the system by few people who behave differently from others generates a cascade of the same behaviour that involves all the other elements of the system and modify its overall comportment. On the contrary, negative feedbacks in complex systems are mechanisms that act to balance the internal state of the system, eventually, subject to external inputs that can alter the system's equilibrium. An example of negative feedback that maintains system stability in complex social systems is the behaviour of a specific individual that does not lead to a behavioural homologation by other social agents. Let's consider the case where a person expresses strongly racialist and/or homophobic opinions in a public space: if the feedback introduced in the system was positive, it would trigger the same behaviour in people listening, with the result of a rapid spread of racialist behaviour. Nevertheless, usually, such a behaviour of an isolated individual would be severely condemned and, eventually, repressed by the surrounding people--a negative feedback that helps to preserve the equilibrium of the social system. In summary, positive feedback mechanisms tend to lead the system out of its (actual) equilibrium, generating cascade of behaviour among all the elements that alter the initial conditions, on the contrary, negative feedbacks work to maintain the system's stability, in opposition to internal and external perturbations. In conclusion, openness, environment influence, adaptation, memory and feedbacks make the complex system "alive". They are all characterizing features of complex systems that lead to the emergence of new and unpredictable phenomena. In other words, such intrinsic characteristics generate the *evolution* of complex systems.

2.2. Evolution of Complex Systems

Evolution is a crucial aspect in complexity theory. It relies on emergent phenomena that arise in complex systems and are not generated by an "invisible hand" or by centralized structures (Johnson 2009), but that are the result of non-linear interconnections between the components of the system. As Dekker points out "the most common way to describe the relationship between parts and wholes in a complex system is to use the concept of emergence" (Dekker 2011, 155): that is the reason why the system's features that generate emerging properties are deeply investigated by complexity scientists in many different domains, with the aim to understand how lower-level interactions result in aggregate outcomes and collective phenomena. Indeed,

[6] In a complex system, such as the financial market, memory can be long- or short-term, with respect to the observed variables, for example, volatility or bond yields (Kwapień and Drożdż 2012).

"The usual notion put forth underlying emergence is that individual, localized behavior aggregates into global behavior that is, in some sense, disconnected from its origins. Such a disconnection implies that, within limits, the details of the local behavior do not matter to the aggregate outcome." (Miller and Page 2007, 44)

As outlined in the previous sections, complex social systems can evolve according to very simple rules that regulate the connections between the social agents. An example of system's evolution arisen from simple micro-level behaviours is proposed by Schelling in his model of spatial segregation (Schelling 1971). His work focuses on how and to what extent some discriminatory variables at individual level–that could be race, gender, income etc.–may affect people behaviour and decisions and, as a consequence, generate changes on social structure. More in detail, Schelling examines if the perception of the kin difference between individuals leads to such forms of neighbourhood segregation in the urban space, with the aim to detect "those mechanisms that translate unorganized individual behaviour into collective results" (Schelling 1971, 145). Schelling's model considers an area partitioned in different cells in which people, belonging to two different kin, are randomly distributed. Individual's decision to move in an empty cell depends on her "satisfaction" about the number of adjacent neighbours of the same kin. The random individual's relocation affects the subsequent decisions of the other people, that will decide to move or not, according to the new composition of their neighbourhood. Such an iterative process will lead to a progressive segregation in urban spaces, mostly composed by people belonging to the same kin. Schelling's model is an example of complex adaptive system that adopts (deterministic) selection mechanisms: it reveals how the interactions between personal decisions result in emergent patterns, as the urban segregation, and how mechanisms of homophily and selection may have a strong impact on overall shape and structure of systems as complex as modern cities. In light of this, the interest of social scientists is to understand the nature of such mechanisms, by detecting if there are differences in individuals' degree of tolerance towards other people perceived as different (with respect to race, sex, social position etc.). The concept of *social distance* (Park 1924) and the *social distance scale* (Bogardus 1933) have been introduced in order to measure the intensity with which people perceive and are willing to accept social relationships with individuals that are different from them. Such concepts will be on the root of the studies carried out by the social scientists of the Chicago school, the pioneers of urban sociology, which focused on different urban issues that erupted in Chicago area after the sudden population growth between the nineteenth and twentieth centuries–such as immigration and social mobility, criminality, ghettoization, homeless etc. (Faris 1967).

It is worth to note that the emergent patterns take the form of organized complexity generated at lower-levels of the system, resulting from the self-organizing property outlined in the previous section. For example, ants act under simple and organizational rules: they move looking for the food and, when they find it, they bring it to the anthill leaving their pheromones on the route, so that other ants can follow the trail and find the food (Dekker 2011). That generates an ordered and organized line of ants that starts from the anthills and ends where the food is. There is no ant leader that coordinates the action of the group, it is a decentralized organization, an implicit coordination in the ants' behaviour that generates an organized complexity. Organized complexity and self-organizing rules allows to suppose that there are some defined structures and elements' behaviours that can be detected within complex systems that facilitate the evolution and the rise of emergent phenomena.

The complexity thinkers' aim is to focus on such properties in order to better understand the overall system behaviour. In light of this, the complexity scientists highlighted some features that are considered the architecture of systems organization and that govern components interactions. First of all, their *hierarchical structure.* Indeed, in complex systems we can detect different levels of emergence since many different levels (or hierarchies) exist within them. For example, society can be

studied by focusing on its different internal micro, meso or macro levels, such as people, families, cities, countries and continents. Each hierarchy has internal rules and emerging properties that cannot be inferred through the lower or the upper level. It means that the hierarchical structure of complex systems implies that the researcher shall focus on the analysis of a specific level, without considering the features of the other levels[7]. Nevertheless, it is worth to note that within the hierarchical structure of complex systems "flat hierarchies" exist (Simon 1996), allowing the subsystems to interact between them. Indeed, whilst each subsystem is specialized and has specific functions, it can collaborate with other subsystems with the aim to pursue the same goals. For example, in the human body different circulatory and respiratory subsystems with their specializations coexist and share the same aim that is the correct functioning of the overall system: "if the respiratory system is not exchanging a sufficient amount of air, the circulatory system initially compensates by pumping more blood around the body" (Hmelo-Silver and Azevedo 2006, 54). This means that, in the short run, the specialized substructures of a complex system act nearly independently from the other units, but in the long period, the behaviours of subsystems influence each other and their aggregated activities have an impact on the overall behaviour of the system, generating emerging phenomena. Such property makes the hierarchical complex systems nearly decomposable (Simon 1962, 1996). Hierarchical and nearly decomposable structures are not so rare in society and accelerate the evolution of complex social systems.

The structural evolution of complex systems also relies upon their organization in different *communities*. Indeed, a society can be partitioned in groups at different hierarchical levels of organization. Therefore, people may be classified as members to the same cluster of team supporters, religious groups, colleagues and so on; families can be grouped in households that live in the same neighbourhood or families with a similar internal structure (as families with offspring); different cities can share some properties and be part of the same group (as cultural cities or metropolis); countries can be grouped in communities, for example nations belonging to the European Union; and continents can be classified into Global North or Global South. Under a sociological point of view, it is worth to note that the concept of community is more than a merely analytic tool through which classifying social groups according to common characteristics. Although community as a topological construct has a long tradition in sociological debate (Brint 2001), at this stage we just mention that on one hand, the classification in communities allows the researcher to trace boundaries between different social groups, on the other hand, the sociological concept of community implies a sense of belonging shared by members of the same group that goes beyond the mere artificial aggregation. Such conceptualization is on the root of the dichotomy society-community, introduced by Tönnies (1887; tr. en. 2001) and then used by Weber (1922; tr. en. 1978) to explain social bonds. In brief: the group, intended as a partition of society, is a purely mechanical construction, an aggregation of social agents whose interactions are formal and mediated by different roles (e.g. a set of colleagues whose only bond depends on being part of the same job category, such as lawyers, doctors, professors etc.); on the contrary, a community is intended as a group of individuals that share values, attitudes, traditions, beliefs and so on, whose interactions are based on the membership criteria and on expectations between its members. Then, to be part of the same group for sharing specific features, such as the occupation, does not imply that the individuals have a sense of belonging that characterize them as a community. The community structure of complex systems suggests that elements belonging to the same group are highly connected between them and they are more linked to each other than they are

[7] In this sense, for example, the hierarchical organization allows to analyse the patterns of expenditures of different households (meso-level) considering them as single units, without taking into account the decisional dynamics or the different purchasing power between the family members (micro-level), as it will be outlined in the empirical analysis of the present work.

with elements from other groups. In social complex systems, people cluster in communities more or less spontaneously: whilst an individual is born in a specific family or with a certain nationality, he may decide to join other communities throughout life–for example, by forming a group with people sharing the same interests. Moreover, individuals can, and often are, be part of different groups at the same time: e.g. group of friends, group of colleagues, religious communities, political parties etc. Such overlapping of communities is far from being uncommon in society. Community structure is a property strongly investigated by complexity thinkers with the aim to detect how a system evolves according to the changes within or between different groups.

The development of some communities of people within complex social systems strongly depends on the concept of *homophily*. It can be explained as the individuals' tendency to create bonds with people with whom they share some particular features (such as socio-demographic characteristics, interests, tastes etc.), or with whom they already form a group for different endogenous reasons (such as a group of classmates or colleagues). If we considered our groups of friends, for example, we might be able to detect the similarities that there are between ourselves and people belonging to the group. Homophily generates emergent properties in complex systems, such as the formation of ethnically homogeneous neighbourhoods that can often be observed within the cities: the already introduced Schelling's spatial model of segregation is an example of how people cluster together according to their preference to live near individuals that have the same socio-demographic features. Such individuals' preference has at least two important implications: 1) the interactions between people who are similar with respect to certain attributes are stronger as compared to the connections with different individuals; 2) people in homophilic relationships tend to behave similarly; 3) in the long run, homophily process may create segregated regions, in which individuals prefer to have relations only with people that have similar characteristics, in such a case, homophily may act as a barrier, and the system tends to be closed to influences or stimuli that arrive from the outside. In complex social systems, homophily acts under two driving forces: selection and social influence (Easley and Kleinberg 2010). The former stimulates individuals to select with which people having connections, according to their attributes of interest; the latter is the result of people that belong to the same group for contextual reasons (as students that are in the same class within a school): in this case, the community is not naturally generated, nevertheless, being part of the same group will "shape people's (mutable) characteristics" (Easley and Kleinberg 2010, 91), pushing individuals to modify their behaviour with the aim to be more similar with their friends.

In complex social systems, homophily may act to model people decisions together with, or in contrast to, *herd behaviour*, which is the tendency of individuals to imitate other's behaviour, ignoring private information signals (Hirshleifer and Theo 2003). For example, one decides to imitate the behaviour because the others did the same–that generates a cascade of information–or because he particularly trusts in specific people's opinions–homophily–. If the individual's decision is in accordance with the previous decisions of the others, cascade continues, if it is in contrast, cascade may interrupt. Let's consider, for example, the case where a couple decides to go out for dinner (Johnson 2009, Easley and Kleinberg 2010). When the individuals arrive at the location, they find that restaurant *A* is quite empty, but in the near local, e.g. the restaurant *B*, there are more people. How do they perceive such external feedback? Let's assume that the couple chooses going to the restaurant *B* under the assumption that if there are more people than in restaurant *A*, it means that the quality of food is superior: here the herd behaviour and the cascade of information starts. If we suppose that all the other individuals that will arrive in front of both the restaurants will perceive the same information of our initial couple, in a short time restaurant *B* will be full of people, and restaurant *A* will stay empty. Which kind of consequences such herd behaviour will have on both restaurants? As in every complex system, the possible scenarios are multiple and unpredictable, e.g. the restaurant *A* will close, the restaurant *B* will not be able to cope with the needs of a huge amount of clients and quality of food

will worsen etc. Such processes are not rare within social complex systems and appear in a range of very different contexts–such as, for instance, fashion and financial markets–, influencing people behaviour and, as a consequence, having an impact on the evolution of the system. Nevertheless, it is worth to note that, in most of the cases, herd behaviour and information cascade are weak processes: they could be altered by numerous events, such as the opposite choice of an influent person that decides to go to the restaurant *A* and modifies the subsequent decisions of people. Such rapid modifications of system's evolution reveal how complex systems are sensitive to perturbations that can derive from internal or external inputs. These quick alterations in system's behaviour are called *tipping points* (Dekker 2011) and suggest how both small changes in elements interactions and extreme events within the complex system may have consequences for the whole system.

On one hand, complex systems are robust to local perturbations, thanks to their community structure and to the negative feedbacks; nevertheless, on the other hand, positive feedbacks, cascade of information and targeted attacks to specific elements, may strongly modify complex systems' behaviour at meso- and macro-level. In light of this, complexity thinkers wonder how complex systems modify their overall behaviour and why, in some cases, they fail. Indeed, failure is one of the possible emergent properties that a complex system may reveal (Simon 1996), this means that failure is an option of the adaptive behaviour of the system (Dekker 2011). It does not occur because of the malfunctioning of a single broken part (like in the complicated systems) but as a consequence of the connections between the elements. Just that point is the Achilles' heel of complex systems (Barabási 2002): the vulnerability of systems is due to the high interconnection between the elements that compose them. Such an observation may seem a paradox, if we consider that the robustness and the resilience of complex systems against errors and accidents is just rooted in highly interconnected sets of self-organized elements that preserve the functionality of the whole system. Nevertheless, as said above, failure is one of the possible options of complex systems' evolution and when an accident occurs, the density of connections between the components facilitates the spread of consequences throughout the system. In this sense, robustness and risk of failure coexist in complex systems. Let's consider the highly interconnected system of electricity power: on one side its correct functioning guarantees the energy service in a very large area, but on the other side, an internal accident may lead to a cascade of failure throughout the entire power grid. With the aim to make the system reliable, people introduce "barriers, as well as professional specialization, policies, procedures, protocols, redundant mechanisms and structures" (Dekker 2011, 127) that, on one hand, improve the system's performances, but, on the other hand, strongly increase complexity. Indeed, by introducing new mechanisms within the system, the number of connections between the elements considerably increases, improving the risk that the effects of an accident spread throughout the system (due to the system's properties highlighted above, such as feedbacks, cascade of information, herd behaviour).

In conclusion, complex systems are constantly evolving entities whose patterns of evolution strongly depend on their intrinsic properties. Their structure and the nature of the relationships between the elements that compose them lead the systems to evolve in many possible scenarios, it means that a complex system evolves in a specific way with respect to a wide range of possible states that it can (in principle) assume. The aim of complexity scientists is to understand how the systems change according to their internal structures, to the interactions among the elements and to the influence exerted by the environment, with the objective to predict the possible patterns of evolutions of complex systems.

3. Networks to describe and model complex evolving systems

The development of systems' theory progressively shifts the scientific interest from the overall control of systems behaviour to their internal structure and to the mechanisms that generate emergent

phenomena (Bocchi and Ceruti 2007). At this point, the main questions for scientific research are: how to deal with complexity? Which tools should be adopted to detect and analyse the emergent properties of a system? But, first of all, is this task possible? The main risk of a researcher dealing with complexity is an analytical paralysis. However, through the adoption of a multidisciplinary approach, one may find different methodological solutions to face the complexity of systems. What is fundamental for studying complex systems is to consider the complexity as a resource and not as an obstacle for the knowledge. In this regard, sociology and all the disciplines involved in complexity science offered both a new theoretical framework (that is the complex systems theory) and new computational models aimed to gain new insights into the emergent behaviour of complex systems: as, for example, agent-based models, neural networks, cellular automata and so on (Castellani and Hafferty 2009). Such computational models are adopted by complexity scientists for their ability to consider the wide range of different behaviours that a system may reveal. Compared to classical mathematical tools, computational models are more flexible, since they allow the researcher to simulate many different patterns of evolution of the system by altering the initial parameters. At the same time, such methods also require a high degree of precision, since all the features that may generate different modifications of system's behaviour need to be clearly defined (such as the elements' nature, the possible interactions between them, the environment in which the system performs and so on). For example, a computational model aimed to infer the behaviour of a complex system as a market, composed by buyers and sellers, requires to "carefully define when each agent is allowed to act, with whom it can interact, and its set of possible actions, [together with] what information each agent has access to, how it can use that information, how to resolve simultaneous offers, and so on" (Miller and Page 2007, 80).

Concerning, in particular, the interest for complex social systems, the questions that rise from the complexity theory are: "How does individual behaviour aggregate to collective behaviour?" (Watts 2003, 42), and "How can the tools used in complexity-based research be adapted to social scientific purposes?" (Byrne 1998, 7).

For some complex systems, the answers may rely upon their internal structure. Indeed, some of them can be represented in the shape of complex networks, composed by a set (or more sets) of elements, called nodes (or vertices), connected between them through links (or edges). In some cases, the structure of a system naturally reveals in the form of a graph. For example: in a biological complex system, the nodes of the network represent the proteins within a cell, and the links indicate the interaction between them. Nevertheless, in other cases, ties might be qualitatively different, and the researcher should choose to focus on a specific connection, according to his scientific purposes. In this regard, for example, if we consider the social system composed by scholars, the links among them might be set based on direct interactions they have, or if they share the same affiliation, if they are co-authors of the same papers, if they participate in the same research projects, and so on. In this example, then, the resulting network is a simplification of the system's structure that, however, might be appropriate to investigate the system for specific purposes. It reveals the high flexibility provided by networks in the representation of complex systems. As Lü et al. state,

> "The key character for a complex network is that it can represent a large-scale system in nature, human societies, and technology with the nodes representing the individual agents and the edges representing the mutual connections. Thus, the research work on fundamental properties, such as dynamics, controls, and applications of various complex networks has become overwhelming recently." (Lü et al. 2016, v)

Nowadays, the technological advancements offer the opportunity to record huge amounts of data and to analyse them, thanks to devices that become every day more powerful in terms of storage and computational performance. In this regard, the so called "Big Data" are used to monitor the evolution

of systems as diverse as online transactions, GPS localization of mobile phones, cars etc., stock prices at the transaction level, phone calls, purchases and so on. These data include details of both the elements that belong to the system and the type of interactions between them. In this regard, Big Data have a very large informative potential. But how to deal with that? In addition to a problem of "size", that is constantly faced by the technological progress, the issue risen from Big Data is how to process them in order to extract meaningful insights from the amount of information they contain. It is worth to note that Big Data carry the information and some properties of the complex systems they are used to monitor, such as the heterogeneity of both elements and interactions, the non-stationarity, the presence of communities, phenomena of herding and cascade behaviour, and so on. Then, for the intrinsic network structure of some complex systems, and for their characterizing features that reflect in the data extracted from them, complex networks appear as the most appropriate tools to represent and analyse them. Moreover, the network approach deals with the exigence to adopt a holistic view for detecting the main features of complex systems, as described in the previous sections. For example, let's consider the GPS coordinates that identify the position of thousands of people and their movements. By means of classical statistical models, we could infer some characterizing features of the system by focusing on a specific part of it, such as the probability that a touristic place receives a number of visitors greater or lower than the previous year, at the cost of missing the overall view of the system. Such a limit is typical of a reductionist approach used to investigate a complex system and the "big data" recorded to monitor its evolution. In this respect, it could be more informative to model such a specific system in the shape of complex networks. We could represent GPS devices, linked to the embedded satellite system, as a network, setting up a list of "relevant" places (attractions, monuments, squares, churches, etc.) in which people go as nodes, and the trajectories people follow for moving from a place to another, as links that connect the places[8]. In this way, we obtain a holistic view of people movements, through an evolving weighted network. Starting from this overall representation, we may detect some relevant features of the system: for example, the rise of communities, such as groups of attractions strongly connected between them, maybe because they belong to the same typical itinerary; the presence of isolated nodes, that could represent places in which no one goes; the identification of overcrowded sites, such as the main routes that a many people take to go to work, and so on. At the same time, the holistic view of the system allows one to observe its evolution, in the event that the state of the system, or its dynamics, are altered by either endogenous or exogenous factors. In this case, we may study to what extent the behaviour of the system changes by looking at changes in the network structure. In the example of the GPS trajectories, we could observe the shift of system's equilibrium if we remove a central node, for example, by closing a main route or a prominent attraction: such an event will drive the individuals to modify their behaviour and will have an impact on the network structure. In this regard, the network approach reveals to be suitable for having an overall representation of the complex system (e.g. the number and the characteristics of elements that compose it, the links between them, the presence of more connected elements and of groups of densely connected nodes, the eventual direction of connections, and so on). At the same time, the representation of a complex system in the shape of a complex network allows one to apply statistical techniques aimed at infer the evolution of the graph and to quantitatively describe its characterizing features. Like a magnifying glass, the complex networks allow to keep a view of the whole system and, at the same time, to zoom in, in order to highlight its internal structures. Such an opportunity enables the researcher to adopt a meso-scale

[8] This is also likely an example of an oversimplification of a system that does not naturally reveal a network structure.

approach that, as we will outline in the next sections, reveals appropriate to analyse the features and evolution of specific social systems[9].

As a consequence of the great opportunity provided by networks in the study of complex systems, we witnessed a rapid growth of network's studies in the last decades, and, in particular, after the complexity turn, in all the disciplines involved. Then, network analysis has become a multidisciplinary area of research–as proven by the recent increase of the term in scientific publications (Cecconi 2016)–, providing the opportunity to model and represent very different systems and the interactions that occur within them: such as sexual contacts (Liljeros et al. 2001; Liljeros et al. 2003); financial markets transactions (Gai and Kapadia 2010; Acemoglu et al. 2015); World Wide Web (Broder et al. 2000); co-authorship (Otte and Rousseau 2002; Sun et al. 2011); biological organisms (Huss and Holme 2007) and so on. Nevertheless, it is worth to note that the network approach applied to "formalise" and "solve problems" has its roots in the eighteenth century, since it was introduced in 1741 by Euler for the purpose to solve the Seven Bridges of Königsberg's dilemma (Euler 1741). Thereafter, the approach had a long tradition in mathematics and in social sciences, with the development of graph theory and social network analysis. In light of this, one could wonder which are the differences between the classical network approach adopted by mathematicians, physicists and social scientists in the past and the new *science of networks* (Watts 2003) embraced by complexity thinkers. Such differences can be identified in three main points. First of all, the main difference relies upon the theoretical shift and its consequences of the way to analyse the networks' structure. In the past, networks were considered as fixed in time and space, and their study was focused on the single interactions between the elements. The complexity turn introduces the idea of the dynamicity of complex systems, implying that the structure of complex networks adopted to describe the systems is mutable: it may change under the influence of particular perturbations to the systems, either endogenous or exogenous. Such an idea leads to a new way to consider the study of the networks: the focus of the scientist is not on the single relationships between the elements, but on how these connections generate the evolution of the network and emerging phenomena, since "small changes in the topology, affecting only a few of the nodes or links, can open up hidden doors, allowing new possibilities to emerge" (Barabási 2002, 9). In light of this, we have witnessed "a substantial new movement in network research, with the focus shifting away from the analysis of single small graphs and the properties of individual vertices or edges within such graphs to consideration of large-scale statistical properties of graphs" (Newman 2003). A second key-point relies upon the adoption of a multidisciplinary approach to study complexity and complex network. The General System Theory already highlighted that an excess of scientific specialization had lead scholars to reduce their research and their findings within the boundaries of their specific domains: "physicists only talk to physicists, economists to economists–worse still, nuclear physicists only talk to nuclear physicists and econometricians to econometricians" (Boulding 1956, 129). In light of this, systems' thinkers promoted the importance to bring together the scientific knowledge coming from different domains for the purpose of the systems' study. Such intention has had an impact also in the network approach for analysing complex social systems, by promoting the collaboration between mathematicians and physicists–that, until then, developed methodological tools to study networks in order to address mathematical and physical questions–with social scientists, who have a wider knowledge of social agents and emerging social phenomena (Watts 2003). Finally, it is worth to note

[9] It is worth to outline that complex networks are not always the best solution to analyse social systems. They certainly are analytic tools that reveal suitable to deal with the complexity of several real complex social systems. Nevertheless, when the complexity within the system is reduced (e.g. the researcher focuses on a specific part of the social system, with limited heterogeneity), a statistical approach might reveal more appropriate and provide more relevant insights.

that all the progresses in the modern science of networks have been made possible thanks to the technological developments occurred in the last decades. The large storage capacity and the speed of the processors of new computers enable the complex network scientists to manipulate and analyse a huge amount of nodes and links, e.g., adding or removing elements and connections, detecting community structures, modifying the nature of the links in order to highlight how different network structures lead to different emerging phenomena.

Therefore, the new science of networks offers the opportunity to analyse complexity by taking into account the dynamicity of complex social systems and their possible different scenarios, deriving from their internal structure and connections. It is made possible by the great flexibility provided by the networks, that allow to consider the dimensions that contribute to determine the complexity of systems (in terms of number of components and interactions, heterogeneity of elements, types of relationships, strength of connections, structure etc.), and by the new advances made by the networks' scientists, that, in the last decades, developed statistical methods to investigate the properties of complex networks (such as the community structure, the information flow, the systems' resilience, their vulnerability to targeted attacks etc.).

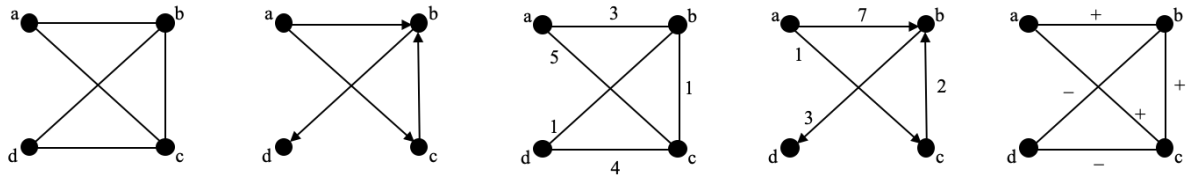
At a practical level, the network approach provides the opportunity to take into account the specific nature of relationships among elements of the system[10]. For instance, networks allow one to consider both the *direction* and the *intensity* of connections. The term "direction" refers to the orientation of the relationship (that is, if it is symmetric or asymmetric), the term "intensity" identifies the strength of the connection:

Direction / Intensity	**Yes**	**No**
Yes	Weighted-directed network	Weighted-undirected network
No	Unweighted-directed network	Unweighted-undirected network

Tab.1.1: Network definition according to the intensity and the direction of connections.

In an unweighted-directed network (fig.1.1a), links' orientation identifies the asymmetric relationships between nodes: this is the case, for example, of a social network as Twitter, where one may follow a person, but it does not imply that such person follows back. In an unweighted-undirected network (fig. 1.1b), links reveal a mutual relationship between nodes (e.g. friendship, family ties, academic collaborations etc.). The weighted networks–both directed and undirected– allow to consider the intensity of the connections between nodes, by assigning a weight to links that reveals the strength of the ties: for example, the links in the undirected network of academic collaborations can be weighted to take into account how many papers two scientists have co-authored (fig. 1.1c); at the same time, directed links that identify the interactions on Facebook may assume a weight indicating how many times user *A* comments, appreciates or shares posts published by user *B* (fig. 1.1d). Finally, in a signed network (fig. 1.1e) the links' signs identify the quality of relationships between nodes, that may be positive or negative: such networks are mostly adopted to describe ties that reveal alliance or conflict between the system's elements (e.g. for identifying coalitions and hostilities between States).

[10] The way in which the features and the evolution of real complex networks can be modelled, will be further investigated in the next section.



(a) (b) (c) (d) (e)

Fig.1.1: Networks describing the different types of relationships within a system.

Then, the network approach allows one to take into account the information deriving from the different types of relationships (that can be natural or created by the researcher) within the complex system.

At the same time, various measures have been introduced in order to investigate the network structure and reveal the "importance" of nodes and links in the information flow. Notwithstanding the huge amount of definitions and measures adopted to quantitatively analyse the network, in this section we present a selection of the most common ones, that will be useful for the further discussion[11]. One main topological measure used to investigate the structure of network is the *geodesic distance* d_{ij} between two nodes, that indicates the minimum number of links (that is the *shortest path*[12]) that connect nodes *i* and *j*. Such measure indicates the path that the information follows to reach the node of interest, and it is used to detect the *network diameter*, that is the maximum distance between any two nodes in a graph. The distance calculated for each pair of nodes allows to quantify a global property of the network called *characteristic path length L*, which is defined as the average of the shortest path lengths between two nodes (Watts and Strogatz 1998):

$$L = \frac{1}{N(N-1)} \sum_{i,j \in N, i \neq j} d_{ij}. \tag{1.1}$$

Low values of the characteristic path length express that, on average, each pair of nodes in the graph is connected through few links. Nevertheless, it is worth to note that such topological measure relies upon the assumption that the network is connected. Otherwise, the measure diverges since if two nodes *i* and *j* are not connected, then $d_{ij} \rightarrow \infty$. To address the problem in the case of a not connected graph, a measure called *global efficiency E* is introduced (Latora and Marchiori 2003):

$$E = \frac{1}{N(N-1)} \sum_{i,j \in N, i \neq j} \frac{1}{d_{ij}}. \tag{1.2}$$

In the event that no path connects the nodes *i* and *j*, $1/d_{ij}$ is null. The greater the values of the measure, the greater the efficiency of the network in connecting its elements.

In the study of networks, it can be informative to know the structural "importance" of one or more nodes, for example, in order to detect which elements are more connected (that is, they are focal for the information flow) and, therefore, removing them may damage the network's structure. For such reason, many different *centrality measures* have been proposed (Freeman 1979). Before introducing the main measures, the concept of "centrality" within the network needs further discussions. Already in 1979, Freeman argues that:

> "Everyone agrees, it seems, that centrality is an important structural attribute of social network. […]. But there consensus ends. There is certainly no unanimity on exactly what centrality is or on its conceptual foundations […] (Freeman 1979, 217).

[11] For a detailed discussion on the study of networks' structure, we recommend the exhaustive book of Newman (2010).

[12] It is worth to highlight the difference between the *path* and the *walk*, that connect two nodes within a network. In a *path*, the links involved to connect nodes *i* and *j* can be traversed more times, in a *walk* they are traversed just one time.

Freeman's words suggest that it is extremely difficult to give a unified definition of centrality, probably because the concept strongly depends on the system that the network aims at representing, on its structure, and on the specific processes that, supposedly, may run on it. Indeed, centrality is a property of a node's position in a network that has to be interpreted in relation to the type of bonds between nodes. For example, in non-negative relationships such as friendship or academic collaborations, central nodes may be people that are more popular and influential compared to the other social agents in the network (e.g. leaders). Then, the "importance" of a node may have a large number of interpretations and this leads to the definition of different centrality measures. In light of this, we introduce the most common measures aimed at detecting the centrality of nodes within the graph, highlighting the conceptual differences between them and the different information they provide about the importance of nodes:

1. Degree centrality. Such measure indicates the total number of connections that a given node has. In the directed networks, we distinguish between in-degree and out-degree, indicating the amount of incoming and outgoing links, respectively. The degree centrality is an informative measure in the event that the distribution of degrees of the entire networks is not homogeneous (e.g. there are few nodes with many connections and a lot of elements poorly connected)[13]. The degree highlights the importance of a node in terms of connections, indicating how many nodes of the network are connected with it.
2. Closeness centrality. It measures the average distance between a specific node and the others. Such measure provides information about how a node is central in terms of how quickly the other nodes reach it. It is calculated as the mean of the shortest paths (that are the geodesic distances) that connect network's elements to node *i*:

   (1.3) $$l_i = \frac{1}{n} \sum_j d_{ij},$$

   where d_{ij} indicates the geodetic distance between node *i* and a generic node *j*. Since low values of l_i correspond to high centrality values, it is common to calculate the inverse of l_i, so that:

   (1.4) $$Cl_i = \frac{1}{l_i} = \frac{n}{\sum_j d_{ij}}.$$

   Therefore, small values of closeness indicate that a node is peripheral within the network. On the contrary, central nodes reveal high values of centrality. Although closeness centrality is a measure widely adopted in network analysis, it reveals some criticisms (Newman 2010). First of all, the geodetic distance between nodes that are not connected (then, they do not belong to the same connected component) is infinite, it implies that l_i = Inf. (since each geodesic distance summed to Inf. = Inf.), and Cl_i = 0 (since *n*/Inf. = Inf.). Therefore, although it is possible to calculate the closeness centrality of a specific node in such cases, it is totally uninformative. To deal with such issue, the most common ways are: 1) to calculate closeness centrality by including just the nodes that belong to the same connected component (although, in this way, it is not possible to compare the centrality measures among different components); 2) to calculate closeness centrality through the harmonic mean distance between vertex, so that if nodes *i* and *j* belong to different components, the infinite value corresponds to zero in the sum. Another issue concerns the small range of values of closeness centrality among nodes. In fact, such values are very low (especially for social networks) and poorly discriminant in detecting the importance of nodes.

[13] The specificity of nodes' degree distribution in complex network will be further investigated in the next section.

3. Betweenness centrality. Such measure indicates the importance of a node with respect to the number of paths that cross it. Therefore, it indicates to what extent a vertex is central for the information flow throughout the network. For a specific node, the measure is given by:

(1.5) $$B_i = \sum_{j,k} \frac{n_{jk}^i}{n_{jk}},$$

where: n_{jk}^i is the amount of paths of minimum length between *j* and *k* that pass from *i*, and n_{jk} is the amount of paths of minimum length between *j* and *k*. As a consequence, vertices with high values take part in many paths, and a lot of information passes through them. Since such nodes often lie among different communities, by acting as a "bridge", their removal may be dangerous for the structure of the entire network. Betweenness centrality is a more robust measure compared to closeness centrality, since it does not suffer from the problems highlighted above. Moreover, the same measure may be calculated for detecting the centrality both of nodes and links. Specifically, in the next section, we consider the betweenness centrality as a measure adopted for partitioning the network in communities (Girvan and Newman 2002).

The above mentioned centrality measures define the importance of nodes in ways that are conceptually different. Then, the choice of the appropriate measure relies upon the research interests. In this regard, figure 1.2 shows that: 1) node *g* has the highest degree since it has the maximum number of connections compared to the other nodes (degree centrality); 2) nodes *b* and *c* can be reached through the small number of paths (closeness centrality); 3) node *h* is crossed by numerous paths since it connects vertices *i* and *j* to the other nodes of the network (betweenness centrality).

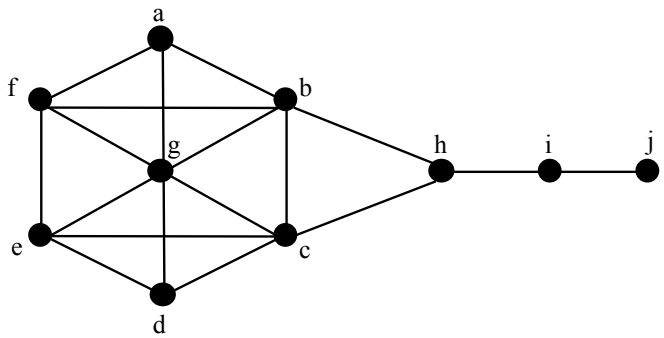


Fig.1.2: Different centrality measures detected within the same network.

For example, if we are interested in investigating the propagation speed of an information, we should concentrate on vertices that show higher values of closeness centrality, since they facilitate a more rapid information flow throughout the network. On the contrary, if we are aimed at detecting to what extent an information may reach people belonging to different communities (that are groups of individuals strongly connected among them and poorly connected with people of other groups), we should be interested in nodes that reveal higher degree of betweenness, since they "work" as bridge that connect different communities.

Finally, it is worth to note that there are some centrality measures that determine the importance of a node as a function of the importance of the nodes to which it is connected. In this regard, a centrality measure named *PageRank* has been introduced (Brin and Page 1998). Such measure has been developed for ranking Web pages according to the importance they have within the network[14]: indeed, the World Wide Web may be considered as a hypertext system (Page et al. 1999), that can be

[14] In fact, such measure has been developed for improving the quality of research among Web pages, and it is at the root of the search engine Google.

modelled as a network, in which nodes indicate the Web pages and edges represent the hyperlinks that allow to navigate from a page to another. As a consequence, this kind of network is directed. *Pagerank* allows to overcome the limits given by a simple measure of citations' counting usually adopted to highlight the importance of a node (that is the in-degree of a specific Web page). Indeed, the intuition that a page can be considered central within the network since it is cited by a huge amount of pages is widely acceptable. Nevertheless, such idea does not take into account the fact that a Web page mentioned by an important site (such as Yahoo.com) may be more relevant than a page having more links (that is a higher in-degree) coming from unpopular sites. In this regard, the importance of a node, according to its *PageRank*, is given by the sum of the *Pagerank*'s values of all the nodes connected to it. Notwithstanding further modifications and implementations, the original algorithm for *PageRank* calculation is:

$$PR(A) = (1-d) + d\left(\frac{PR(1)}{C(1)} + \frac{PR(2)}{C(2)} + \cdots + \frac{PR(N)}{C(N)}\right), \tag{1.6}$$

where $PR(N)$ is the *PageRank* of the n-th Web page, $C(N)$ is the number of links from such page to external pages, the sum is taken over all the web pages pointing to page A, and parameter d is a damping factor (usually set to 0.85) that identifies the probability that an imaginary surfer continues to randomly clicking on links instead of stopping his research. In brief, such measure allows one to take into account to what extent a specific node is connected to other nodes that have many links and, then, that are fundamental for the information flow throughout the network. The idea of *PageRank* measure reflects a property of social relationships easily observable in the interactions between the nodes (individuals) belonging to a social complex system. Indeed, if we consider such measure as "the importance of an element with respect to the importance of the elements it is connected to", we assume that if a person aims at increasing his prestige (in terms of richness, social status, popularity and so on), she is oriented to create relationships with "very prestigious people". Then, in a social complex system in which the connections between the actors are oriented, as in the one introduced by Brin and Page for the formulation of the *PageRank*, we may assume that the greater the centrality of an individual, the greater will be its appeal. At the same time, such centrality is often used by individuals in social systems in order to maintain their authority in the relationships they have with less central people.

Such a brief description of the main quantities adopted to analyse the importance of a node, in terms of centrality, can be concluded by introducing a measure of local and global aggregation (of a specific node and of the entire network, respectively) that indicates the degree to which the neighbours of a given node link to each other. Such a quantity, called *clustering coefficient* (Watts and Strogatz 1998), measures a common property of real social networks, that is the tendency to form groups in which members know each other. Indeed, if the social agent *a* is friends with *b* and *c* (fig. 1.3a), there is a concreate possibility that *b* and *c* become friends over time (fig. 1.3b). As figure 1.3 reveals, the triad composed by individuals *a*, *b,* and *c* forms a triangle as soon as a tie between *b* and *c* appears:

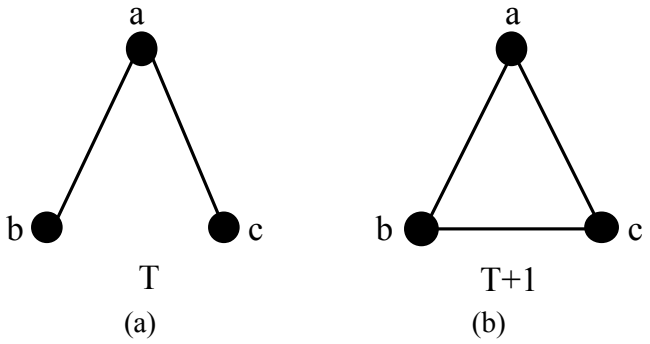


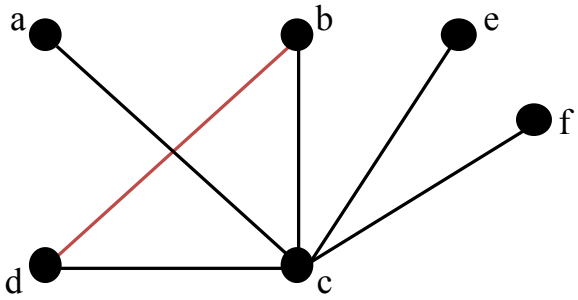
Fig.1.3: The effect of the triadic closure.

Typically, in social systems, the triadic closure process is generated by internal mechanisms among the involved nodes. Specifically, the reasons that favour *b* and *c* (fig.1.3) to become friends can be related to: 1) *opportunity*, since they can meet at the events organized by *a*; 2) *incentive*, since if *b* and *c* are not friends with each other, it is a source of stress in the relationships that person *a* has with both; 3) *trust*, since *b* and *c* are more inclined to become friends knowing that they have a mutual trustful relationship with the person *a* (Easley and Kleinberg 2010). In this sense, the triad is the backbone of network structure and evolution.

For that reason, the clustering coefficient is a useful measure to detect both local and global structure of a graph (calculated for a specific node and throughout the graph, respectively). More in detail, the local clustering coefficient of a node *i*, C_i, identifies the probability that nodes adjacent to node *i* are also connected to each other (then forming triangles including vertex *i*). C_i is calculated as the ratio between the actual amount of connections that exist between nodes adjacent to vertex *i*, and the total number of connections that there would be if all of the nodes adjacent to *i* were connected among them:

(1.7) $$C_i = \frac{2E(i)}{k_i(k_i-1)},$$

where, *E(i)* is the total number of actual links among the neighbours of node *i*, k_i represents the degree of node *i*, and $k_i(k_i - 1)/2$ indicates the maximum allowed number of links, and, therefore, of triangles with *i* as a vertex, among the k_i neighbours of vertex *i* . For example, in fig. 1.4, node *c* has degree 5 and only two adjacent nodes *b* and *d* are connected between them, forming a triangle whose vertices are *cbd*. Then, its local clustering coefficient is 0.1.



$$c_c = \frac{2*(1)}{5*(5-1)} = \frac{2}{20} = 0.1$$

Fig.1.4: Example of clustering coefficient of node *c*.

The global clustering coefficient is a network measure that quantifies the tendency of vertices to form triangles. Specifically, it can be calculated as the average of nodes' clustering coefficients:

(1.8) $$C = \frac{1}{N}\sum_{i\in N} c_i.$$

A high value of clustering coefficient indicates that there are many connections between neighbouring nodes. For a fully connected graph, *C* is equal to 1.

To analyse and mathematically describe the network characteristics, for instance by using the measures introduced above, the starting point is usually to report the elements' connections in the system in terms of an adjacency matrix. The structure of a complex system, in the shape of a complex network, is often presented in terms of an adjacency matrix. For an unweighted-undirected graph[15], in which the connections between the elements are neither weighed nor oriented, the adjacency matrix *A* is a matrix *N x N*, with values:

[15] In this section, we only focus on undirected networks, since they are the networks considered in the empirical part of the present work.

(1.9) $$A_{ij} = \begin{cases} 1, \text{if there is a link between nodes } i \text{ and } j, \\ 0, \text{if the nodes } i \text{ and } j \text{ are not connected} \end{cases}$$

In the event that links have different weights, the weighted-undirected network is presented through a *N x N* matrix *W*, in which:

(1.10) $$W_{ij} = \begin{cases} \text{the weight of link between nodes } i \text{ and } j, \\ 0, \text{if the nodes } i \text{ and } j \text{ are not connected} \end{cases}$$

Obviously, the adjacency matrix of an undirected graph (both weighted and unweighted) is symmetric, since $a_{ij} = a_{ji}$ and $w_{ij} = w_{ji}$, moreover, a_{ii} and $w_{ii} = 0$ if there is no self-link. Therefore, the adjacency matrix summarizes all the system's connections and it is used to calculate the metrics that describe the characteristics of the network.

After having quickly discussed the flexibility of the network approach to describe and model complex systems, we conclude this section by highlighting that such an approach allows one to overcome the dichotomy between micro- and macro-level of analysis that has divided social researchers for a long time (Trobia 2001). In fact, the network approach can be considered as a *meso-level* of analysis, since it allows to take into account both the individual interactions–micro-level–and the overall behaviour and evolution of the system–macro-level–(Watts 2004).

3.1. Complex Networks and their evolution

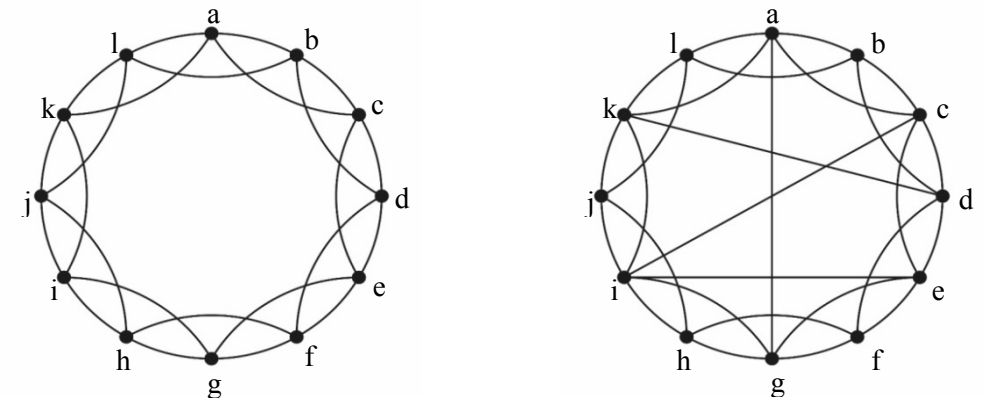
In the previous section, we highlighted that networks can be considered the skeleton of some complex systems, and that to adopt a network approach, in some cases, reveals an appropriate way to study the characterizing features and the patterns of evolution of complex systems. Indeed, a network approach allows one to detect the internal structure of very different systems–by identifying, for example, the presence of groups of elements densely connected between them, isolated nodes, isolated communities, central elements and so on. We also noticed that the shift from the classical social network analysis to the new science of network relies upon the fact that the second approach considers the network as an entity that *evolves* under specific conditions of interaction between its nodes. In light of this, the main challenge for the science of networks is to detect how a system evolves and modifies its behaviour, in response to internal or external stimuli. To study the properties of graphs and their patterns of evolution, different theoretical models of network have been proposed. Some of them rise from the observation of specific properties of real systems and aim at reflecting them in the topological and dynamical properties of a network. In this section, we briefly present the most representative network models.

In graph theory, the classical model to generate random networks and observe their growth, has been introduced by Erdős and Rényi (ER model) in 1960. The creation of the network starts by initially considering isolated nodes that are gradually connected. In the creation process of the graph, links are randomly set between nodes with the same probability, so that all the nodes have the same chance to be connected (Erdős and Rényi 1960). If the connections added are few, the result is a network composed by isolated groups of nodes. Nevertheless, by increasing the number of links, the evolution of network drastically changes, and we observe an emergent phenomenon: a giant *connected component* of vertices appears, in which the nodes are connected between them by small paths. In a large network created by randomly connecting nodes with the same probability, all the nodes will have approximately the same degree. The degrees of nodes in ER model follow a Poisson distribution, indicating that the majority of nodes have the same number of links as the average node does (Barabási 2002). What the ER model highlights is that one node requires, on average, one link to stay connected with the entire network. Nevertheless, the theoretical model of random graphs reveals inadequate to describe real complex networks, especially the social ones, since it does not take into

account some properties that are typical of complex systems and that influence the evolution of real complex networks, such as 1) the qualitatively different types of connections (Granovetter 1973), 2) the assumption that nodes tend to cluster together (Watts and Strogatz 1998), 3) the heavy tailed degree distribution (Barabási and Albert 1999), 4) nodes' payoffs in the choice of setting or removing connections (Jackson and Wolinsky 1996), and 5) the community structure of the network (Zachary 1977; Girvan and Newman 2002).

In contrast to the ER model, the work carried out by Granovetter in the late 1960s reveals that social complex networks are partitioned in groups that are highly connected within them and weakly connected between them. This implies that the information flow throughout a social network comes through qualitatively different types of connections, that can be "strong" if the individuals are linked by bond of friendship, for example, or "weak" if they simply are acquaintances. In light of this, Granovetter (1973) describe the social complex system in the shape of a complex network, revealing that social network structure helps people to find a job. Specifically, the outcomes of his work highlight the importance of *weak ties*: most of the jobs are found by individuals thanks to "weak" acquaintances, and not through people with whom they have a strong friendship tie. The study of Granovetter introduces the idea of a connected world partitioned in subgroups that "are connected by virtue of individuals who belong to more than one group" (Watts 2003, 111). Such an assumption is behind the research question from which the study of Watts and Strogatz (1998) has its roots: "What is the likelihood that two friends of mine know each other?". According to the ER model, in which all the nodes have the same probability to be connected, "the likelihood of my two closest friends knowing each other is the same as the chance that an Australian cobbler's best friend is an African tribal chief" (Barabási 2002). Nevertheless, we may argue that, in a real complex social system, such probability is actually quite high. The intuition that we live in a *small-world* (proven by Milgram's study in 1967)[16], in which people all over the world are linked through a small number of relations (as two nodes of a network are connected with a small path length), leads Watts and Strogatz to develop a random rewiring procedure of the connections within the network, that reflects such property. They conceive a network model in which the nodes are directly connected between them, e.g. a node a is connected to its immediate neighbouring nodes b and l, and he has also a direct link with the nodes adjacent to its neighbouring nodes c and k (fig. 1.5a). As a consequence, the clustering coefficient of the graph (Eq. 1.8), which measures the tendency of nodes to cluster together, is quite high. Such a graph is a regular network that shows one small-world property, that is the *clustering structure*; nevertheless, it does not present another small-world feature, that is the *short path length*, since, in such a network, there are many steps for connecting two nodes on the opposite sides of the network. To deal with this problem, Watts and Strogatz randomly add extra links to connect the nodes, by selecting a connection of a generic node i, and replacing it with a link that connects the node i with another random selected node of the system. As a consequence, the evolving structure of the graph depends on the probability of rewiring a link: if $p = 0$, the network shows only the clustering property (fig. 1.5a); if $p = 1$, the network is random; for $0 < p < 1$, the network reveals both the small-world effects simultaneously, that are clustering and short path length. To make the calculation simpler, Newman proposes to also keep the original links, maintaining the structure of Watts and Strogatz's model (fig.1.5b) (Newman 2010).

[16] The concept of "small-world" has been introduced by Milgram's experiment (1967), which demonstrated that the geodesic distance between people is, on average, 6.



(a) (b)

Fig.1.5: Graphical representation of a small and clustered world. Source: Watts and Strogatz model (1998), with our labelled nodes.

Properties of small-world are observable in many real systems, revealing the existence of a highly connected world, in which two people that are not directly connected may reach each other by few acquaintances they have in common (short paths). A typical example of complex system that reveals a small-world structure is the scientific community. Let's imagine the scientific community as a network in which the nodes are the scientists and the links between them identify individuals that collaborated at the same article(s) (that is, they are co-authors). The more an author collaborates with different scholars, the higher his degree is. Let's assign to the mathematician Paul Erdős the number 0, to the scientists that have written a paper with him (more than 500) the number 1, to the co-authors of scholars that have a paper in common with Erdős (but never directly collaborated with him) the number 2 and so on. Such values describe the distance between scholars and Paul Erdős, in terms of collaborations. It has been revealed that such values are quite low, demonstrating that each scientist is connected to the mathematician by short paths. This example highlights that the small-world properties are typical of many different the social systems.

It is worth to note that the small-world model, such as the Erdős-Rényi one, relies upon the assumption that the degree distribution[17] of nodes shows a peak in the average values, indicating that the nodes have, on average, the same number of connections. Such assumption implies that nodes join to each other independently. Nevertheless, as we highlighted in the previous sections, in complex systems, the elements connect between them according to some contingencies or preferences: for example, in a complex social system, the relationships between people are not random, but they may result from mechanisms of homophily and selection. Such an evidence highlights the non-trivial nature of connections between the elements of a complex system, and it has to be taken into account for the study of the evolution of a complex network. In light of this, Barabási and Albert (1999) observe that a characterizing feature of many networks is the presence of long-tailed degree distributions: typically, most of nodes have few connections and a small number of nodes present a lot of links with other nodes of the network. Such degree distributions are named *power-law distributions*, and can be detected in many real-world systems. In this regard, typical examples of distributions that have been identified as a power-law are: the income distribution, the earthquake magnitude, the words frequency in a corpus of texts, the population of cities, the World Wide Web (Newman 2005, Clauset et al. 2009). In all of these cases, it has been observed that the quantities

[17] The degree distribution *P(k)* is the probability that a randomly chosen node in the network has degree *k*: $\mathrm{P(k)} = \frac{n_k}{\mathrm{N}}$, where: n_k is the number of nodes of degree *k*, and *N* is the total number of nodes in the network.

measured are not centred around a typical value, but they vary over a large range of values (also many orders of magnitude). If we considered, for example, the cities' size (in terms of number of citizens) throughout the world, we may observe that there is a huge amount of cities in which a moderate number of people live, and a tiny number of cities that are overcrowded. In this sense, it is clear that the mean number of citizens is an uninformative measure of the system. The networks characterized by a power-law distribution of nodes' degree are called *scale-free networks*, since their degree distribution is scale-invariant (Érdi 2008), it is not possible to detect a "typical node" and, as a consequence, some metrics, as the average node degree, are not informative. In light of this, Barabási and Albert study the formation and the evolution of networks by considering such property of real-world systems, and analyse how the system behaves when a new node is introduced in the network. Their model takes into account two aspects of network evolution that may be observed in real complex systems: 1) real networks constantly grow as new members enter in the system, and 2) new members show their preferences of connection with specific elements that already are part of the system, so their connections are not random. In light of this, Barabási and Albert develop a model that reproduces the power-law distributions detected in many complex systems, by generating scale-free networks in which the new nodes reveal a *preferential attachment* when they join the system (Barabási and Albert 1999). The idea of preferential attachment implies that the new nodes entering in the system tend to connect with members that already have many connections. Then, preferential attachment procedure offers a plausible explanation for the formation of power-law degree distributions in networks. In light of this, in the model conceived by Barabási and Albert, nodes are added one by one within an undirected network, and they are linked to pre-existing nodes with a probability depending on the degree of these nodes:

(1.11) $$p_{(\rightarrow i)} = \frac{k_i}{2*L},$$

where, k_i is the degree of a generic node *i*, that is already part of the network, and *L* is the number of links that connect the existing elements in the graph. and, then, $2 * L$ indicates the total number of nodes in the graph. In the scale-free network the fraction of nodes with degree *k* goes as:

(1.12) $$P(k) \sim k^{-\alpha},$$

with $\alpha > 0$ for large values of *k*. In the Barabási and Albert's network, resultant from the mechanism of preferential attachment, the estimated exponent α is 3. In some real systems whose distributions follow power-law, it has been detected that the estimated parameter α generally ranges from 2 to 3, such as the word frequencies, the number of scientific citations, the population of cities in USA, the received telephone calls, the actors' collaborations, the World Wide Web etc. (Barabási and Albert 1999; Newman 2005, Clauset et al. 2009).

In many complex social systems, modelled in the shape of graph, it has been detected that the degree distributions approximately follow power laws (at least in the tail of the distribution): such as the scientific collaborations, the movie actors, the aviation system, Internet and so on (Barabási et al. 2002; Érdi 2008). In these systems, the new nodes joining the network, tend to connect with the more "popular" ones: the preferential attachment mechanism appears as a reasonable explanation for this behaviour. Let's consider a simple but explicative example of real system's behaviour, in which it is possible to understand the extent to which the mechanism of preferential attachment works well, and how it can be used to make predictions on the evolution of the system. Let's consider a (simplified) system composed by 1) consumers, heterogeneous among them in terms of age, and 2) high-tech items, such as smartphones, smartwatches, e-readers, tablets, home automation products, action cams, and so on. We could assume that such items are more appealing to younger people, more open to new technologies and closer to the trends of the moment. What is the probability that a newly introduced

high-tech product will be purchased by the different "categories" of consumers? According to the preferential attachment mechanism, we may suppose that such a probability is proportional to the number of high-tech items a consumer has purchased in the (recent) past, i.e., the degree of the consumer, which is likely to be greater for younger individuals.
The Barabási and Albert's work accounts for a widespread evidence in many real systems, which is that "in most real networks, the majority of nodes have only a few links and that these numerous tiny nodes coexist with a few big hubs, nodes with an anomalously high number of links" (Barabási 2002, 70). The connections within a network generated through the preferential attachment is, then, guaranteed by the presence of "hubs" (namely, nodes with a number of connections very high). Nevertheless, it is worth to note that despite the network structure generated by preferential attachment is robust and resilient to random attacks (e.g. randomly removing nodes does not typically alter network's properties), at the same time, it is sensitive to intentional attacks directed to highly-connected nodes, since the removal of hubs might even cause the breakdown of the network's connectivity. Let's consider, for example, the impact that the Lehman Brothers' bankrupt had on the interconnected global economies in 2008. Until its collapse, the company was the fourth-largest investment bank in the United States, and it was involved, as a hub, in different economic markets, mainly the credit market (providing home mortgage and loans for low and middle companies) and the stock market. The consequences of Lehman Brothers' collapse were not limited to the US economy. Indeed, the effects of the bankrupt also reached, through ripple effect, the financial markets of foreign countries, revealing a typical weakness of complex systems (the fact that they are strongly affected by the failure of very important elements in the system) due to the high degree of interdependency between its components. After Lehman declared bankruptcy, the major global stock indices fell down, although with different magnitude, across the regions (Tab.1.2). As Table 1.2 reveals, the emerging market economies of Brazil, Russia, and China have been strongly impacted: these results are in line with the countries' dependency on US stock market. As Aloui et al. (2011) state, such a dependency is stronger in Brazil and Russia, which depend on commodity prices more than India and China, which economic growth mostly depends on the export of finished-products (Aloui et al. 2011).

Index	**Region**	**Rate of change 15/09/08**	**Rate of change 16/09/08**	**Rate of change 17/09/08**
DOW JONES	USA	-4.37	1.41	-4.04
S&P 500	USA	-4.65	2.13	-4.46
NASDAQ	USA	-1.02	2.71	-3.62
MIB	Italy	-0.88	-1.57	-4.26
CAC 40	France	-0.37	-0.27	-3.83
FTSE 100	UK	-3.92	-3.43	-2.25
DAX	Germany	-2.74	-1.63	-1.75
NIKKEI 225	Japan	-	-4.95	1.21
IBOVESPA	Brazil	-7.58	1.71	-6.72
MOEX	Russia	-6.18	-17.45	-3.11
BSE SENSEX	India	-0.45	3.58	-2.62
SSE	China	-	-3.08	-2.18

Tab.1.2: Open-to-close daily returns after Lehman Brothers bankruptcy (rate of change in percentage values). For DAX and NIKKEI indices, the close-to-close daily returns have been calculated. Online sources: Yahoo! Finance; TradingView; Macrotrends; Trading Economics[18].

[18] Yahoo! Finance: https://finance.yahoo.com
TradingView: https://uk.tradingview.com

In this regard, the behaviour of international stock markets, in response to the financial shock coming from the US, has been investigated in the literature (Roy and Sarkar 2011; Jiang et al. 2017; Kim and Song 2017). Studies confirm that, despite the global character of the financial crisis erupted after Lehman failure, its impact on international economies varied across regions. Roy and Sarkar (2011) demonstrate, through a network analysis based on the similarity between 93 stock indices, that, after September 2008, some groups of global financial markets behaved similarly: South American indices (except the Brazil's IBOV), revealed trends more similar to Japanese and UK indices, than to the USA and Canada ones; the Indian stock index changed its behaviour, that was similar to the one of EU indices before Lehman collapse and, then, became similar to the Asian stock markets behaviour; SXXP and SXXE European indices revealed the most central stock indices pre and post Lehman failure, respectively. Such a study introduces the idea that the contagion effects of collapse of the fourth-largest investment bank in the United States involved global financial markets, but with different magnitude. The reason of such a difference relies upon the specific financial conditions of impacted countries, such as the openness to external markets and the degree of capital control. In this regard, Kim and Song (2017) analyse the spill-over effects of Lehman Brothers collapse on volatilities of stock prices, in different financial markets. Results reveal that, although an increase of volatility can be observed for all the countries considered, the ratio of stock price volatility between the post- and the pre-Lehman period of considered economies varies from 1.244 to 7.902, being greater for Croatia, Mauritius, Slovenia, Bulgaria and Lithuania (top five countries with respect to the volatility ratio). The impact of Lehman Brothers collapse revealed to be lower for economies that have lower financial openness and greater stock market than countries, suggesting that having stronger capital control prevents the shock transmission due to a hub failure within the stock market network.

Finally, it is worth to note that the evolution of the network through a preferential attachment process implies that the initial nodes insert in the graph will be the most connected elements. By reflecting such property in the real social networks, we should find that the "oldest" actors have the highest number of connections with other people within the network, and their links tend to increase each time that a new individuals join the system, since the new social agents will have higher probability to be connected with them. Nevertheless, this phenomenon is not often observed in real complex networks.

The Albert-Barabasi model does not consider the possibility that nodes may set or remove a link according to their own convenience, which is definitely relevant when dealing with social networks. Indeed, social agents may form or break ties with others, in order, for instance, to improve their individual payoff. In this regard, let's consider, for example, alliances among political parties, firm collaborations, marriages among people belonging to powerful families: all of these ties aim at improving the benefits of the entities involved. Such a consideration is behind the model of evolution of *strategic networks* proposed by Jackson and Wolinsky (1996). The authors conceive a connection model in which the payoff of the generic social agent *i* is calculated according to the following utility function:

$$u_i = \sum_{j \neq i} \delta^{l(ij)} - \sum_{j:ij \epsilon g} c_{ij} \tag{1.13}$$

Where g is the graph, ij is the link among nodes i and j, $l(ij)$ indicates the geodesic distance between the considered nodes, c_{ij} indicates the cost for i to have a connection with j, and δ is a parameter

Macrotrends: https://www.macrotrends.net
Trading Economics: https://tradingeconomics.com

representing the benefit of node i of having a link with j[19]. In such a way, it is possible to calculate the incentives of every node to set, maintain or remove a link each time the network configuration changes[20]. The concepts of benefit and cost that incentive social agents to create or remove connections may be useful to explain some real-network properties, such as the ones also highlighted in the small-world model. Indeed, individuals might have an incentive to create local ties with people similar to them according to some features, which leads to the formation of communities in the network. On the other hand, social actors may benefit from setting distant connections, since they can get access to information not available within their own community (for example, in the job search), which results in a low diameter of the network; at the same time, maintaining distant connections may have high cost for the people involved, which makes such (weak) ties rather unstable. Once we have described how people may behave within a strategic network, we can 1) model social agents' choices–if setting or not new connections, or deleting existing ones–and 2) evaluate the overall welfare of the network. Such dimensions are investigated through the concepts of *pairwise stability* and *efficiency*, respectively. According to the authors, a graph is pairwise stable if 1) any two linked social actors do not gain any benefit from removing the connection between them (Eq. 1.14), and 2) no two disconnected social actors get mutual benefit from setting a link between them (Eq. 1.15):

(1.14) $$\forall\, ij \in g,\ u_i(g) \geq u_i(g - ij)\ and\ u_j(g) \geq u_j(g - ij)\ ;$$

(1.15) $$\forall\, ij \notin g,\ if\ u_i(g + ij) > u_i(g)\ then\ u_j(g + ij) < u_j(g),$$

where g indicates the set of links in the (pairwise stable) network. Pairwise stability is a concept that considers people's incentives to form bonds one at a time and applies to networks with a constant number, N, of actors. To measure the overall welfare of a society in the shape of a network, a graph, g, is considered "strong efficient" (Jackson and Wolinsky 1996, 47) if it maximizes the total utility of the society:

(1.16) $$\sum_i u_i(g) \geq \sum_i u_i(g'), \forall\, g' \in G(N),$$

where *G(N)*, represents the set of all of the possible link configurations among the *N* social agents. Nevertheless, social actors often behave according to their own incentives in order to maximise their payoffs, without considering if their actions may create disadvantages for the other individuals and, in general, for the society. That is the reason why, in modelling the evolution of social networks, it is interesting to evaluate which networks' configurations reveal pairwise stable and efficient at the same time.

Another important feature in the topology and in the evolution of complex networks that the above presented models do not consider is the community structure. As we already highlighted in the section concerning the evolution of complex systems, people tend to cluster together by forming groups internally highly connected and with few connections with the other sets. Such property may also be detected in networks that model and reproduce the social structure. Therefore, detecting the communities that characterize a system is a main task for network scientists and, in recent times, they tried to find the best way to identify the network substructures. The scientific interest on

[19] Quantity $\sum_{j \neq i} \delta^{l(ij)}$ is named *decay centrality*, which measures the centrality of a node by weighting adjacent elements more than distant ones. The measure relies upon the idea that an individual gets benefit from having direct friends, friends of his friends, friends of friends of his friends and so on, with values of the benefit that decays proportionally to the distance between the considered individual and her indirect connections. Delta ($0 < \delta < 1$) is the decay parameter that indicates such benefits.

[20] In the symmetric version of the connection model, the authors set benefits and costs (δ and c) equal for all the nodes.

communities' detection is focused on how to interpret the global organization and evolution of the network by considering the groups (clusters, communities or modules) that compose it and how such groups interact between them. Nevertheless, there is still a lack of a shared definition of network's community that complicates the comparison between the different community detection algorithms[21] (Lancichinetti and Fortunato 2009). The traditional method for discovering the presence of groups within a network is the clustering (Newman 2003, 2012) that, starting from a measure to evaluate the strength of nodes' connection, groups the elements in a hierarchical way. Nevertheless, the method does not always give adequate results, since it "group together those nodes with the strongest connections but leave out those with weaker connections, so that the divisions it generates may not be clean divisions into groups, but rather consist of a few dense cores surrounded by a periphery of unattached nodes" (Newman 2012, 27). An alternative method for partitioning the network in sub-groups highly connected has been introduced by Girvan and Newman (2002). They focus on the structurally important edges that connect more groups, by detecting the links that reveal higher betweenness values[22]. Such links have a central role in the network. The Girvan and Newman's iterative procedure calculates the edges betweenness and finds the edge with highest score, removes it and counts the number of subgroups created after the removal. As the algorithm iterates, different partitions are obtained. To establish the network's partitioning that better reflects the community structure within the graph, a measure named *modularity* has been introduced (Newman 2004; Newman and Girvan 2004; Newman 2006). It is a quality index for graph partitioning. Indeed, considering a network partitioned in *n* groups, such measure is calculated as the sum, for each community, of the fraction of observed links within the community less the fraction of the expected links in a random rewiring of the graph[23]:

$$Q = \underbrace{\frac{1}{2m}\sum_{ij} A_{ij}\,\delta(c_i, c_j)}_{\text{Fraction of observed links}} - \underbrace{\frac{1}{2m}\sum_{ij}\frac{k_i k_j}{2m}\delta(c_i, c_j)}_{\text{Fraction of expected links}} = \frac{1}{2m}\sum_{ij}\left(A_{ij} - \frac{k_i k_j}{2m}\right)\delta(c_i, c_j)\,, \tag{1.17}$$

where $k_i$and k_j are the degrees of two generic nodes *i* and *j*; A_{ij} is an element of the adjacency matrix; m is the amount of links in the graph (so that $2m$ is the total number of connected nodes); $\frac{k_i k_j}{2m}$ is the probability that elements *i* and *j* are connected between them; and $\delta(c_i c_j)$ is the Kronecker delta, that equals to one if *i* and *j* belong to the same community, and 0 otherwise. Therefore, modularity measure compares, for the all the groups emerged at each step of partitioning, the number of links within the communities with how many links one would expect to observe if the connections were distributed at random. Modularity allows to test if the observed groups emerge since they depend on a random connectivity between vertices (that is on the basis of chance), or if they are the result of a real community structure of the network. The underlying idea of this measure, aimed at detecting the goodness of a partitioning, is that a community of nodes should have more links between themselves than a random group of vertices. Modularity values range from 0 to 1, indicating that the fraction of edges inside communities is no better than the random case, or that the graph has a strong modular structure, respectively. The aim is to maximized such measure over all possible

[21] For an overview of the most common algorithms for community detection we report the work of Lancichinetti and Fortunato (2009).

[22] As introduced in the previous section, the edge betweenness is a measure that quantifies the centrality of a specific link as the number of the shortest paths that go through it in a graph.

[23] It is worth to note that the randomized version of the original network used to test the goodness of partitioning is created through a random rewiring procedure that re-allocates links but, at the same time, preserves the degree of nodes observed in the real network (configuration model).

assignments of nodes into any number of *r* communities. Then, the highest value of modularity suggests the best partitioning of the graph.
Eq. 1.17 can be rewritten by taking the sum over communities, making it clear that modularity is linear with respect to them. Indeed, after little algebra, modularity can be rewritten as

(1.18) $$Q = \sum_{r=1}^{C}(e_r - a_r^2)\ ; \qquad \text{with } a_r = \frac{1}{2L}\sum_{i \in r} k_i,$$

where *r* is the community of interest; C is the number of communities detected; e_r is the proportion of links in the community *r*; L is the total amount of links in the network; and k_i is the degree of a generic node *i*. The great advantage of modularity measure, also in computational terms, is that it is an additive measure that can be applied in a recursive process: once a community is identified, the following partitioning will be executed starting from each one of the already detected groups, and the modularity measure will be calculated for the new emerged modules. Such mechanism ensures that, once the quantity is estimated at step T, if the following partitioning gives a quantity, at step T+1, lower than the previous one, the process can be stopped at the previous step, and the subgraphs previously identified can be considered the best way in which the network can be partitioned. It is worth to note that both modularity and global clustering coefficient are adopted to measure the community structure and the groups' cohesion within a graph. Nevertheless, such quantities are not always directly proportional. It is in the case, for example, of regular graphs, in which the clustering coefficient may reveal high values and, on the contrary, modules are absent. At the same time, in the graphs composed by two sets of nodes qualitatively different, in which the connections are made possible just between elements belonging to different sets[24], the clustering coefficient is null (since triangles cannot be formed) but modularity value can be high. Finally, although modularity optimization is widely adopted for detecting community structure in graphs, it is not free from limits. The most recognized issue is probably related to the formulation of the random null model, according to which all the nodes can connect to every other vertex in the graph, just depending on the degree. However, such an assumption is questionable, especially for sparse networks, or for networks that represent complex social systems, in which individuals interact with a reduced portion of people that compose the network. Such a problem leads to a resolution limit: the small communities (composed by a very low number of nodes) are systematically forced to be part of larger groups, offering a misleading characterization of the underlying (hierarchical) community structure (Fortunato 2009).
To conclude this section, we may argue that the features highlighted until now reveal that, in the new science of networks, scale-free networks, small-world properties and community structure are some of the more interesting insights that complexity thinkers gave to the study of complex evolving networks. From these models, one can argue that these outcomes:

> "[…] gave researchers some confidence that complex networks, although overwhelming in their structure, are not entirely random. Instead, they adhere to one of the dominant principles of the universe: order exists amidst chaos." (Castellani and Hafferty 2009, 143)

This suggests that the network approach, more than just giving a description of the system's structure, is an essential tool to describe and model complex systems and their evolution.

3.2. Multipartite Networks

Until now, we introduced complex networks without making any distinction between the different nature of nodes that compose them. Simple, or *unipartite*, networks (in which the elements are qualitatively similar, such as colleagues, friends, or pupils attending the same school) are the typical

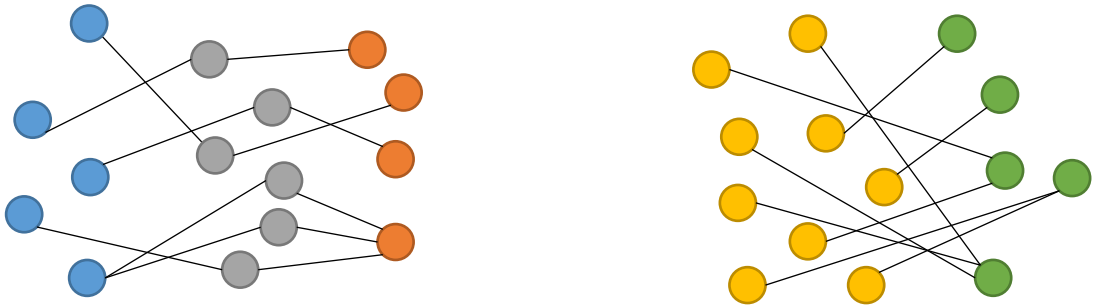
[24] Such networks, named bipartite networks, will be better investigated in the next sections.

framework for complex networks study. Nevertheless, the great opportunity provided by network approaches is to take into account an intrinsic feature of complex systems, concerning the nature of elements that compose them and their connections: their *heterogeneity*. As we have already outlined with regard to complex social systems, the elements that compose them, e.g. the social agents, and the interactions between such components may be of various kind. For example, people can be connected because they are part of the same group of friends, they are colleagues, they belong to the same neighbourhood and so on. At the same time, individuals often have interactions with elements that are qualitatively different from them, such as consumers that purchase goods and services, companies that trade stocks in the financial market, actors that play in different movies and so on. Therefore, elements' characteristics and their different rules of interaction introduce an important source of heterogeneity within the system that may deeply influence its structure and evolution. Let's consider a system in which all the components are homogeneous and they behave in the same way. In this case, any evolution would be perfectly predictable by knowing the behaviour of only one of the elements of the system. It is the heterogeneity of social agents and the different nature of their interactions that makes the evolution of a social system difficult to predict, since by introducing just a bit of heterogeneity within the system its behaviour may be considerably altered. As Miller and Page point out:

> "If heterogeneity is a key feature of complex systems, then traditional social science tools–with their emphases on average behaviour being representative of the whole–may be incomplete or even misleading." (Miller and Page 2007, 14)

Indeed, without considering the diversity within complex systems it becomes harder to infer their possible evolution. As a consequence, complexity scientists have to adopt appropriate analytic tools for taking into account the different nature of the elements and their interactions. In light of this, the network approach reveals to be adapt to consider the role of heterogeneity within the complex systems. It provides a description of the system that takes into account the different nature of the elements' connection (e.g. by differentiating between symmetric interactions, as in the case of family relationships, and asymmetric connections, as in the case of not mutual relationships, or by evaluating the strength of the connections)[25] and the different characteristics of the nodes. In this last case, the network approach gives one the opportunity to distinguish between the different nature of nodes. In particular, multipartite networks allow one to represent systems where connections can be set only between qualitatively different nodes. By definition, a k-partite network is composed by nodes that are part of k qualitatively different and independent sets. Two nodes of the same set cannot be directly connected between them, but they can share the same link with one or more nodes of the other sets (not necessarily with all the other sets: also direct connections between elements of specific different sets can be forbidden in some cases. For example, in chapter 3, we will consider a tripartite system in which it is not possible to observe a direct link between a specific family type belonging to set A, as nuclear family with children, and one (or more) purchasing product(s) belonging to set C, as television. Nevertheless, we can draw a link among the elements of group A and C, if one or more household(s) of set B, that belongs to the family type considered, made the specific purchase). Example of multipartite graphs rise from networks composed by $k = 3$ and $k = 2$ sets of nodes. Such graph structures are named, respectively, *tripartite and bipartite networks* (fig.1.6a and 1.6b).

[25] In section 3, we introduced how the science of networks allows to deal with the heterogeneity of links in terms of different type of relationships they describe, by assigning them signs, weights and directions. At the same time, it is worth to note that, depending on the nature of connections, the links are not always directly observable, so that it is necessary that the researcher conceptually defines which kind of relationship he wants to study. For example, in the study of brain connectivity, two brain elements are connected if they activate simultaneously during brain activity.



(a) (b)

Fig.1.6 Examples of the structure of multipartite networks. The tripartite graph is presented on the left (a), the bipartite one on the right (b). The different colours indicate the belonging of each node to a qualitatively different group.

The study of networks that reveal a bipartite structure has attracted the scientific interest in very different scientific fields, as table 1.3 reveals:

Set 1	**Set 2**	**Source**
Actors	Movies	Newman 2010; Tumminello et al. 2011
Criminals	Crimes	Tumminello et al. 2013
Mobile phone subscribers	Mobile phone calls	Li et al. 2014
Consumers	Item purchased	Newman 2010
Customers	Hotels	Kaya 2019

Tab.1.3: Examples of networks composed by qualitatively different sets of nodes (e.g. multipartite networks).

Beside the growing interest in bipartite networks, to the best of our knowledge, there are not network studies that consider more than two qualitatively different sets of nodes. Such an apparent lack of interest may be related to the fact that quantitative techniques for dealing with the heterogeneity of such particular systems have not already been developed. Nevertheless, tripartite structure can be easily detected in real-world systems. Let's consider, for example: 1) the respondents to a survey (set A); 2) their responses to specific domains of interest, such as their purchasing decisions, their political preferences, or their opinions about particular topics (set B); 3) and their socio-demographic information, such as work position, countries, family structure they belong to etc. (set C). Through these data, it could be possible to construct a graph with a high informative potential, composed by three qualitatively different groups of elements.

Many real systems can be represented as bipartite networks, also called two-mode networks in sociology. As regards such kind of multipartite structure, the matrix representing the connections between nodes that belong to two qualitatively different groups is an *incidence matrix* (Newman 2010). Let's consider N_A as the amount of nodes of group A, and N_B as the number of nodes of group B. Then, the incidence matrix M is an N_A x N_B matrix with values:

$$M_{ij} = \begin{cases} 1, \text{if node } i \text{ of group A is connected to node } j \text{ of group B,} \\ 0, \text{oherwise} \end{cases} \tag{1.19}$$

The incidence matrix is adopted to reduce the dimension of the representation of an n-mode network. Indeed, the impossibility that nodes belonging to the same set have a link between each other implies that an adjacency matrix, usually adopted for representing connections in one-mode networks, would be characterized by a huge amount of 0s.

Bipartite graphs have a long tradition in social sciences' studies (Faust 1997), that analysed them in terms of *affiliation networks*, in which the sets of nodes represent the social actors and the events (in a broad sense) they attend. Dual structure of such graphs allows one to detect sub-groups of elements belonging to one set, starting from the connections they have with elements of the other set. As an example, by considering an affiliation network composed by social agents and different leisure events

they may attend (such as concerts, football matches, theatre, museum etc.), one can detect different sub-groups composed by individuals that share the same interests for a specific leisure activity. This aspect is really interesting for social scientists, since, on one hand, joint participation in events provides the opportunity for individuals to interact, on the other hand, it also increases the probability that direct ties will develop between pairs of social agents, such as becoming acquainted or becoming friends (Wasserman and Faust 1995). In light of this, and by considering the importance to take into account the social context in which the ties arise and the influence of environment on the network structure, Feld suggests that "individuals whose activities are organized around the same focus will tend to become interpersonally tied and form a cluster" (Feld 1981, 1016).

In general, social networks represent systems in which the actors have direct social relations (e.g., they are friends or colleagues). In the case of bipartite social networks, typically, one set of nodes consists of subjects (or groups of them, such as households), while the other one includes entities to which subjects may connect to, e.g., institutions, social events, political parties, papers. In such networks, the presence of two subjects connected to the same entities likely indicates a potential or actual social interaction between them. Nevertheless, it is worth to mention that bipartite graphs are also widely used in order to describe the relationships among social agents and items: these are user-object bipartite networks, in which a link is set if a user selects a specific item (as a consumer who decides to buy a specific good). User-item networks are particularly relevant in the analysis of financial markets (Baker 1990; Bonanno et al. 2004; Onnela et al. 2004; Boginski et al. 2005), where investors (the subjects) buy and sell stocks (items) from other investors. Such an interconnectedness is at the very basis of complexity the arises in such a system. User-item networks are also widely used for marketing purposes: recommendation systems (Montaner et al. 2003; Massa and Bhattacharjee 2004; Walter et al. 2008), for instance, are heavily used by giants such as Google, Amazon, and Ebay (to mention a few) to suggest items of potential interest to their customers or users (Sarwar et al. 2000; Linden et al. 2003). The interest of scholars in user-item networks significantly increased in recent years, thanks to the possibility to precisely monitor the evolution of such systems, by collecting comprehensive data on e-commerce and market transactions. The main difference between *actor-actor* and *actor-item* ties is that, in the latter, the connection process begins with an individual choice (a consumer decides to buy a product, to watch a movie or to save a song in his personal playlist), whereas, in the former, a connection between two actors may arise as a consequence of a multiplicity of non-deterministic factors–endogenous or exogenous to the system–which, however, usually involve both the connecting agents. In other words, link formation in an *actor-item network* merely depends on the choice of the nodes belonging to one set, namely the social agents. On the contrary, in social networks, there is a joint decision of two actors to become friends, collaborate to the same project, participate in the same events and so on (Shang et al. 2010). Nowadays, useful insights about the users-items relationships are provided by the recommendation networks, that are mostly used by online merchants in order to detect people's preferences for online purchases (Newman 2010). Indeed, these bipartite networks usually represent two sets of nodes composed by individuals and items for which they show a preference or release a comment, such as users and their reviews on online movies database IMDb (Grujić 2008); consumers and purchased products on online firms; users and movies or songs they decide to watch or insert in their playlist (Liu et al. 2013). Recommendation systems in the shape of bipartite graphs allows one to detect similarities between consumers based on the list of selected items in common, and to provide personal suggestions to the consumers, on the basis of purchases made previously by individuals whose consumption patterns are similar to his.

Although the bipartite networks are mostly analysed by focusing on properties of one of the two groups of nodes (as it will be further discussed in the next section), some attempts to study the

bipartite structure by simultaneously considering the different sets of elements have been carried out (Feld 1981; Wasserman and Faust 1995; Guillaume and Latapy, 2004; Jesus et al. 2009).
In conclusion, in the last decades, a growing interest in study multipartite networks–especially concerning the bipartite ones–arose. In the empirical studies that are part of the present work, both the tripartite and the bipartite network's structures of real world systems will be considered.

3.3. Projecting and filtering Multipartite Networks

As we saw in the previous section, many real systems have an intrinsic multipartite structure that arises from the qualitative heterogeneity of the systems' elements. Whilst the multipartite network contains all the information of the complex network that represents (that is all the connections between nodes that belong to different groups), it is also the starting point to investigate the properties of a specific set of nodes. Indeed, considering a multipartite network, it is possible and very informative to focus on a particular set of elements in order to detect the association, that is, the similarity between them. To do this, the common way is to *project* the multipartite network on the set of nodes of interest (Newman 2010). Let's consider the simplest case of a multipartite network structure, the bipartite one, in which two sets of qualitatively different nodes are represented (fig. 1.7a): e.g. set *A* is composed by actors, set *B* is composed by movies and the links between the groups indicate in which movie (or movies) the actors played (Newman 2010). If the researcher is interested in investigating the association between the nodes of the group *A*, for example, he may create a projected network in which such elements are connected between them if they have *at least* one connection in common with the elements of the group *B* (fig. 1.7b). In the above example, the projected network on set *A* is composed by the actors, and the links between them indicate that they played together in at least one film. Obviously, the same procedure can be applied, in order to project the elements of group *B*. The resultant projected network allows the researcher to detect the similarity between two nodes belonging to the same group–according to the connections they share with the nodes of the other group. The connections between two elements of a projected network on set *A* can be weighted by assigning a value based on the number of nodes in set *B* to which both nodes are connected in the original bipartite network (fig. 1.7c). For example, by considering a set of items sold online and a group of consumers, we can suppose that the more purchases two individuals have in common, the higher is their similarity. Such association is widely considered by companies, which aim at detecting consumers who are similar in terms of purchase decision, for targeted marketing purposes: for that reason, it is not surprising to find, after an online purchase, recommendations about products that could interest the consumer, since they have been bought by customers that previously made the same purchase (and that can be considered similar). Such considerations cannot be generalized for all the types of connections, and the links have to be weighted with respect to the structure of the network and the research interests. In this regard, we may define a stronger association between two actors that played together in 2 movies in quality of main characters, and, at the same time, we may assume that two actors that played together in 10 movies with minor roles have a weaker connection. In the analysis of the one-mode network such differences should be taken into account.

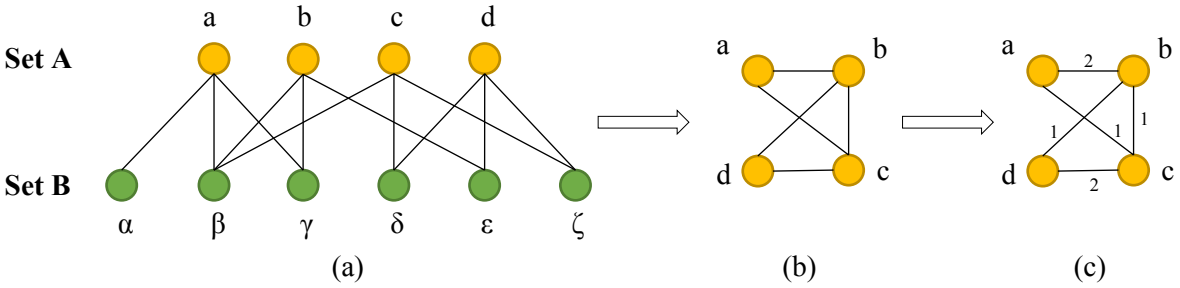


Fig.1.7: Graphical representation of a bipartite network (a), the projected network on set A (b), and the weighted projected network on set A (c). The different colours indicate the belonging of each node to a qualitatively different set (A or B).

The projected network, then, allows to study the similarity within a specific group of nodes based on their shared connections with the other set. Nevertheless, one could suppose that in the projected network some links are stronger than others or that the connections between two nodes come from random links with the same elements of the other group. For example, let's consider the bipartite structure composed by a group of online buyers and a group of products and let's suppose that a researcher aims to study the similarity of consumers, according to their purchasing choices. In such case, two buyers are connected in the projected network on set *A* if they have at least one item in common. Nevertheless, the purchase decisions, and then the connections, may be random. In these cases, it would be advisable to "filter" the system from the connections that probably occurred by chance. To test the association between the nodes in the projected network, under the null hypothesis of a random co-occurrence of the items they have in common in the other set–that is, in our example, to verify if consumers of set *A* have randomly chosen the same item (or items) from all those available in the set *B*–, Tumminello et al. (2011) introduced a statistical method to test the statistical significance of the connections between the nodes in the projected network (Tumminello et al. 2011). Let's consider that, in a bipartite undirected network, the set *B* is composed by N_B elements and that the elements *i* and *j* of the set *A* form, overall, n_i and n_j connections, respectively, with the nodes of set *B*. Let's suppose that we are interested in constructing a projected graph with the elements that belong to the set *A*, based on their co-occurrences with nodes of set *B*: what is the probability that *i* and *j* have *X* connections in common with nodes of set *B* (fig.1.8)? If we aim to express the previous example of online buyers and purchased products by means of an urn model (projecting on the set of consumers), this is equivalent to say: if person *j* randomly picks n_j items in the set of N_B available products, and counts how many of such items are intersecting with the n_i products picked by person *i*, what is the probability of observing exactly $n_{ij} = X$ products picked by both consumers?[26]

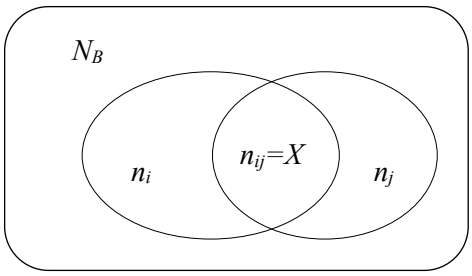


Fig.1.8: Intersection between the links of two nodes belonging to the same set.

[26] Since items in set B are heterogeneous in this example, the correct procedure would be to stratify set B according to the degree of items, construct several bipartite networks buyers-items, each one being homogeneous in terms of degree of items in subset B, and proceed with the statistical tests separately for each bipartite (sub)network (Tumminello et al. 2011, Tumminello et al. 2013, see page 35).

In this regard, the method of Statistically Validated Networks (SVN) introduced by Tumminello et al. (2011) proposes to test the co-occurrence of links between a pair of nodes against the null hypothesis that the elements of set *A* randomly connect to the nodes of set *B*[27]. The probability to observe the co-occurrence equal to *X* between a pair of nodes, is described through the hypergeometric distribution. Therefore, it is possible to associate a p-value with each test performed, as the probability to observe by chance a co-occurrence, *i*, between *i* and *j* that is higher or equal to the actual one, *X*:

$$p - value\left(n_{ij} = X \middle|\, N_B, n_i, n_j\right) = \sum_{i=X}^{\min(n_i, n_j)} \frac{\binom{ni}{i}\binom{N_B - n_i}{n_j - i}}{\binom{N_B}{n_j}} \tag{1.20}$$

A link between the generic nodes *i* and *j* is set in the projected network if the associated p-value is smaller than a specific threshold α[28]. In such a way, the reduced projected network that results from the filtering process will be composed by nodes of set *A* that show a *preferential link* (Tumminello et al. 2011), indicating that the weight in the connection of the two vertices in the projected network cannot be explained by a random co-occurrence.

Dealing with complex systems implies the necessity to consider the heterogeneity of the systems in terms of different number of elements' connections (that are the nodes' degrees). As a consequence, by adopting a network approach for the study of complex system's properties, the challenge is to develop statistical methods through which the researcher is able to take into account the relevant information on nodes and on the relationships between them, and to get rid of the uninformative links, that is, links which likely derive from random connections in the original bipartite network. In the case of bipartite networks, one deals with a double quantitative heterogeneity of the system: indeed, the nodes of both the set *A* and the set *B* may present different degrees that it would be better to take into account. The approach to statistically validate the nodes' connections in the projected network described above, offers the advantage to account for the heterogeneity of set *A* of elements. In the case of the set to be projected, e.g. the set *A*, the hypergeometric distribution guarantees that the different degrees of a pair of nodes are simultaneously considered in the performed tests: $\Pr\left(n_{ij} = \mathrm{X} \middle| N_B, n_i, n_j\right)$. Therefore, the hypergeometric distribution allows one to take into account both the *exact* amount of co-occurrences between a pair of nodes, and the *exact* number of connections that both nodes have with the other set. A specific procedure can be used to deal also with the heterogeneity of degree of elements in set *B* (Tumminello et al 2013 - see below). Moreover, the symmetry property of the hypergeometric distribution guarantees that, by changing the nodes *i* and *j*, the probability to observe a co-occurrence between the considered nodes remains unchanged: indeed, $\Pr\left(n_{ij} = \mathrm{X} \middle| N_B, n_i, n_j\right) = \Pr\left(n_{ji} = \mathrm{X} \middle| N_B, n_j, n_i\right)$. In this regard, let's consider, for example, a bipartite system in which the sets *A* and *B* represent the actors and the movies, respectively, and the links between nodes indicate in which movie each actor played. Let's indicate the set *B* as the urn containing N_B movies: if actor *i* draws n_i movies and replaces them into the urn before actor *j* choices n_j movies, or vice versa, it is exactly the same in terms of distribution of the co-occurrence n_{ij}. In other words, if we consider n_i as the number of successes and n_j as the number of draws (without replacement, of course, since an actor cannot play in the same movie two times), from a finite population of size N_B, it makes no difference to exchange the successes n_i with the sample n_j, due to the symmetry property of the hypergeometric distribution.

[27] In this example, we focus on projecting the set *A*, but the same procedure can be applied for creating the one-mode projection of set *B*.

[28] The methods for setting a statistical threshold α, corrected for multiple hypothesis tests, will be discussed in the second part of the current section.

Aimed to control also the heterogeneity of the other set of the bipartite network, e.g. the set *B*, in terms of degrees distribution, Tumminello et al. (2011) propose to partition the bipartite network *S* in S_k subsets composed by N_B^k nodes of group *B* with degree *k* and the nodes of group *A* that are linked to them. In such a way, the subgroup of nodes belonging to set *B* are homogeneous in terms of degree. Let's indicate as B_k the set of nodes of group *B* with degree *k*. If we consider again the nodes *i* and *j* of the set *A* with degrees N_i^k and N_j^k , that have N_{ij}^k common connections in B_k, the probability that *i* and *j* have the same connections with *X* nodes of B_k is described through the hypergeometric distribution introduced in equation 1.20, but, in this case, the tests of co-occurrence are performed in each subgroup in which the set *B* has been partitioned. The probability estimated through the partitioning of the set *B* in homogeneous groups of nodes is preferred to the one estimated through Eq. 1.20 when the degree of the nodes belonging to the set *B* is very heterogeneous. Nevertheless, it has been argued that, in some cases, the probability approximation obtained through Eq. 1.20 reveals quite good also if the nodes in set *B* show different degrees (Miccichè and Mantegna 2019).
As said, the nodes and links in the projected network are set when the null hypothesis of random connectivity is rejected. Nevertheless, it is worth to note that, in a complex network, the number of hypothesis to test is extremely high, considering that a statistical test is performed for each pair of nodes connected in the bipartite graph. Then, a multiple comparisons' problem arises from the process of statistical validation of all the links of the complex networks, and requires specific test corrections for multiple hypothesis testing. When performing statistical tests, the possible errors related to the evaluation of the null hypothesis are the following:

		H0	
		True	**False**
H0	**Not rejected**	Correct inference	*Type II error (false negative)*
	Rejected	*Type I error (false positive)*	Correct inference

Tab.1.4: Possible outcomes of the decision to accept or reject the null hypothesis H0. In the case of Statistically Validated Networks, H0 is that there is a random co-occurrence between elements that belong to the same set with elements belonging to the other set.

By convention, for accepting or rejecting the null hypothesis, an appropriate statistical significance threshold α (0.05 or 0.01) is pre-set by the researcher. Nevertheless, such level needs to be corrected in the case of multiple hypothesis tests, since the probability of committing false statistical inferences (type I error and type II error, in table 1.4) considerably increases. According to the SVN procedure, the type I error (that is, to reject a null hypothesis that is true, instead) leads one to set an incorrect link between two nodes in the one-mode network, generating a misleading result; on the contrary, the type II error (that is, to maintain a null hypothesis that is false, instead) leads one to not include a connection between two elements that actually should be set, resulting in a lack of information. The most common methods for p-values adjustment aim to guarantee to not incorrectly reject a null hypothesis when it is actually true, that is, to avoid type I error (Chen et al. 2017). With the aim to control the probability of obtain false positive results in SVN (also named "false discoveries", that are type I error), the Bonferroni and the False Discovery Rate (FDR) corrections for multiple comparisons are usually adopted. The Bonferroni procedure (Miller 1981) aims at controlling the *familywise error rate* (FWER), i.e., controlling the probability of rejecting *at least* a null hypothesis that is actually true. Specifically, the Bonferroni corrected threshold is calculated by dividing the original significance threshold α by the number of performed tests. It implies that, for a given p-value p_i the null hypothesis $H0_i$ can be rejected and, as a consequence, a link is statistically significant, if:

(1.21) $$p_i < \frac{\alpha}{M}.$$

In the equation above, α is the level of statistical significance set by the researcher (e.g. 0.01 or 0.05) and M is the total number of tests performed. The Bonferroni procedure, which creates a statistical level of significance α_1 lower than the pre-set one, is very conservative, since it strongly reduces the probability of getting a false positive result. Such a correction minimizes the rate of false positives, but at the cost of a (potentially) large number of false negative results. When the amount of multiple comparisons is high in presence of low statistics, the Bonferroni correction could be too restrictive, making it the resulting SVN too small and uninformative, since affected by a high number of false negative outcomes. In this case, the risk for the filtering procedure of complex networks is that the number of connections in the filtered projected network could be very low, with few validated links, and a large amount of missing connections (false negatives).

To face such an issue, the False Discovery Rate (Benjamini and Hochberg 1995) is considered a valid alternative method to correct p-values for multiple comparisons, in the construction process of statistically validated networks. It is less restrictive, as compared to the Bonferroni correction, since it allows to control for the *expected proportion* of false positive results (that is the proportion of wrongly set links), in the overall tests performed. On the contrary, the Bonferroni correction aims at controlling the probability of *at least* one false discovery. For such a reason, the FDR method is recommended also in cases in which there is a low number of elements in the network, and the Bonferroni method could give limited, although robust, results. To achieve a FDR correction, the p-values of different performed tests are arranged in increasing order. Then, for the specific p-value p_k, ranked in the k-position of ordered p-values, the null hypothesis $H0_k$ can be rejected and, as a consequence, a link is statistically significant if:

(1.22) $$p_k < \frac{\alpha * k}{M}.$$

In the equation above, M is total amount of tests performed, k represents the position of the p-value p_k, in the list of ranked p-values, and α is the level of statistical significance set by the researcher (e.g. 0.01 or 0.05). Both the FDR network and the Bonferroni network (created through the FDR and Bonferroni correction, respectively), are then the result of a filtering process of large bipartite systems. It is worth to note that the p-values corrected with Bonferroni method are included in the FDR procedure of correction. Therefore, the Bonferroni network is properly contained in the FDR network.

In conclusion, SVN technique reveals as a very flexible method to investigate many different types of complex bipartite networks. Indeed, it has been widely adopted to study the structure and the properties of very heterogeneous systems, such as financial system (Tumminello et al. 2012, Curme et al. 2015, Hatzopoulos et al. 2015), interbank market system (Iori et al. 2015), biological system (Coronnello et al. 2016), communication system (Li et al. 2014) etc.

The next chapter of the present thesis aims to adopt the concepts of complex systems theory, and the innovative methodology developed for analysing complex networks, for the study of family consumption. With regard to the methodological approach, in the empirical part of the work (Chapter 3), a generalization of SVN will be adopted for the study of tripartite networks, in which the three sets of nodes reveal different degrees of heterogeneity, and are composed by 1) family types; 2) households; and 3) expenditure categories for different goods and services, in which households may allocate their family budget.

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CHAPTER 2

Complex Systems as a Theoretical Framework for the Sociology of Consumption

Abstract

The scientific interest in consumption has its roots in the 20th century and has grown in the last decades. Classical and contemporary sociological approaches to consumption aim at detecting how it rises, the symbolic value that consumers attribute to products and services they experience, the influences on individuals' consumption choices, and how consumption is reflected in practices that determine lifestyles. Nevertheless, sociological scholars never treated consumption as a complex system, taking into account the multiple dimensions that generate it and adopting a holistic approach to study how different patterns of consumption emerge from people's interactions. In this regard, we present the main classical and contemporary sociological approaches for the study of consumption, with the aim to underline their limits and the points of connection among some theoretical intuitions and the complex systems' theory. Therefore, we propose to frame the sociology of consumption in the theory of Complex Systems, in order to highlight the opportunities of knowledge provided by such a new approach. In this regard, we introduce the characteristics of families and their consumptions that allow us to consider and analyse them as elements of a complex social system. More in detail, we demonstrate that: 1) in the evolution of family structure, emergent phenomena as the rise of a new family type composed by young (worker) adults that still live with their parent can be detected, resulting from multiple dimensions that interact among them, and having an impact on different systems, included consumption; 2) the technological progress changes consumers' habits, involving both the demand and supply, this shows the mutual influence among consumption and production systems; 3) households and their expenditures reveal a strong heterogeneity, both qualitative and quantitative; 4) family expenditures can be affected by exogenous or endogenous events that alter households' consumption habits; 5) patterns of consumption that are characteristic of specific family types or geographic areas can be detected; 6) mechanisms of information cascade, herding and adaptation modify households' expenditure habits. Through this work, our aim is then to demonstrate how the theoretical framework of complex systems well adapts on the study of consumption under a sociological perspective.

Keywords: sociology of consumption, complex systems, households, expenditures.

1. Theories of Consumption

1.1. Sociological approaches as specific perspective to consumption

The studies on consumption in sociology, and in social sciences in general, exploded in the middle of the 20th century and have grown in the last decades, through a wide range of theoretical approaches and an increasing interest with respect to different types of consumption (Miller 1995; Corrigan 1997; Blue 2017; Askegaard and Heilbrunn 2018). However, it is a difficult challenge to clearly define the historical period in which consumption started to attract the interest of social scientists. In this regard, major scholars of contemporary age date the origins of consumption's interest in different epochs. For

example, Chandra Mukerji, in her study on the origins of Western materialism (1983), leads back the new forms of consumption to the born of a *materialistic culture*, that she dates in the Renaissance period (between the 14th and the 17th century). In this epoch, the commercial revolution leads to a new western economy based on maritime trade, facilitating the introduction, in occidental societies, of new products that come from exotic countries. As a consequence, starting from the 15th century, one assists in the early changes of individuals' consumption habits and in the new interests of consumers towards material goods: such behaviours will become more evident during the industrialization period.

Indeed, it is in the 18th century that we assist to the burst of a *consumer revolution* (McKendrick et al. 1982), resulting from the socio-economic effects of industrial revolution. In particular, the industrial revolution leads to: 1) the mass production of standardized goods and services, and the related growth of new needs and desires; 2) the adoption of marketing strategies (such as advertised products through hoardings and magazines); 3) the entry of women into the labour market, and the related purchasing power they obtain (McKendrick et al. 1982). All of these factors strongly modified the idea and the ways of consumption, by giving the opportunity to men and women belonging to the lower social classes to purchase products that, until then, had been prerogative of richer classes. Such a period marks the birth of the *modern consumerism*: the significant increase in demand of products relies upon the fact that the "new consumers" reveal the willingness to buy inessential goods, overcoming the traditional attitude to save money and allocate their income just in order to face with primary needs. We are dealing with a new attitude towards consumption: in this regard, the debate on consumption overcomes the traditional (and restrictive) economic view of supply and demand, by placing in the broader context of social science (Campbell 2018). A renewed interest on the *motivations* behind consumers' behaviour emerges, driving towards the birth of the new conceptualization of a *consumer society* and the implications that it has for sociological theory.

Other scholars agree that a deeper interest in consumption dates from the Second World War, when the occidental societies experienced a boom in economy that generated employment, improved the quality of life, strongly modified people's lifestyle and, as a consequence, gave rise to new habits and new forms of consumption. Although in this period, between the industrial revolution and the Second World War, consumption was still not a central topic in social sciences, it was already well recognized that the macro-economic changes strongly affected people's patterns of consumption and, starting from this, a new sociological interest emerged, together with a new vision of consumption as a *social phenomenon*. This is the period in which academic scholars start to study the process and the content of consumption itself and in which one may date the born of sociological approaches as specific perspective to consumption (Blue 2017). Rather than a new interest in consumption, maybe it is better to talk about a *new idea* of consumption that develops in the second post-war period: indeed, practices of consumption are no longer considered just merely tools through which one may satisfy personal needs, but, on the contrary, they are viewed as activities that have strong implications on people's existence and to which consumers give specific meanings (McCracken 1987). This idea of consumption, that will be developed throughout the 20th century, implies that the items (in a broad sense) that people consume communicate their social position, reflect the socio-economic changes, make and maintain the social relationships and create self-identity. Such concepts are clearly highlighted through Paterson's words:

> "Especially with newly experienced post-war affluence, young people in particular had more money to spend, and more things to buy with it. Marketing advanced in order to accelerate this process, and interesting and notable cultural phenomena started to become visible, such things as changes in gender relations, in perceived status, expressions of individual and group identities and subcultures; notions of belonging, of taste and style. Along with these sometimes highly visible phenomena, other

less visible cultural effects arise out of consumption too. By examining consumption as one thing people 'do', therefore, we are also discovering a series of cultural effects […]" (Paterson 2005, 2).

The "cultural effects" cited by Paterson will be widely investigated by sociologists during the 20th century, giving rise to studies that adopt sociological approaches by analysing consumption as a distinct sphere of human activity and by overcoming the traditional view of economics, that considers consumption as a merely utilitarian aspect of everyday life (e.g. appropriation of goods and services) and as dependent on production system. In this regard, it is worth to note that economics became interested in consumption before other social sciences. It was the first discipline to differentiate between production and consumption processes, and to define the role that consumption has in modern societies (Sassatelli 2004). However, the approach adopted by economists in studying consumption patterns is extremely different from the sociological one. Indeed, for a long time, economics considered and analysed consumer's behaviour as the result of an individual *rational choice*. Such consideration is on the root of the *Homo Oeconomicus* model introduced by classical economists, according to which consumer is a rational individual, having tastes and preferences that are independent from the desires and the influences of other people. To satisfy his own needs, consumer acts in a rational way, by gathering information on goods, analysing all the possible alternatives and finally choosing specific products in order to maximise his own usefulness. Nevertheless, such a model has its limits: in a complex society, in which every individual has to deal with many different offers and stimuli, a complete consciousness and an objective assessment of all possible alternatives become impossible to acquire. Moreover, classical economics does not investigate the motivations behind consumption, on the contrary, it is mainly interested in how people's needs and tastes are reflected on purchasing choices. In this sense, the economic model of *homo oeconomicus* ignores the formation process of consumers' preferences–especially in relation to the social and cultural factors that influence them–, and the meaning that individuals attribute to the purchased goods.

Under a sociological point of view, it is clear that the economic approach is inappropriate to understand and explain consumption practices[1]. In summary, what may be considered deeply different among sociological and economic approaches is the perspective through which consumer's needs, tastes and attitudes are analysed: whilst they are considered as "innate" for economics, sociologists look at them as socially constructed, and influenced by social context in which consumers live (Miller 1995).

1.2. Classic, modern and contemporary sociological approaches to consumptions

Although it is quite recent, the sociology of consumption is a specific field of sociological studies so broad and variegated that it is not possible to discuss comprehensively all the different theoretical approaches and the corresponding empirical studies here. Nevertheless, we try to give an overview of the history of consumption, by identifying the major theoretical contributions on topic that have influenced the way in which consumption's practices have been conceived and empirically studied, and by reading such approaches in view of the complexity theory that we will adopt for the study of consumption.

[1] It is worth to note that modern economists tried to overcome the limits of the classical rational choice's model. In this regard, Hebert Simon introduced the idea of *bounded rationality* (Simon 1983), according to which individuals cannot consider all the possible alternatives for a series of human limits (such as lack of memory, time, knowledge and so on). For this reason, people tend to adopt the first solution (and the strategy of consumption) that they evaluate as the more satisfactory among the limited alternatives they can consider.

To trace the evolution of the sociology of consumption, we start from classical social theorists as Marx and Veblen that, although interested in consumption only incidentally in order to capture the nature of modern industrial societies, gave ample coverage to reflexions on consumption in their main theoretical works. According to Marx, goods and services–or *commodities*, as he calls the items produced to satisfy human needs–are the result and the manifestation of human labour power (Marx 1867; tr. en. 1974). Nevertheless, in the market economy, he notes that people conceive the value of commodities as if it were "inhered in the objects themselves, rather than in the amount of real labour expended to produce the object" (Paterson 2005, 16-17). He denominates such an attitude "commodity fetishism", in order to highlight that as soon as a good or a service acquires *exchange-value* (when the object acquires a symbolic value higher than its material use), individuals tend to neglect that such a commodity has been produced through people's labour. In light of this, market forces acquire more power than labour forces in affecting items' values given by consumers.

Beyond the Marxist theories, another contribution to the literature on consumption comes from Veblen, that introduces the idea of "social emulation" and "conspicuous consumption" to define class consumption in the United States at the end of 19th century (Veblen 1899). Veblen claims that all the people, without distinction of social position and income, have the same desires of consumption. In light of this, the concept of social emulation highlights that people belonging to lower classes tend to emulate lifestyle of upper classes and, once they take over the attitudes, goods and services specific of richer people, the latter leave such habits in order to adopt new styles of consumption that differentiate them from lower classes. This implies that consumption becomes a way to express the social prestigious of higher classes through the purchased goods, and to create (and maintain) clear boundaries among social classes. In this sense, the value attributed to the items is merely economic: the greater the economic value of good, the greater the prestige of consumer, that tends to flaunt his wealth in order to maintain status differences clear. Such an attitude is defined by Veblen "conspicuous consumption" and it is typical of capitalists, that do not directly produce goods and services, but consume products resulting from the work of other people.

The critical views of consumption introduced by Marx and Veblen at the end of 19th century influence the second post-war wave of theories, carried out by the Frankfurt School, whose leading figures are Horkheimer and Adorno[2] (1947; tr. en. 1973). These scholars introduce a new idea of *mass culture industry*, according to which consumer capitalism orients people to purchase products for satisfying fruitless desires, or "false needs" (Paterson 2005), created by mass culture industry, rather than primary (and real) needs. According to this view, Adorno and Horkheimer outline the idea of a *mass society* that consumes *mass culture*, intended as the set of products specifically created for the enjoyment of a massive amount of people–such as popular music, theme parks, Hollywood films and so on (Paterson 2005). Consequently, the media (as radio, television and press) are considered as functional tools of the capitalist system, through which the new desires are promoted and the critical judgment of consumers is nullified. Frankfurt School's theorists introduce then a new idea of consumer as a man weak, passive and easy to manipulate. As a consequence, goods produced (and sold) in standardised forms lead to the homologation of consumption's practices and to the destruction of consumers' individuality (Miller 1995).

We have to wait until the *Cultural Studies*, introduced in Great Britain in the late 1950s, for observing a new theoretical approach to the study of consumption opposed to the concepts of Frankfurt School (Hall 1973; Fiske 1989). Instead of considering consumption as a mean of social control and consumers as passive individuals, Stuart Hall and the scholars of Centre for Contemporary Cultural Studies (Birmingham University) introduce a new idea of consumption, by reaffirming the role of

[2] Some sociologists agree that it is the first time that consumption is treated in a sociological sense (Warde 2015; Blue 2017)

consumer in purchasing choices and in value-assignment to products. This view of consumption has its roots in the idea that consumers play an active role in purchasing decision, by evaluating goods and services offered by market and by choosing the products that better reflect their needs and desires. This is the process that Stuart Hall describes as *encoding-decoding* (Hall 1973): the encoding moment occurs when the producer gives a "meaning" to the product addressed to the consumer, and the decoding process occurs when the individual receives and interpret such meaning. Hall argues that a consumer can adopt different forms of decoding: 1) in accordance to the meaning given by the creator, 2) in contrast to such meaning, 3) or negotiated between the meaning imposed by the producer and the consumer's elaboration.

In the same period in which scholars of the Centre for Contemporary Cultural Studies emphasize the active role of individuals in consumption process and the symbolic value attributed to products, Pierre Bourdieu carries out empirical studies on consumption which probably have had the strongest impact in the history of consumer's theories, influencing the subsequent theoretical developments. According to Bourdieu (1979), people's consumption choices are strongly connected to their social positions and are means through which upper classes, that enjoy *legitimate culture* (e.g. classical music, fine arts and theatre), differentiate them from the lower social strata, that consume popular (or mass) culture. Bourdieu introduces, for the first time in consumption studies, the concept of *cultural capital*, strongly connected to the social origin and the level of education, which represents the set of cultural consumption practices, tastes and lifestyles adopted by each individual. Cultural capital, together with financial resources (economic capital) and relational resources (social capital), becomes a tool for the hierarchical classification and differentiation between classes, in a perspective that considers consumption as the new reflection of the social structure. In Bourdieu's thought, *habitus*, that is unconsciously internalised by individuals, generates the practices of consumption, that are characterizing of each social group. Therefore, specific patterns of consumption guarantee the distinction among social classes and their social reproduction. Although Bourdieu's theory and his empirical works strongly influenced the subsequent studies of consumption (Sobel 1983; Katz-Gerro 2002; Aydin 2006; Lizardo 2008), they were also criticised, and new approaches, probably more appropriate to deal with the changes occurred in post-modern societies, have been recently adopted.

Among all, Peterson's theory had a strong success (Peterson 1992; Peterson e Kern 1996). Such an approach distinguishes between *omnivore and univore consumers* in relation to cultural consumptions: people belonging to upper classes have greater cultural capital through which they can enjoy all the practices of consumption, from the legitimate ones to the popular ones (they are *cultural omnivores*); on the contrary, individuals of lower social strata have a lower cultural capital and a narrower range of consumptions, all belonging to the lowbrow culture[3], that they may understand and appreciate (they are *cultural univores*). In this view, the distinction among social classes relies upon the heterogeneity of cultural products that individuals belonging to different social strata–and with different cultural capitals–may consume.

Sociological approaches to consumption in contemporary age have also been influenced by Bauman theories on *liquid society*, where an individual may shift from one specific consumption to another in a fluid manner. The *homo consumens* of post-modern society (Bauman 2007a) enjoys goods and services in order to feel part of a social group in which he recognizes himself. Nevertheless, the gratification given by the consumption in contemporary age does not last long, but it is just a temporary satisfaction. Individual's consumption is in constant evolution: as soon as the he feels gratified by a consumed good, the market provides a new and more attractive product, pushing him to orient his desires towards new consumptions in order to satisfy his new needs. As a consequence, in

[3] The term "lowbrow culture" indicates the set of attitudes, tastes and consumption choices lacking any artistic or intellectual ambition, attributable to the cultural products created by mass industry.

post-modern society, it is impossible for individuals to be fully satisfied. Consumerism (Bauman 2007b), therefore, bets on the irrationality of consumers, and this is how the consumer society survives: creating desires that are not fully achievable and constantly replacing them with new ones.
Finally, this brief excursus on the main theoretical approaches embraced by the sociology of consumption, should include the *theory of practices* introduced by Bourdieu (1979) and widely adopted by contemporary scholars. Specifically, Alan Warde proposes to adopt the practices theory as a theoretical framework to better understand the processes of consumption, by paying more attention to the *ways of consuming* rather than to the goods consumed (Warde 2005; Warde 2017). Indeed, analysing consumption as practice allows one to overcome the idea that consumer's behaviour solely rises from a rational choice–as classical economics argued–, or from an individual decision, related to the symbolic meaning given to consumption and to the development of self-identity through specific consumption choices and styles of life. These approaches do not consider that consumptions can be the result of endogenous factors (e.g. peers' influence) or the result of practices embedded in people's everyday life. Consumption, intended as *practice*, involves an *appropriation* of the good consumed (Warde 2017). Such an appropriation implies an active engagement of consumers: people are constantly exposed to different inputs (that come from, for example, radio broadcasting, television programs, new technologies etc.), nevertheless some inputs may not have a concrete impact on people lifestyle. When the mere use of a service or a product results in practices that become part of people's routine and lifestyles (e.g. the preference for using specific social media compared to others, the choice to produce social media content, the awareness that new technologies may be used for purposes that do not only concern leisure time), the process of appropriation begins and people start to attribute a symbolic meaning to the routine experiences they do. Such a practice of appropriation is in line with, and, at the same time, influenced by, the attitudes, the tastes and the styles of life shared by the social group to which people belong (Bourdieu 1979). In the last years, the new sociological studies adopted the theoretical framework of practices' theory in order to analyse new topics and new aspects of consumption's choices, such as sustainable and digital consumption (Røpke 2009; Eden 2017; Feiereisen et al. 2019).

1.3. Households consumptions: a brief literature review of sociological approaches

Under a sociological point of view, consumption is considered an individual human activity influenced by the social context in which individual lives, developing his desires, tastes and attitudes. This is the reason why sociologists of consumption show a growing interest for the first social group that affects human behaviour: that is the *family unit*. Indeed, family plays a central role in influencing individual consumption attitudes since, for each consumer, household represents the first social context in which he discusses with other members about purchasing choices and he develops his own identity through the goods he consumes. As Epp and Thomas point out, "family acts as a key organizing force that shapes our behaviours and experiences in the marketplace" (Epp and Thomas 2018, 40). Notwithstanding the sociological interest on household's consumption, it is worth to note that, actually, the first studies on families' purchasing habits have been carried out by economists. The results of economic analysis reveal which kind of goods and services households prefer, and how families decide to distribute their budget. However, such studies do not consider which dimensions may affect consumption patterns–mostly in terms of internal dynamics between family members–, the meaning that people give to the purchased products, and the motivation behind consumption choices. These points are, instead, the dimensions of interest of sociological studies on families' consumption: analysing the material culture of households (e.g. the goods and services purchased) may reveal interesting insights about the consumer's identity formation, the interactions among family members and the development of family consumption's patterns. Moreover, by adopting a sociological

approach for the study of family consumption allows one to overcome the idea that household and market are two separate spheres and to accept that the market logics are part of everyday life[4] (Epp and Thomas 2018).

Empirical sociological research on households' consumptions mainly focused on the influence in decision-making processes exerted by different members of family (Davis 1976). In fact, as studies of households' consumption reveal, family's purchasing choices are the result of attitudes, tastes, needs and choices of different family members that merge together (Epp and Price 2008), and that are mediated within the group in accordance to different roles, strategies adopted and purchasing power of components. Indeed, although the family may be considered and analysed as a consumption unit, in which everyone is involved in the decision making process and the choices of consumption are oriented to meet the needs of all family members (McDonnel 2013), its components do not have the same power to influence the purchasing choices. Such a consideration is the reason why the traditional scientific interest of researchers focused on discovering which family member affects more the choices of consumption and how internal dynamics are adopted by members in order to increase the decisional power.

For the sake of brevity, we may classify the main studies on households' consumptions in two major groups: women influence-oriented and children influence-oriented. The former had a rapid growth in the 1980s, following the increase in labour force participation rate of women, which, as a consequence, modified the structure of family units along several dimensions, including income, time dedicated to home and children care, and general services. In this regard, Soberon-Ferrer and Dardis (1991) focus on couples in which both parents are workers, with the aim to detect the impact of family composition and female working hours (part-time or full-time), age and education on family expenses for different services, such as children care and clothing, domestic services, food away from home and personal care. The results show significant differences in households' expenditure patterns depending on wife's working hours. In families with a full-time working woman, variables as income, education level and family composition, significantly affect the expenditure on food away from home and other services; on the contrary, just the wife's working hours are significant for the expenditure on children care, according to the leading role of women in this domain. The age of wife has an impact on personal care, but it has not significant effects on clothing expenditure and domestic services; on the contrary, women with a higher educational level spend more on clothing, personal care and domestic service. According to the interest towards the female impact on family consumption, Martinez and Polo (1999) focus on the female role in decision making, investigating whether the husband, the wife or both decide in which products and services allocate the family economic resources. The results show that, in general, there is a high level of co-decision in young couples in which the wife works. Indeed, in these family structures, man and woman decide together, especially with regard to the purchase of very expensive goods (as vehicles, house, furniture etc.) and expenditures that involve important decisions (as insurance, investments, holidays etc.).

More recently, the study of children's impact on household's purchasing decisions attracted the interest of scholars, according to the idea that the offspring are not passive actors in the decision-making process, but they can exert influence like the other members. In this regard, Cotte and Wood (2004) adopt a consumer socialisation approach, in which the future position of young consumers in the marketplace will be the sum of skills, knowledge and attitudes that the young people acquired from several socialisation agents. Considering parents and peers as the main socialisation agents, the

[4] To highlight the contemporary thinning of boundaries between the private sphere of family and the market, we may consider how technological devices invaded intimate connections (with both positive and negative consequences), or market encroachment in travel programs, through holiday packages customized for every specific target of household.

researchers investigate the inter-generational and intra-generational influence on young people in the purchase of technological products. The analysis shows that the parents' influence is higher than the peers' one on the developing of children purchasing behaviour. According to this, children future consumption will be more affected by their parents' teaching, values and attitudes than their peers' influence. In studies cited until now, the relationships among the family members and their influence are investigated in terms of dyads–husband-wife and parents-offspring–, not considering the entire family structure. It is probably due to the complexity of considering the simultaneous and mutual influence of more than two family components in decision making processes. To overcome such a limit, Filiatrault and Brent Ritchie' s research (1980) considers multiple actors in the choice of the expenditure on vacation, investigating the influence of husband, wife and offspring. The results highlight little direct influence of children on the decision process, though they can exert greater influence by forming *alliances* with either parent to form a majority position. The study suggests that children influence should be investigated in light of specific mechanisms they adopt in certain phases of decision process. In this view, the work of Thomson et al. (2007) attempts to investigate in which steps of decision process children have major influence. The authors outline that the offspring's most adopted strategy for influencing parents' decision is the *experience*, as the sum of knowledge and information that they implement during the decision process. For example, from the interviews about the choice of vacancy destinations, it rises that the willingness of taking part of the decision pushes children to gather information on Internet and show the alternatives to their parents. Parents confirm that knowledge that children add to the purchase decisions is taken into account and perceived as beneficial: the more information the children give, the greater their influence in the purchasing process is. The results of the study also reveal that, when the knowledge is not sufficient to influence parents' decision, children adopt further strategical behaviours, such as the *coalition*, both inter-generational (with one parent) and intra-generational (with siblings), in order to increase their influence. Finally, the studies of households' consumption also considered the impact of different generations in influencing purchasing choices of parents and offspring. An example of such approach is given by the study of Moore-Shay and Lutz (1988). The aim of the scholars is to detect if and to what extent consumption's attitudes and preferences are transferred from the older generation to the younger one. For this purpose, the authors investigate how mothers and daughters share specific brand preferences and shopping strategies. The results highlight a significant agreement among mothers and daughters in relation to the brand preferences. However, concerning brand loyalty, daughters seem more inclined to experience new brands and products than their parent. Such a result confirms the new generation's tendency to be more open to the novelty and more influenced by advertising than the previous conservative generation.

Finally, in this brief overview on sociological approaches for studying households' consumptions, it is only right to mention to what extent the new relevance of sustainable consumption impacted the empirical works on families' purchase decisions. Indeed, the contemporary shift of interest towards new forms and ways of consumption oriented to sustainability pushed scholars to analyse if families perceive social and environmental changes as a problem and how they adopt patterns of sustainable consumption in order to face these new global issues (Hobson 2003; Holden and Norland 2005; Tukker et al. 2010; Pellandini-Simányi 2014; Wheeler and Glucksmann 2015; Walker et al. 2019). In this regard, recent scientific research focused on recommendations and policy interventions aimed at improving households' interest to adopt strategies of consumption more ecologically and socially sustainable. Among the others, it is worth to mention the increase of the co-housing practice, that has a low environmental impact and, at the same time, limits the problem of alienation and social exclusion (Stevenson et al. 2016; Tummers and MacGregor 2019); the policies of reduction of water,

energy and food waste (Foden et al. 2019); and the retail strategies adopted to orient the consumer to make sustainable choices in the marketplace (Ehgartner 2018)[5].

2. Complexity as a unifying framework of Consumption Theories

2.1. Consumption as complex social practice: a new paradigm or just a new sociological approach?

As we noticed in Chapter 1, the *complexity turn* (Urry 2005) had an impact on the way in which the emerging social phenomena are considered and studied. New concepts (as elements' interactions, self-organization of social agents, emergence, environment's influence, system's adaptation, feedbacks mechanisms etc.) arose in different scientific fields such as biology, physics, economics and so on. While a complex system's view of the world has been also introduced in some branches of the social sciences, such as marketing and economics (Simon 1996; Allen et al. 2011), there is still an overall lack in sociology of studies that adopt such approach in order to analyse social phenomena under a complexity's point of view. Such a lack is due to the fact that sociologists tried "to understand the changing complexity of western society, but [they were] still basically unprepared to do so" (Castellani and Hafferty 2009, 17), probably for a resistance to abandon the classical reductionist approach, to overcome the dichotomy between micro and macro analysis and to adopt the new methodological tools introduced by complexity science in order to model the outcomes of an evolving society. However, some scholars reveal that sociology, and social science in general, are not unfamiliar with many concepts of complexity theory (Page 2005; Sawyer 2005; Davis 2019):

> "Some scholars see the complexity sciences as transformative, as a "new kind of science" that will disrupt current scientific practices (Wolfram 2002). I stake a more modest claim and suggest that the complexity sciences hold promise as a complement to existing methods of social scientific inquiry by shining light and focus on unasked questions" (Page 2005, 22).

Page's words suggest that the great contribution of complexity science is that it offers new ways (both theoretical and methodological) to address the growing complexity of social systems. Nevertheless, there is still not an agreement among the scientific community if complexity is a new paradigm that completely distorts previous sociological theories, or if it is a new approach for investigating social questions that sociologists have been asking for a long time (Davis 2019).
What is certain is the lack of sociological studies on consumption that adopt a complexity perspective. In light of this, the aim of the present work is to introduce the complex systems' theoretical framework for the study of consumption in order to demonstrate that, as well as in biology, economics, physics and other disciplines, it offers new opportunities of knowledge and new insights. What allows us to adopt the complexity framework for studying consumption is that in the complex social system composed by households and their purchase decisions, we detect some main features of complex systems[6], introduced in the first chapter. Our assumption is that since complexity science focuses on system's processes (such as feedbacks, adaptation, emergence, self-organization, non-

[5] Although, in the empirical studies of the present thesis (Chapter 3 and 4) it would have been interesting to investigate the family consumption behaviour also with respect to the growing scientific interest in sustainability, lack of suitable microdata prevented us from pursuing this line. Nevertheless, it is worth to mention that environmental policies and aggregated data on sustainable consumption are provided by the major international agencies, as OECD (2012), European Social Survey (2018); Eurostat (2019), and so on. They represent a big source of information that researchers may use to improve the scientific discourse on topic.
[6] Such features will be further explained in section 4.

linearity etc.) that can be detected in society, these processes can also be identified in consumption practices. Mainstream social research concentrated on the individual behaviour, considering a wide range of dimensions that affect consumption choices (peers pressure, attitudes, goals). However, it neglected how consumption, in terms of aggregated behaviour, rises from local interactions among social agents. Indeed, consumption choices are socially constructed and are one of the possible results of multiple interacting dimensions that influence them. In light of this, in order to study consumption's patterns, we have to look at them as phenomena that rise from the local interactions between social agents and from mutual influence among the system and its environment. The advantages to adopt complex theory as theoretical framework is that it allows the researcher to change its point of view, by considering a specific pattern of consumption (e.g. the birth of a new fashion trend) as a phenomenon that emerges from multiple possibilities. For a complexity theorist, social system is the result of social practices (Castellani and Hafferty 2009): if consumption is a social practice, and a social practice is a part of a system, then consumption can be analysed in terms of a complex system. Classical sociology has always considered the different objects of study as "ontologically given" entities: society, man, culture, and also consumption. The mechanisms that generate them and their different evolutions have never been questioned: the theory of complex systems allows us to adopt a new approach, in which the only assumption is that the "subjective social action at the local level can be reified into objective structure at macro level through distributed interaction" (Davis 2019). It means that, by adopting a complexity approach to study consumption, nothing is supposed a priori and all the possible outcomes of the system's evolution are expected.

2.2. Tracks of complexity theory within classic and modern sociological approaches

Although scholars started to adopt the complexity framework for the study of social systems only in the last decade, it may be interesting to detect tracks of complexity theory within sociological approaches, in order to reveal that social complexity has always been part of the sociological discourse, more or less explicitly. In such effort, we try to adopt a critical reading of the main consumption's theories, keeping in mind the characterizing features of social complex systems presented in Chapter 1.

Frankfurt School–with its theories on tastes' homologation, passive consumers and loss of individuality– probably may be considered as the major opponent of complex systemic thinking in the history of sociology of consumption. In light of this, only when consumers gain a new active role in purchasing decisions within sociological discourse, we may detect the first hints to a complexity framework.

An attentive analysis of Bourdieu's thinking reveals that the taste's theory and the concept of practices derive from a deterministic assumption: in brief, different lifestyles and patterns of consumptions are the result of the belonging to different social classes. Nevertheless, if, on one hand, it is possible to detect an excess of reductionism in Bourdieu's approach (or maybe, a "class" reductionism), on the other hand, we may trace in the formation of specific consumption of particular social classes, the tracks of what the science of complexity calls "*self-organization's rules* of the system". Indeed, we can consider the aggregated consumption of a group as an emerging phenomenon that rises from the interactions of people that belong to a particular social class. The fact that individuals adopt styles of life through which they recognize themselves as part of a group and, at the same time, they differentiate from people belonging to different social strata, can be viewed as a self-organizing process. Indeed, such a behaviour–that is the result of habitus' influences–allows one to maintain high boundaries between classes, preserving the peculiarity of every social group, that expresses its identity through the consumptions adopted. Therefore, the self-organizing rules of consumption within a social group reveal how the dynamics of social classes and lifestyles they adopt

reflect the characteristics of a complex social system. Moreover, according to Bourdieu, individuals' consumption is the result of multiple dimensions–economic, social and cultural–that interact between them: this assumption introduces that the different practices of consumption rise from the entanglement among different interacting elements that influence consumers' decisions.

2.3. Tracks of complexity theory within contemporary sociological approaches

McCracken introduces the terms "Diderot effect" (1988) in order to highlight that when individuals buy something, the goods that they already have appear as obsolete, pushing them to replace the items with newer and more modern ones. What McCracken points out, by reaffirming the central role of cultural meaning embedded in consumer goods (Dunn 2008), is that items (but also lifestyle, activities, preferences etc.) tend to group together, according to the symbolic value that consumers attribute to them. Such a social phenomenon may be detected, for example, in the purchase of luxury goods as Rolex watches and BMW automobiles (McCracken 1988): these products are expression of a social status, they are coded according to cultural categories and the purchase of one among them may generate a ripple effect on sales of other items that have the same symbolic and social value. Such process is at the root of the consumers' herd behaviour and fashion trends, and through this attitude we may detect, in the interactions between social agents (consumers) and items (goods purchased), the co-existing robustness and instability that characterize complex social systems. Indeed, the Diderot effect,

> "First, it helps illuminate the process of lifestyle formation by drawing attention to the consistency factor in lifestyle patterns. Second, it suggests an important counterweight to the weakening of status boundaries accompanying a rapidly changing marketplace" (Dunn 2008, 145).

For the contemporary sociological approaches on consumption, then, marketplace dynamics rely upon the fact that tastes, desires and needs that push people to consume products and services are *constantly changing*. Such *dynamicity* in consumption processes has been clearly highlighted by Bauman in his analysis on consumption in contemporary age (Bauman 2007a; Bauman 2007b). According to him, consumer society survives creating desires and needs that can never be fully achieved and replacing them continuously with new ones. Then, in post-modern societies, people's needs are never satisfied and it leads to discontinuities in consumption, to constant renegotiations of the meaning of goods purchased and to the continuous research of new consumptions. Such a reason why fashion trends, resulting from consumers' herd behaviour, are temporary. In light of this, Bauman compares consumers to a swarm, in which there are not hierarchies between agents, neither leaders, and that self-organize. Consumer society tends towards the dissolution of groups to the formation of swarms, since consumption is considered by Bauman as a solitary activity that does not stimulate the creation of lasting ties, but facilitates links between people that last only for time of consuming.

3. Families and consumption

3.1. Family and generations

Thanks to the intuitions and theoretical contributions of Karl Mannheim (1928), the notion of *generation* gained attention as sociological phenomenon and as a mean for distinguishing generational cohorts and locating individuals within historical time (Pilcher 1994). In a sociological sense, the term "generation" identifies a group of individuals, living in the same historical period, that experience social, economic and political modifications that have a strong impact in their ways of living and perceiving the reality. Such definition distinguishes the concept of generations from the

idea of cohorts, that merely refers to people born in the same period and that share the same age (Bagnasco et al. 1997; Alwin and McCammon 2003). The born of a new generation determines a shift of values, attitudes and behaviours: people belonging to the same generation share a *collective imagination* (intended as a set of values and views of the world) that is different from that of their parents. As a consequence, the generationalist perspective for the study of consumptions allows one to make the assumption that different generations reveal different patterns of consumption, that are specific to every social group. In this regard, it is possible–and fruitful–to study consumption's practices by adopting a generationalist approach, in order to empirically detect how people belonging to different generations have different tastes, purchasing behaviours, preferences concerning goods and services and meanings that they attribute to them (Alegre and Pou 2004; Valentine et al. 2010; Brosdahl and Carpenter 2011; Chhetri et al. 2014; Yahoo! Advertising 2015; Funches et al. 2017). The opportunity given by the theory of generations for studying the different patterns of consumption also attracted marketers that, in the last decades, widely adopted this framework for economic purposes, by creating systematic categories for distinguishing generational cohorts and their consumptions (such as Silent generation, Baby Boomers, Generation X, Millennials or Generation Y and Generation Z)[7]. Each generation defines its social practices within–and influenced by–the social groups people belong to, one of which is the family unit. In this sense, we may observe, within the same household, multiple influences in consumption choices determined by the belonging of family members to different generational cohorts. For example, the analysis of the purchasing dynamics within a family unit in which there are offspring belonging to Z-generation–also called "digital natives" and approximatively born around 1995–, may reveal a greater propensity of parents to purchase digital devices and a greater speed of adaptation to the new technologies, influenced by digital natives. Moreover, through a qualitative approach, it should be possible to highlight how family members, belonging to different generations, attribute different meanings to the same goods and make different use of them: a clear example may be the use of social media, that reveals how individuals of different generations prefer specific social networking services, using them for different scopes and in different ways. This suggests to analyse the influence of family members on family consumption choices by adopting a generationalist approach, in order to reveal how different generations influence the patterns of consumption of the entire family unit.

3.2. The family life cycle

The family life-cycle is a theoretical approach for studying attitudes, behaviours and consumptions of households. The concept has its roots in the middle of the last century (Lansing and Morgan 1955; Lansing and Kish 1957; Kain and Quigley 1972), and has been recently adopted also by marketers (Solomon et al. 2006), in order to highlight that market interacts with family across all life stages, offering households what they need in the specific phase of the life-cycle in which they are (Epp and Thomas 2018). The underlying assumption of the family life-cycle theoretical approach is that:

> "[…] pivotal events alter role relationships and trigger new stages of life which modify our priorities. These events include the birth of a first child, the departure of last child from the house, the death of a spouse, retirement of the principal wage earner and divorce. Movement through these life stages is accompanied by significant changes in expenditures on leisure, food, durables and services, even after the figures have been adjusted to reflect changes in income" (Solomon et al. 2006, 408).

[7] It is worth to note that there is not a scientific community's agreement on the definition of generations in terms of born years, rather, approximate dates are used. Moreover, attitudes, behaviours, needs and patterns of consumption of the same generation may differ from a country to another.

It means that family needs and related expenditures change overtime, according to the phase of family life-cycle in which the household is. For example, households with babies may be mainly oriented to expenses to cope with the needs of young children, such as baby sitting, nursery, toys and all the expenditures that concern childcare. Elderly couples, instead, may tend to allocate their income for a small range of purchases, mostly related to healthcare and food products for which they are loyal consumers. On the contrary, young couples and young individuals that live alone can reveal patterns of consumption more oriented to leisure time, food away from home and clothing.
Some structural variables are necessary to describe changes in the stages of family life-cycle, such as the age of parents, the presence or absence of offspring, and their ages. These variables determine the main phases of household life-cycle: single young adults; new couples; families with young children; families with adolescents; families in which the adult children leave the parents (empty nest); families in later life (Carter and McGoldrick 2005). In each stage, households face new challenges, and members need to adapt to family changes: it is a constant renegotiation of attitudes, behaviours and consumptions. Nevertheless, it is worth to note that, in contemporary age, revised stages of family life-cycle need to be adopted. Indeed, not everyone passes through these stages smoothly since, nowadays, the transition to adult life (the shift from the birth family to the residential independence) is not a linear process: in this regard, we assist to a de-standardization of transitions from a stage of family-life cycle to another (e.g. to leave home for creating a new family, skipping the first stage of living alone; to come back to the birth family after a divorce; to continue living with offspring in elderly life etc.) and to the appearance of new family types.

3.3. Consumption within the family: a negotiation activity

The decision making process of households with regard to the purchase of goods and services is affected by different variables that are related both to the family's structure (in terms of number of components, income, educational level, gender, generation etc.) and to the stage of life-cycle. Therefore, we should consider, within family, multiple forces that interact between them for the choices of consumption, revealing a purchasing power in line with the role of different members. Such assumption allows one to suppose that the emerging patterns of consumption of households are the result of a negotiation activity among family members, whose different sets of attitudes, experiences, needs, and desires differently affect the purchasing decisions. Some pivotal events of modern age (such as a wider female access to labour market, more equal opportunities, large-scale distribution and mass production of goods and services, and so on), made families more "democratic", for example by empowering women to participate in purchasing decision as well as the male. In light of this, all the family members may participate to the decisions concerning the allocation of household's resources and the purchase of goods and services. Nevertheless, not all the members have the same influence on the overall decision making activity: for that reason, they may adopt strategies for empowering their influence within the negotiation process (Davis 1976). In this case, different strategies come into play, such as persuasion, coercion (adopted when there are large authority differences among family members), or alliance. As we introduced in section 1.3, some empirical works on households' consumption already highlighted some negotiation mechanisms that rise during the purchasing process.

3.4. Family as a budgetary unit

According to Weber's definition (Swedberg and Agevall 2005), a budgetary unit is a group oriented to the acquisition of resources, services and goods with the aim to meet the needs and tastes of its members. This view is in contrast to the individualistic idea of consumption, but it does not exclude

the existence of a non-uniform distribution of decision power among the members of a budgetary unit, and of forms of negotiation in decision making processes. Each component of a budgetary unit, depending on his influence, acts in light of specific goals that could have an impact on other members: e.g. the parents' choice to invest in their children's education with the aim to provide them with appropriate skills and competences to enter in the labour market. Therefore, by considering the main characteristics of a budgetary unit, McDonnel (2013) suggests to apply such a definition to modern families, in order to interpret the expenditure patterns as the result of decisions aggregated at group-level. As a consequence, to apply the concept of "budgetary unit" (Weber 1947) to the family unit (McDonnell 2013) allows one to analyse households and their attitudes to consumption as unified social groups, without invoking complicated internal mechanisms of individual negotiation in the decision making process. Indeed, although family purchasing choices are the sum of individual practices, interactions, tastes and needs of different household's components, the concept of budgetary unit for studying households gives the opportunity to consider their consumption as the aggregated result of internal negotiation mechanisms that are oriented to the benefits of the family unit, overcoming the single individual preferences (Epp and Price 2008; Epp and Thomas 2018).

3.5. Family consumption and Complex System Theory

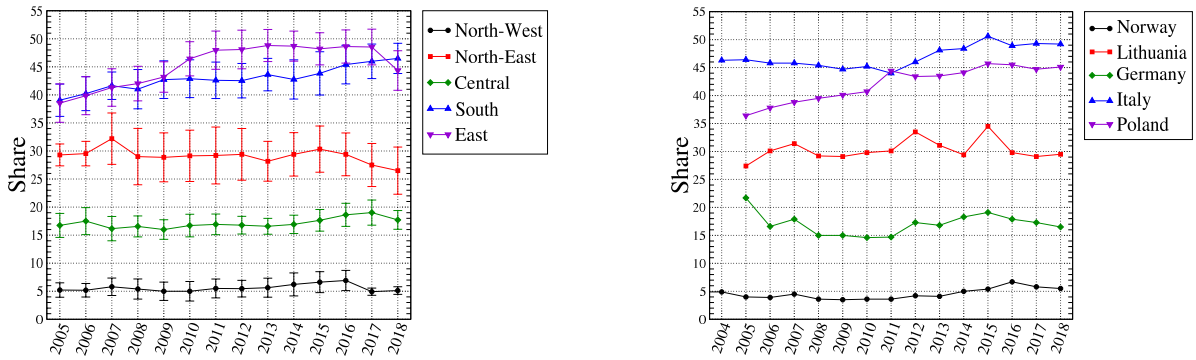
As the previous sections highlighted, family consumption patterns are influenced by several interacting factors–e.g., the presence of children and their generation–that give rise to specific purchasing choices. It means that consumption cannot be merely explained as a linear cause-effect relationship (a household makes purchases to meet family needs), rather as the entanglement of multiple factors, both endogenous (such as, family structure, stage of family life cycle, level of education, income, negotiation processes, etc.) and exogenous (such as, peer or social pressure, herd behaviour, social status etc.). Therefore, by focusing on a single (or just a few) dimension(s), in order to understand households' patterns of consumption, risks to constraint the analysis on considering limited and disconnected factors, without taking into account the impact that the interplay between different factors may have on orienting consumption's choices. Such a limitation is typical of a reductionist approach. To face these constraints, we decided to frame the study of families' expenditures within the Complex System Theory. Indeed, adopting a holistic view allows us to consider multiple dimensions that may affect households' consumption at once. In such a way, we may observe the emergence of patterns of consumption that are typical of specific family types and that distinguish them from other households' categories. In this regard, one may detect, for example, different purchasing choices between 1) families with young children (at an early stage of family-life cycle), and households with young or adult children (in a later phase of family life-cycle); 2) high-income families and low-income families; 3) nuclear families (composed by parents and offspring) and extended families (that are family structures involving parents and their children that live in the same household with, for example, aunts, uncles, and grandparents); 4) family units living in rural areas and households living in big cities, and so on. Moreover, the study of families' purchasing choices under a complex systems' perspective enables one to adopt methodological tools specifically conceived to deal with systems' complexity, such as the methods discussed in Chapter 1. The aim of the next sections is then to demonstrate that households' consumption data display several properties that are typically considered as a mark of complexity, which allows us to investigate consumption's patterns of family-types through the lens of Social Complex Systems. In particular, in the reminder of this chapter, we will show that i) households and expenditure categories are both qualitatively and quantitatively heterogeneous; ii) consumption is non-stationary and tipping points are observed; iii) heteroschedasticity of consumption data; iv) consumers adapt to external changes and display herd behaviour; and v) endogenous and exogenous factors strongly affect the overall behaviour and the

evolution of the system. In summary, the aim of the next sections is that analysing households consumption within the framework of complex systems theory is not only useful in order to gain new insights about the structure and evolution of the system, but it is also advisable, since classical methods based on a reductionist approach may fail to properly take into account the aforementioned properties in the empirical analysis.

4. Households and their expenditures: an evolving complex system

4.1. Evolution of family structure

In the last decades, we assist in the widespread phenomenon of children that live with their parents in adulthood, even if they have a job (Choroszewicz and Wolff 2010; Aleni Sestito and Sita 2014). In a complex systems' theoretical framework, such a common behaviour among young adults can be considered as an emergent phenomenon, generated from the interplay among multiple dimensions: i) the economic one, in terms of high unemployment rate and uncertainty of the job market; ii) the social and political one, in terms of welfare, inclusion policies and social equalities; iii) the cultural one, in terms of family ties and parenting style. The emerging phenomenon of young adults still living at home gives rise to a series of cascade effects that involve social and economic systems, e.g., the decrease of the birth-rate, the deadlock in the real estate market, the crisis of pension system etc. Moreover, it has an evident impact on consumption, since the self-organizing rules that regulate the actions (and, then, the patterns of consumption) of members in families with an adult child, mostly if he works, strongly differ from the processes of self-organization of other family types.
It is worth to note that the phenomenon of adult children that extend their stay with the birth family is observed at different levels throughout the European countries. Indeed, as figure 2.1a reveals, the mean share of children aged 25 to 34 that still live with their parents varies greatly across Europe[8]:



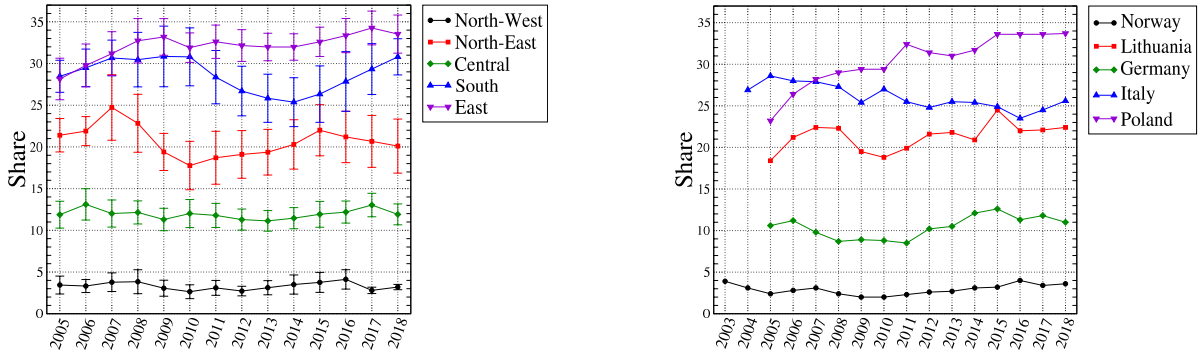
(a) (b)

Fig.2.1: Share of young adults, aged 25 to 34, living with parents in five European macro-areas (a, mean values), and in five countries that are representative of each macro-area considered (b). Error bars indicate the standard error of the mean.

[8] European countries have been grouped as follows: i) Group 1 is composed by Denmark, Finland, Iceland, Norway, Sweden, that represent the Nordic model of social democracy; ii) Group 2 includes Estonia, Latvia, Lithuania, that compose the Baltic States, under Sovietic occupation until 1991; iii) Group 3 is composed by Central Europe countries as Austria, Belgium, France, Germany, Ireland, Luxembourg, Netherlands, Switzerland and United Kingdom; iv) Group 4 includes Cyprus, Greece, Italy, Malta, Portugal and Spain, that share the Western Mediterranean cultures; v) Group 5 comprises Bulgaria, Croatia, Czech Republic, Hungary, North Macedonia, Poland, Romania, Serbia, Slovakia and Slovenia, these are countries located in the East Europe and that have been affected by the Soviet influence. Such a grouping allowed to take into account both the geographical position and the economic, cultural and historical dimensions that characterize countries belonging to each group.

The "delay syndrome" towards adulthood seems then a phenomenon that differs among the European areas. Indeed, figure 2.1a shows a low percentage of young adults living with their parents in the North-Western countries (5%, on average), quite-low values in Central states, quite-high values in North-East Europe, and very high values in East and South Europe (among 40% and 50%, on average). These trends are confirmed by the values of some countries representative of the macro-regions (figure 2.1b). One may argue that such a difference relies upon the different welfare levels and the economic conditions: indeed, the unemployment rate is higher in Southern and Eastern countries–the former sharing the Mediterranean culture, the latter having been deeply influenced by the Soviet Union–than in the North-Western ones[9]–in which the Nordic model prevails, characterized by an inclusive welfare model, low income inequalities (associated with a low intergenerational elasticity), flexible labour market and promotion of social equalities. It may be a plausible explanation since both the job uncertainty and the youth unemployment rate discourage young people to make long-term plans (Bernardi and Nazio 2005; Worth 2015).

Nevertheless, in a holistic complex systems' perspective, we are led to consider that the economic dimension cannot be the only explanation of the family system's evolution. In this regard, fig. 2.2a displays the percentages of people aged 25 to 34 who have a job and live with their family: the values are low and quite-low in Northern and Central countries, respectively; quite-high in North-Eastern countries; and very high in South and East Europe. Such results, confirmed in figure 2.2b, reveal that the offspring's tendency to not leave the birth family persists despite the working condition, in some groups of countries.



(a) (b)

Fig.2.2: Share of young adults, aged 25 to 34, living with parents and having a job, in five European macro-areas (a), and in five countries that are representative of each macro-area considered (b). Error bars indicate the standard error of the mean.

To detect if, under the same welfare and socio-cultural conditions, the patterns of household evolution differ, we may analyse the behaviour of family system at a lower level (i.e. within a specific country). In this regard, the figure 2.3 shows the percentage of Italian young people that live with their parents (fig.2.3a) and the share of young Italians that work and still live with their parents (fig.2.3b), across macro-regions:

[9] For an overview of youth unemployment rate throughout Europe, see: https://ec.europa.eu/eurostat/databrowser/view/tesem140/default/table?lang=en. Source Eurostat.

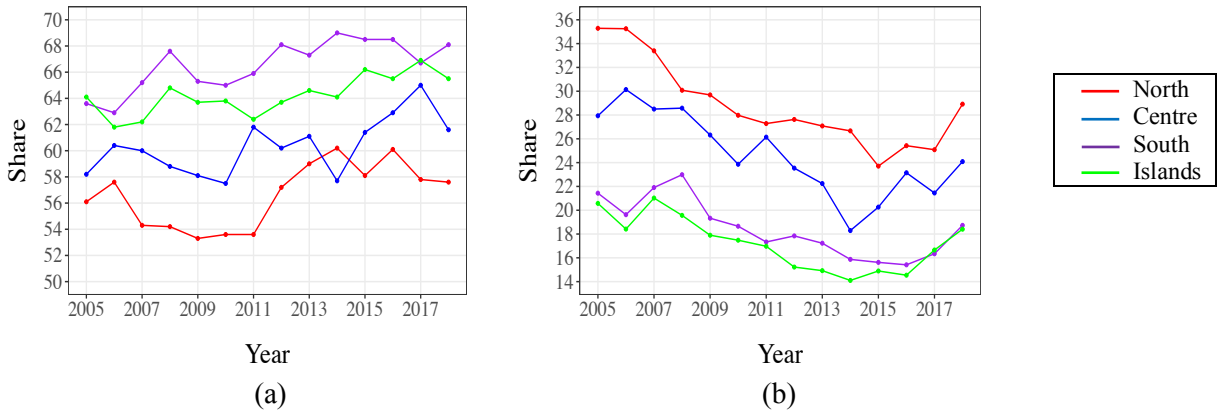


Fig.2.3: Share of Italian young adults, aged 25 to 34, living with parents (a), and share of Italian young adults, aged 25 to 34, living with parents and having a job (b). Cross-regional differences.

The trends confirm high percentages of both young adults that still live with their family and young adult that have a job and live with parents. Nevertheless, some differences among macro-regions are highlighted: the shares of young adults living at home are lower in the Northern regions than in the Southern ones and in the Islands, even if, after 2011, we observe an increase of the phenomenon in North-Italy (figure 2.3a). While Northern regions show lower percentages of young adults still living at home, they also reveal the highest values of people that stay with the birth family despite they have a job (Figure 2.3b). These evidences can be interpreted in the light of some differences among Italian macro-regions: 1) the inequalities of labour market, since there are more job opportunities in the Northern part of Italy than in the South; 2) the high rental cost of living arrangements in some northern regions (Di Stefano 2019), that explains why there is a significant amount of young people that work and still live with their parents (fig. 2.3b); 3) the Central European culture with which people living in Northern regions are constantly in contact, that may have an influence on accelerating the process to leave home, as it is revealed by the shares of young adults that live with their parents, that is lower in the Northern regions than in the Southern ones and in the Islands (fig. 2.3a). Moreover, the analysis at a lower level allows one to investigate the behaviour of Italian family system with respect to the gender differences. In this regard, the Italian Institute of Statistics (ISTAT) reveals that, in 2013, the share of Italian males aged 25-34 still living with their birth families was equal to 52.5%, whereas, the share of young women was lower, amounting at 36.3%. Among young males living with their parents, 58.4% of them were workers, and, also in this case, the percentage was lower for women, 47.9%. While the higher values for men than for women in relation to the occupational status are expected–considering the lower female employment rate in Italy–, what is interesting to note is that more men than women live with their parents. Since Italian families are still represented by the "male breadwinner model" (León and Migliavacca 2013), such a phenomenon can be due to the tendency of young women to leave home before–also not having a job–in order to create a new family, as a consequence of a marriage or a cohabitation with the partner. Instead, the results for young men may depend on two aspects: 1) the inability to perform their tasks of "male breadwinner" in a new born family, due to a low income; 2) the decision to live with their parents for the resulting comforts, at the expense of a complete independence, revealing a specific male "delay syndrome" in the transition to adulthood (Maya 2010).

Therefore, the different attitudes to live with the birth family despite having a job across European countries, displayed at macro-scopic, meso-scopic and micro-scopic level (figures 2.2a, 2.2b and 2.3b, respectively), lead us to suppose that there are other prominent factors, beyond the economic one, that come into play, interacting among them, in children' decision to extend the stay with the birth family. What is quite common among working young people is that leaving home implies facing

with economic constraints, at least in the early period of the residential independence[10]. The strategies adopted by family units in different countries (or macro-regions), in order to face with the same issues (transition to adulthood, intergenerational elasticity and economic difficulties), show different outcomes. Indeed, 1) in the Northern countries (group 1 in figures 2.1a and 2.2a), individuals tend to leave the birth family early, in order to gain their independence and start their adult life, maybe by adopting some solutions for dealing with the financial constraints (such as to share an apartment with flatmates for reducing the expenses, or to cohabit with partner); 2) in other countries, especially in the Mediterranean and Eastern ones (groups 4 and 5 in figures 2.1a and 2.2a), young adults prefer to stay with their parents, maintaining a lifestyle that could be considered higher than the one of young people that obtain residential independence (thanks to the parents that provide for the basic needs). These different strategies lead us to suppose that the emergence of different phenomena in relation to living arrangements observed across Europe relies upon the interplay among economic, social and cultural dimensions. In this regard, beyond the welfare regimes and the labour markets, we introduce other factors that play a prominent role in shaping young people's transition to adult life:

- Ambition to permanent job position in Southern and Eastern countries. It pushes young people to keep living with their parents, "waiting" for a more stable working condition. Such a point is strongly connected to the offspring risk aversion, also due to the job uncertainty: while in Scandinavian countries the flexibility of job market allows one to change the working position without experiencing long-term unemployment, in countries like Italy, Spain, Greece or ex-Soviet Union States the job market is not so flexible.
- Ambition to an economic status equal or higher with respect to the one of their parents. It comes into play an unconscious desire of emulation, that incentives young adults to strive for the lifestyle that their parents had at the same age: permanent position, low working mobility, guarantees etc., without considering that their optimistic economic expectations are unrealistic (Charles Schwab 2018).
- Family conception and family ties. Southern countries are characterized by the Mediterranean "familistic model" (Calzada and Brooks 2013; León and Migliavacca 2013), according to which the family replaces the insufficient welfare regime, by providing for children needs, transmitting family values and, as a consequence, reinforcing parental attachment. The familistic model implies that, for example, it is considered socially acceptable that parents are actively engaged in children's job search, provide for them the money they need for buying a house, or take care of their grandchildren when the offspring are at work. Northern families, on the contrary, are more oriented towards the complete independence of children, to the extent that moving out from birth family to new housing solutions represents a natural step in transition to adult life (Newman 2008).
- The "helicopter parenting" (Van Eck Peluchette et al.2013; Gomes and Deuling 2019), intended as the tendency of Baby-Boomer parents to adopt an exaggerated caregiving with regard to their children, mostly belonging to the Y-generation (or Millennials). Although it is a widespread phenomenon across the world, we may suppose that such an attitude is more prominent in familistic societies and it surely represents an incentive for young adults to prolong their stay with the birth family.

The helicopter parenting is a phenomenon that needs further discussion since it is generated from– and, at the same time, produces–a series of mechanisms that can be framed in the complex systems'

[10] Mean monthly earnings of young people (under 30) across European countries can be found at: https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=earn_ses14_21&lang=en. Source: Eurostat. Year: 2014.

theory. Its roots can be detected in multiple factors that made it unprecedented the quality of life of Baby Boomers–as the economic prosperity, the job guarantees, the welfare–, leading them to be less worried about their present and their future than the previous generations, and focus their attention on a form of excessive children care. The positive outcomes of such a deep involvement in child's educational experiences, in terms of good academic results, children sense of protection, pro-social behaviour (Day and Padilla-Walker 2009; Fingerman et al. 2012; Wilder 2013), may have triggered a mechanism of positive feedbacks, that encouraged more and more parents to be increasingly involved in their children lives. Such an excess of care is observed in parents that provide for anything, even if the children do not expressly ask for it, without giving them the chance to try to achieve goals on their own, fail and learn from their mistakes (Crepet 2005). The phenomenon of helicopter parents may be more prominent in families in which the woman does not work and, therefore, is more dedicated to children care: such a phenomenon creates a special tie "offspring-mother", which reflects in an unconscious emulation of mother's standards of living and styles of consumption by the children. Moreover, housewives are extremely involved in all of the aspects of their children life, mostly in school-age: it may generate both a positive feedback among mothers' behaviour, reflected, for example, in the choice of same leisure-time activities their children have to do, and a consequent selection process of children with regard to their peers, in this case, for example, they are inclined to become friends (selection process) with individuals that do the same activities (homophily).

Nevertheless, such "bubble", or deadlock, resulting from Baby Boomers behaviour, will be probably reabsorbed by the system as an effect of negative feedbacks, introduced by Y-generation, that will not homologate their parenting style with the ones of their parents. It implies that the Baby Boomers' parental behaviour will last until they end their parenting role and the Millennials become the new generation of parents. Indeed, Y-generation children will not adopt the same exaggerated form of childcare for two main reasons: 1) Millennials parents declare that they tend to disclaim the intense parental support received, since they have experienced its negative effects (Darlow et al. 2017); 2) the negative outcomes of helicopter parenting on Millennials, such as difficulties to take responsibilities, *naïveté*, dependency, desire to be cared for themselves etc. (DDB Worldwide Communication Group Inc. 2012[11]) do not make them able to adopt the same parenting style of Baby Boomers. Therefore, we may assume that, as long as Millennials' children grow up, we will assist to a reversal trend in parenting. Early signs of such a change in Millennials' parenting can be observed, for example, in the attitude to share through Social Media private information about their children: from birth date, to embarrassing photos. It has been demonstrated that such a common practice is the result of a narcissistic behaviour of Millennial parents, adopted to satisfy their need for self-realization and social approval, without considering the negative outcomes that the media exposure could have on children, such as embarrassment, digital kidnapping of baby photos etc. (Brosch 2016). This thoughtlessness and lack of responsibility are not in line with the behaviour of overprotecting helicopter parents.

Parenting style, familistic model, ambition to a permanent position of young adults and, more generally, to an economic status equal or higher than the one of their parents are, then, declined in different ways across Europe[12]. It allows one to group countries in communities, according to the specific behaviour of family units and to the processes that generate it. Therefore, by assuming that households that live in States belonging to the same community share similar attitudes, we may consider the trend of the young (working) adults that live with their parents at macro-scale, by

[11] Online source: http://www.ddb.com/.

[12] Beyond the spread of young (worker) adults still living at home, such factors are also connected to the growing phenomenon of young people neither in employment or education or training (NEETS), that is receiving nowadays both social and scientific attention (Bruno et al. 2014; Batini et al. 2017).

comparing groups of countries that are similar within them (and different among them) in terms of values, welfare, family ties, parenting style, ambitions and so on (Figures 2.1a and 2.2a).
Outlined the emergent phenomenon, at different cross-national levels, of young workers still living at home, how does such a new family structure affect households' consumptions? Working young adults that still live at home surely have a style of consumption that is different from younger children and, at the same time, from young adults that decide to leave the birth family. Indeed, although Millennials tend "to consume and to use the totality of their income in the purchase of the goods that define them or in experiences" (Moreno et al. 2017, 141), we cannot suppose that people living alone show the same purchasing patterns of workers that stay with their parents. While the former have to allocate their budget to provide for primary needs (bills, loan, rent, food etc.), the latter may spend on non-necessary goods (travel, food away from home, leisure activities, body care, amenities in general), since they benefit from parental support on primary needs. The different purchasing attitudes are strongly connected to the new exigencies, views of the world and long-term plans that adulthood entails. Indeed, the residential independence changes young adults' habits and priorities, such as learning to cook, pay bills or save money for taking the consequential steps in the transition to adult life (such as to get married and have children). To live alone implies an assumption of responsibility that young adults that live with the birth family do not experience, since their parents continue to provide for them also in adulthood. It implies that they have less economic constraints and less responsibilities for engaging in experiences such as travels abroad, last minute holidays, body-care. In this regard, we may suppose that worker Millennials still living at home represent an appealing market share for low cost flight companies, marketplaces for renting of a short-term dwelling and tour operators. Moreover, they may express, more than Millennials living alone, the new interest on body culture–intended as physical activity, fashion clothing consumption, cosmetics, spa etc.–(Bauman 2000), improving their physical attractiveness, and orienting their expenditure for fashion and cosmetic consumption (Bakewell and Mitchell 2003; Bakewell and Mitchell 2006; Nellikunnel et al. 2015; Valentine and Powers 2013). Finally, it is worth to note that, at least in Italy, the impact on consumption of young worker adults still living at home may be more prominent for specific expenditure categories that are more related to the male universe–purchase of a car, expenses for vehicle maintenance, sport events subscriptions and so on–, since the rate of young adults who work and live at home is higher for men than for women.
In conclusion, we may consider that the emerging phenomenon of young adults that prolong their stay with the birth family generates a cascading effect that involves other systems. For example, the postponed transition to adult life implies that other steps in family life-cycle are delayed, such as the marriage and the child birth. To get married late, or to have the first child late, reduces the probability to have other babies: it may be one of causes of the overall drop of the birth rate in some countries. Moreover, strong family ties are reflected in the desire of young people to live near to the birth family, reducing their stimuli to move from the hometown, not even to gain better working conditions and higher quality of life: such an attitude clearly has an impact on both the generational mobility and the job market. Finally, in the long-run, the interplay among low fertility rates and late entrance in the labour market will negatively affect the pension system of countries in which the contributions payed by people are directly used by social security institutions to pay pensions (Di Stefano 2019).

4.2. The effects of advertisement and technological progress

Nowadays, we assist in the constant production and evolution of technological goods and services. Technological progress affects consumption behaviour in terms of changes in purchasing habits (the *way* in which people consume), interests towards new products (*what* people consume), and places of consumption (*where* people consume). At the same time, also the sale market is invested by

technological revolution, resulting in a competition among companies aimed at producing technological items ever more in line with consumers' desires and expectations. Technology then involves both the supply and demand; in which we can detect some characterizing features of complex systems.

Economic system, indeed, reveals the mutual influence among sale and consumption, that is among supply and demand. In this regard, companies create desires (Bauman 2007b), by commercializing products that are meant to be appealing to consumers. Individuals' purchasing attitudes may generate positive feedbacks within the consumption system since, in order to emulate the consumption choices of their reference group, people tend to adopt purchasing patterns similar to the ones of individuals surrounding them. Such a propensity to emulation in consumption choices may be due to: 1) a herding phenomenon, that is, buying decision is the result of irrational consumer's behaviour, which rises from a need of social approval (an example can be the choice to purchase an expensive product, despite its cost and utility, just because it is popular); 2) information cascade, that is, to adopt a specific consumption style as a consequence of an exigence of adaptation to a widespread habit. In this regard, the different distribution of messaging platforms throughout the world can be considered an example of how the use of Social Media is determined by the decision of emulation, aimed at adapting to a widespread behaviour among reference group. Indeed, as the report of Hootsuite and We Are Social reveals (2019), the main messaging services differ among them in terms of global penetration rate: for example, WhatsApp is the most popular platform in Canada, Central and South America, Russia, and in part of Europe and Africa; on the contrary, Facebook Messenger is the most common messaging service in USA, Portugal, North Africa, Oceania and in part of Asia. Moreover, it is interesting to note that less popular messaging platforms, such as Viber and Telegram, are the typical communication services in specific countries, like Belarus-Ukraine and Middle-East states, respectively. The changes in consumers' behaviour result in a growth of goods and services' demand, encouraging companies to develop ever more products that meet the new desires of consumers in terms of user-friendliness, appeal, possibility of customization and loyalty to the brand. Such goals generate positive feedbacks mechanisms in production system, in which companies compete between them in order to best fit people needs (that are the result of all the product's requirements described above). At the root of the economic market, then, supply and demand represent two systems that interact among them and influence each other: an increase in the demand corresponds to a rise in the offer, and vice-versa.

Nevertheless, when supply and demand do not meet, it may result in negative outcomes for one or the other system. A typical case of such phenomenon can be detected in the near-collapse of Nokia in the mobile telephony industry. Indeed, until the early 2000s, Nokia was the leader firm in the mobile-phone market, with a market share of about 40% (Cord 2014). Nevertheless, starting from 2010, company experienced a strong drop in sales[13] and, as a consequence, of market shares, that went from 25% in 2011 to 1% in 2015 (Peltonen 2019). The reason of such collapse relies upon the company's inability to react to a new competitive environment, to the technological challenges and to the consumption changes. In a period of constant technological evolution and spread of new desires in consumers, Nokia failed to meet the demand of individuals, interested in new technological products (e.g. smartphones with performing cameras), and to keep up with competitors, such as Apple, Google, and low-cost companies. In a complex systems' theoretical framework, the history of Nokia's near-collapse reveals how, in order to survive, the system has to modify its behaviour (that is, its internal self-organizing rules) in relation to the changes that occurred in the system with which it interacts (composed by consumers and competitors).

[13] Infographic online: http://lab24.ilsole24ore.com/cellulari/. Language: Italian.

With the aim to "survive" and do not lose market share, by adapting to the new forms of consumption created by technological progress, retailers adopted new strategies of advertising. In this regard, a prominent role is played by Social Media (Nadeem et al. 2015; Chadha et al. 2017), through which firms address their products and services to targeted consumers, mainly belonging to Y- and Z-generation. It gives rise to new models of advertising, such as the collaborations between companies and prominent figures in fashion and show business, highly popular on Social Media, that promote firms' products to their followers: this is the emergence of *influencer marketing* (Kaur and Sharma 2018; Influencer MarketingHub 2019). The basic idea behind such a new form of product promotion is that people that are popular among Social Media users, use their popularity to promote a product, influencing their followers that, in their turn, get involved with their communities as leaders. Therefore, movie stars, models, and famous personalities in general, are able to influence their followers who would like to be associated with them in some way. The cascade behaviour mechanism implies that once that individuals are "influenced", and then induced to purchase of specific items, their purchasing behaviour will be emulated by their reference group, with whom people share values, beliefs and attitudes.

Together with the ripple effect that advertising generates, publicity campaigns are mainly conceived for stimulating herd behaviour in consumers, even before the impact of Social Media and the new technologies. In this regard, an interesting case of herding can be observed in the success that the "Torches for Freedom" campaign had in 1929. Conceived as an advertising campaign aimed at promoting cigarette sales, it encouraged women to smoke in public, despite the common taboo, leveraging on female empowering desire. As a result, women started to smoke in public for emulating other women, and such an attitude made them feel emancipated (Rudy 2005; Prasad et al. 2014). The example shows how advertising system pushes people to behave irrationally if the promoted products are connected to their emotional desires and feelings.

Finally, it is worth to note to what extent the impact of technology reflects in changes of consumers' self-organizing rules. In this respect, the spread of e-commerce (that is, online marketplaces as Amazon, eBay, Zalando etc.) in consumers purchasing habits, reveals the ability of the consumption system to modify its internal rules (that govern the interactions between consumers and purchased products) in order to deal with the stimuli coming from the outside (from the supply market). With respect to Italian consumers, the annual report, produced by Hootsuite and We are Social, on how people around the world use the internet, mobile devices, social media, and e-commerce (Hootsuite and We Are Social 2019), shows that a high percentage of Italians are used to make online purchases. Specifically, among Italian Internet users aged 16-64:

- 86% searched online for a product or a service;
- 93% visited an online store;
- 75% made an online purchase (any device);
- 53% made an online purchase via computer;
- 42% made an online purchase via mobile device[14].

It is an evidence of how consumers change their purchasing habits: e-commerce then surely modified *how* and *where* people consume. Online marketplaces, besides their utility as online stores in which people can buy items comfortably seated on their sofa, are spaces in which consumer imagination is stimulated, giving rise to new needs and bringing up latent desires (Denegri-Knott and Molesworth 2010).

[14] Results of a survey conducted by GlobalWebIndex.

4.3. Double heterogeneity: households and expenditure categories

Beyond the impact on consumption of the evolution of family structure and the technological progress described above, that allow one to consider households and their consumptions as a complex social system, the purpose of the present work is to apply the theoretical framework of complex systems–and the methodological approaches that derive from it–to the study of Italian households and their expenditures. Such an interest rises from the fact that when we approached our database–composed by families and products they purchased from 2001 to 2013[15]–, we noticed that the system revealed many of the characterizing features of complex social systems. First of all, we dealt with the double heterogeneity (both qualitative and quantitative) of elements that compose the system, that are the sampled Italian households (from 2001 to 2013) and the expenditures categories concerning goods and services they buy.

- Qualitative heterogeneity of households. According to the Italian Institute of Statistics, that carried out the survey on Italians' consumptions, the term "household" defines people that live together, linked by emotional ties, relationship, marriage, affinity or adoption. It means that, in the representative sample of the Italian population, very different families–in terms of internal composition and stage of family life-cycle–are present, e.g. nuclear families, extended families, multiple families, single people that live alone, elderly couples, single-parents that live with their offspring and so on. All of these types of households necessarily reveal different patterns of consumption, since the needs, attitudes and behaviours of members that compose them can be extremely different. Moreover, the heterogeneity of households can be detected by considering other dimensions, such as the socio-demographic characteristics of family components (such as educational level, sex, age etc.), or the macro-area, region or town in which the households have been sampled.
- Qualitative heterogeneity of expenditure categories. Data on expenditures consist of 279 goods and services that households may purchase. Such expenditure categories refer to a wide range of products that qualitatively differ among them. For instance: furniture, travelling (e.g. accommodation in Italy or abroad), loans, sport equipment, food for pets, clothing (for women, man or children), public transportations (such as tickets for buses or trains), tickets for events (museums, concerts, cinemas, sporting events) and so on. Such a heterogeneity also reflects within the macro-categories in which the expenditure categories may be classified (e.g. products for primary versus secondary needs, goods and services for childcare, purchases for primary or secondary house etc.).
- Quantitative heterogeneity of households. According to the above highlighted heterogeneity of households, in terms of composition and stage of family life-cycle (together with number of components, number of working members, ages and so on), we may argue that the total family budget that every household allocates for purchasing goods and services strongly varies among family's types. Indeed, the annual expenditure of a family may depend on multiple dimensions that affect the purchasing decisions, such as, financial resources, negotiation processes among family members, tastes and preferences, household's structure (in terms of number of components, ages, educational level, gender and working status of members), and so on. In this regard, in figure 2.4 we may observe the total expenditures of households, for every year of the survey. The plot of the families' total expenditure each year (from 2001 to 2013), reveals that the Complementary Cumulative Density Function (CCDF), that is the probability to observe a total expenditure larger or equal to a specific value, $P(X \geq \mathrm{x})$, decreases of more than three orders of

[15] A more detailed description of the database will be presented in section 5.

magnitude as far as the total amount increases from 10,000 to 100,000 euros. It means that, within the databases, there is a significant amount of households that have a low total expenditure, and few families whose total expenditure has quite high values.

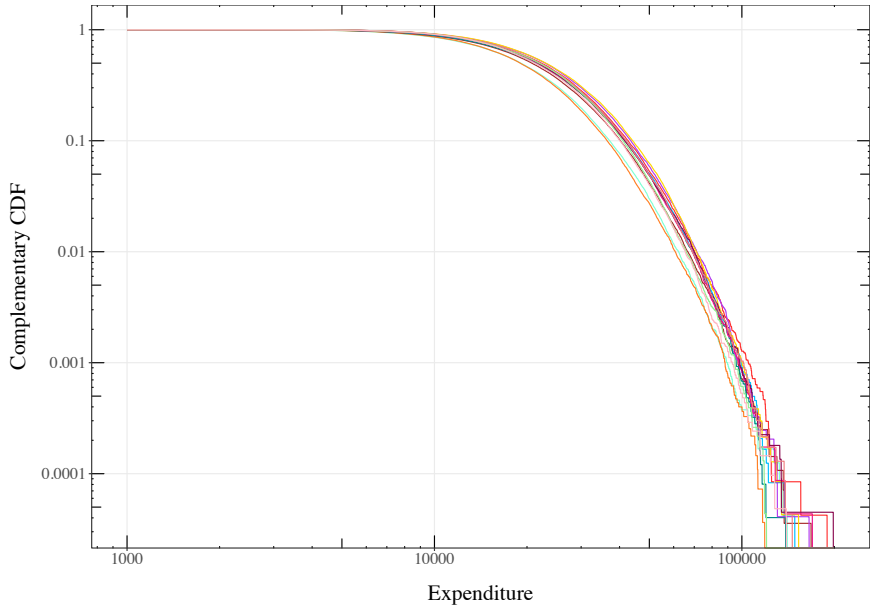


Fig.2.4: Complementary CDF of the annual total expenditure of households throughout the observed time-window (from 2001 to 2013). Lines' colours indicate different years. Log-log plot.

The visual inspection of the empirical complementary CDF shown in Fig.2.4 in a log-log scale suggests that data might be described through a Log-normal distribution. Nevertheless, a straightforward analysis of the goodness-of-fit between the data and the Log-normal distribution, as performed through the Kolmogorov-Smirnov (KS) test (Kolmogorov 1933), indicates that the hypothesis of log-normality should be rejected. Therefore, we have considered a lower-bounded Log-normal distribution, in order to better analyse the right tail of the empirical distribution. The probability density function (PDF) of a lower-bounded Log-normal distribution is:

$$\mathrm{pdf}(x) = \frac{\mathrm{Exp}\left[-\frac{(\ln x-\mu)^2}{2\,\sigma^2}\right]}{x\,\sqrt{\frac{\pi}{2}\sigma^2}\;\mathrm{Erfc}\left[\frac{\ln(x_{\min})-\mu}{\sqrt{2}\,\sigma}\right]}, \tag{2.1}$$

for $x \geq x_{\min}$ and $\mathrm{pdf}(x) = 0$ otherwise. The survival function of the distribution, which is used in the Kolmogorov-Smirnov test, is:

$$\mathrm{S}(x) = \frac{\mathrm{Erfc}\left[\frac{\ln x-\mu}{\sqrt{2}\,\sigma}\right]}{\mathrm{Erfc}\left[\frac{\ln(x_{\min})-\mu}{\sqrt{2}\,\sigma}\right]}, \tag{2.2}$$

where

$$\mathrm{Erfc}[x] = \frac{2}{\sqrt{\pi}}\int_x^{+\infty} e^{-t^2}\mathrm{dt}, \tag{2.3}$$

and μ, σ, and $x_{\min}$ are the parameters of the distribution. The three parameters of the distribution have been estimated independently for each year of the survey. In particular, given a value of $x_{\min}$,
μ and σ have been estimated using the method of maximum likelihood (Barndorff-Nielsen and Cox 1995), whereas $x_{\min}$ has been estimated by numerically minimizing the KS statistic (Clauset et al. 2009). Finally, a K-fold cross-validation analysis (K=10) has been performed, and the

results indicate that our data of total expenditure are well fitted by a lower-bounded Log-normal distribution, with a lower bound ranging between 14,000 and 22,000 euros across the thirteen years of the survey. The details of the analysis are reported in Table 2.1. It is worth to notice that a similar analysis has been performed by considering a power-law distribution in place of the bounded Log-normal. Results indicate that also the power-law hypothesis could not be rejected (p-values larger than 0.01 associated with the KS statistic). However, estimates of parameter $x_{\min}$ were always above 70,000 euros across the years, suggesting that the power-law behaviour could not be ruled out only in the far right tail of the empirical distribution, which lead us to conclude in favour of the bounded Log-normal hypothesis.

Time	Parameter Estimation				K-fold cross-validation (K=10)										
Year	$x_{\min}$	μ	σ	KS-test	$x_{\min}$			μ			σ			KS-test p-value	
	Estimate	Estimate	Estimate	P-value	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Min	Max
2001	19060	9.96	0.475	0.971	17510	14450	19650	9.96	9.93	9.99	0.477	0.466	0.486	0.050	0.778
2002	14710	9.92	0.478	0.979	14566	13300	14990	9.92	9.91	9.93	0.478	0.474	0.482	0.016	0.943
2003	15410	10.01	0.482	0.933	15575	12860	18880	10.02	10.00	10.03	0.482	0.475	0.491	0.044	0.923
2004	19550	10.10	0.463	0.932	19463	19230	19550	10.10	10.09	10.10	0.463	0.461	0.468	0.117	0.982
2005	19710	10.08	0.470	0.725	19361	16380	19980	10.08	10.06	10.09	0.470	0.465	0.478	0.031	0.987
2006	20630	10.10	0.470	0.926	20349	18550	21950	10.09	10.08	10.11	0.471	0.464	0.477	0.042	0.773
2007	17330	10.12	0.466	0.997	17313	17010	17650	10.12	10.11	10.12	0.466	0.464	0.469	0.073	0.960
2008	18740	10.14	0.462	0.462	19427	18570	21320	10.15	10.14	10.16	0.460	0.453	0.465	0.043	0.957
2009	21960	10.10	0.462	0.404	20680	18360	21960	10.09	10.07	10.11	0.464	0.454	0.474	0.026	0.906
2010	15580	10.05	0.480	0.957	15813	14230	17260	10.05	10.03	10.06	0.479	0.476	0.489	0.011	0.954
2011	20320	10.09	0.461	0.980	19116	18220	20490	10.09	10.08	10.10	0.463	0.458	0.466	0.078	0.987
2012	17990	10.12	0.433	0.981	17760	17260	18540	10.12	10.11	10.13	0.434	0.431	0.437	0.031	0.937
2013	19550	10.08	0.446	0.914	20126	19330	21350	10.08	10.07	10.09	0.444	0.440	0.450	0.087	0.991

Tab. 2.1: Analysis of the distribution of total expenditure through a lower-bounded Log-normal distribution.

- Quantitative heterogeneity of the expenditure categories. The qualitative heterogeneity of goods and services reflects on the different costs that products have: for example, the price for buying a new car differs from the price of bread in many orders of magnitude. As a consequence, the part of income that all the families allocate for purchasing bread has a very lower values range with respect to the one allocated for buying car, traveling, or renovating home. Such a quantitative heterogeneity is clearly highlighted in figure 2.5, that displays the annual mean expense for each purchase (N=269)[16] made by all the families, in the considered time-window. We may observe that, among the expenditure categories, there are products whose average values are order of magnitude higher than others.

[16] Although the original dataset contains 279 expenditure categories, the average value of the annual expenditure for each good and service has been calculated for 269 expenditure categories, since for 10 variables it was not possible to asses if they concerned occasional or regular expenses (e.g. the expenditure category concerning public transport tickets contain both annual subscriptions and single tickets).

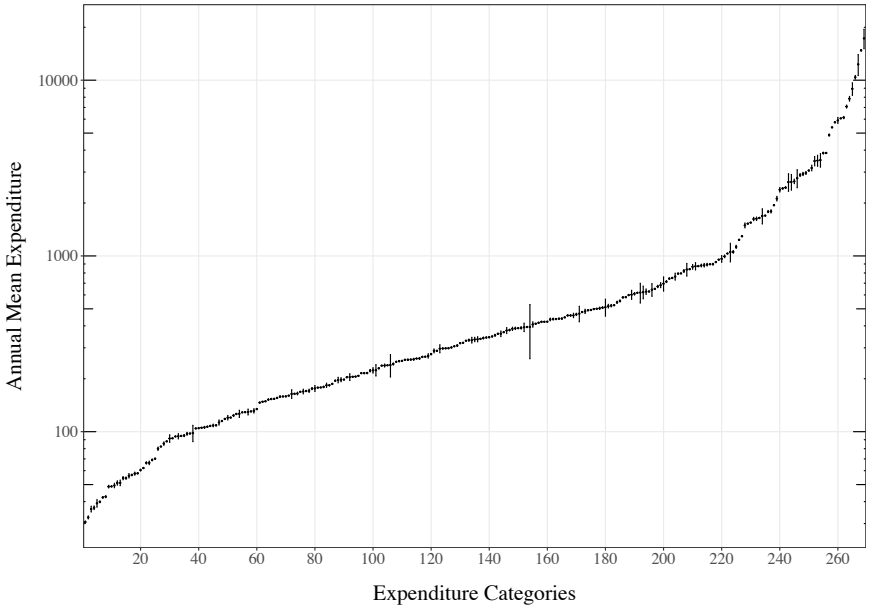


Fig.2.5: Average value (in euro) of the annual expenditure for each expenditure category in the observed time-window. Error bars represent the three times standard error of the mean. Log-linear plot.

4.4. Non-stationarity of consumption

In a complex system it is possible to observe the impact of exogenous (coming from the interaction with the environment) or endogenous effects (generated within the system) on the interactions between systems' elements and, as a consequence, on the overall systems' behaviour. By considering Italian households and their expenditures as a complex social system, we may observe that social, political and economic changes, occurred during the considered time-window, strongly altered the patterns of consumption of families. The non-stationarity of consumption can be highlighted, for example, in relation to the total amount of goods or services purchased. In this regard, figure 2.6 reveals the trend of the average number of non-null expenditure categories (that is the mean number of goods and services purchased by Italian households), from 2001 to 2013:

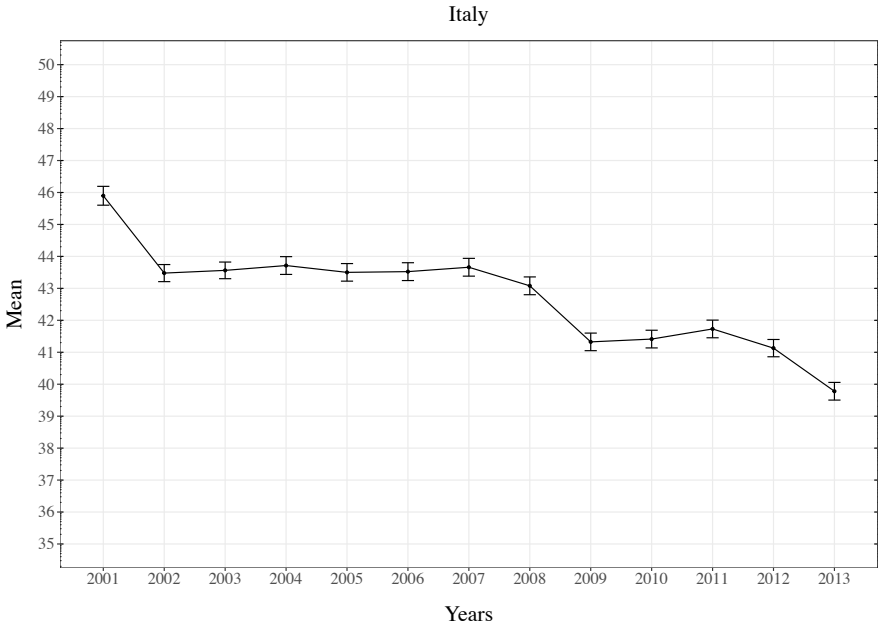


Fig.2.6: Mean number of non-null expenditure categories, from 2001 to 2013. The error bars indicate the three times standard error of the mean.

Figure 2.6 shows that over time Italian households reduced, on average, the number of the expenditure categories for which they allocate their budget[17]. This contraction, that is more prominent for specific years (e.g. 2002, 2009 and 2013), suggests that the consumption patterns have been strongly affected by events (e.g. the financial crisis in 2008) that pushed families to modify their habits by reducing the number of products purchased.

The non-stationarity of consumptions may also concern specific expenditure's categories. In this regard, we want to demonstrate that, in our social complex system, the expenses for products that should be considered "stationary" (being common or necessary), may be altered by exogenous factors that, having a direct impact on specific goods, reduce their consumption. For example, in the late Nineties, we assisted in the spread of the Bovine Spongiform Encephalopathy (BSE), commonly named "mad cow disease". Such a disease, and the following BSE crisis, mostly interested North American and European cattle farms, and received an impressive media attention all over the world. Concerning Italy, this phenomenon generated a sort of collective psychosis that pushed households to reduce the number of beef purchased at the end of 90s (Baldi and Banterle 2005), although the Italian Ministry of Health declared that the farms and the importations of beef were under control. We calculated the rate of change of the percentage of households that purchased beef in 2002 compared to 2001: the result reveals an increase of 17% of families. Such outcome is in line with a recovery, in the early 2000s, of the beef purchase, as a result of the preventive measures taken by the Italian government to control the risk of an epidemic spread (Baldi and Banterle 2005). A similar pattern can be detected in the Italian households' reduction of poultry consumption as a consequence of the Avian Influenza. Although the pandemic threat has been anticipated, and countermeasures have been taken by the World Health Organization, recommending strategic actions for countries (WHO 2005), the National Confederation of Farmers (COLDIRETTI) revealed that the reduction of expenses on poultry strongly impacted the economic sector[18]. As COLDIRETTI declared, the avian psychosis and the unjustified alarmism have been fed by little information on the virus and the lack of clarity of media news. Our data reveal that the rate of change of the percentage of households that allocate their budget for purchasing poultry becomes positive after the release of WHO 2005 program, concerning the strategic actions that each country should adopt to prevent the Avian Influenza spreading[19]. Therefore, according to the trends of the expenses for beef and poultry in the observed time-window, it seems that once the threat has been overcome (or it is less perceived by people), consumers tend to re-adopt their purchasing habits. Moreover, it is worth to note that the above mentioned epidemics did not have an impact just on households' purchasing habits (the consumption system), but they also influenced the sales market (the production system): on one hand, consumers became more aware of the importance of knowing the origin of products they consume, on the other hand, new laws concerning the control and the traceability of items have been introduced.

Finally, together with the endogenous and exogenous factors that may lead to a non-stationarity of family consumptions, it is worth to note that also the structural modifications of the household's composition (e.g. growing up of the offspring, shift in the stage of family life-cycle etc.) have a strong impact on family patterns of consumption. In this regard, we may observe that, for example, families in a specific stage of family life-cycle, such as couples with babies, are more oriented to allocate their

[17] The linear regression performed on the mean number of goods and services purchased by households in the observed time-window reveals a slope equal to -0.37075, and a p-value equal to 0.0000192 (statistically significant at 1%).

[18] Online source: https://www.repubblica.it/2005/j/sezioni/cronaca/aviaria4/coldiretti/coldiretti.html (Language: English).

[19] After a period of strong contraction in poultry purchase, we observe a rate of change equals to 4.64 from 2006 to 2007 and a positive trend in the following years.

budget for products aimed at satisfying the primary needs of offspring and of a new born family unit. Nevertheless, when the children grow up, the stage of family life-cycle changes, together with the needs, the desires and the attitudes of family members: as a consequence, households modify their patterns of consumption, orienting towards different and more heterogeneous expenditures categories, related, for example, to education, leisure, look style and so on.

4.5. Heteroscedasticity of consumption

The heteroscedasticity is a typical property of complex systems that can be represented in the shape of a complex network and partitioned in communities, in which the elements that compose each group are similar between them, according to specific features, and have many connections among them, but they show few or no links with the elements belonging to different groups. In our complex system, we may observe that family types, grouped together according to common specific characteristics (such as, for example, the age of members, the presence of children, or the stage of family life-cycle), reveal very similar patterns of consumption among them. On the contrary, we may detect different styles of consumption by comparing, for example, the expenditure's patterns of families with adolescents with respect to the set of goods and services purchased by elderly couples. In this regard, the analysis on households' consumptions carried out by the Italian Institute of Statistics reveal that the allocation of family income for goods and services strongly depends both on the structure (in terms of number and age of members) and on the employment condition of the reference person. Among the results, the Italian Institute of Statistics shows that large families (five components or more) mostly spend for foods, on the contrary, households composed by single members allocate their income especially for expenditure categories related to the house. Moreover, total expenditure is lower when the reference person is a woman, such an evidence relies upon the fact that, in Italy, households in which the head of the family is a man are mainly composed by couples with or without children, on the contrary, households with a woman as reference person are mainly composed by elders and single parents. Specific patterns of consumption can also be detected in relation to the occupational level of the head of the family. Indeed, it has been demonstrated that families in which the reference person is a businessman or a self-employed spend twice more than households with individuals out of the job market (as retired people, housewives or unemployed). Moreover, households with scarce economic resources allocate their family budget only for basic commodities, concerning food and house[20].
Moreover, the heteroscedasticity of consumption in the complex system composed by households and their expenses, can be observed at macro-regional level. It means that, by grouping households according to the territory in which they live, patterns of consumption characterizing specific areas of Italy rise. In this regard, figure 2.7 shows the average number of non-null expenditure categories (from 2001 to 2013), according to five macro-areas in which the twenty Italian regions have been grouped:

[20] Source: ISTAT Reports from 2004 to 2013, available at: https://www4.istat.it/en/archive/consumption+expenditure (years: 2009-2016).

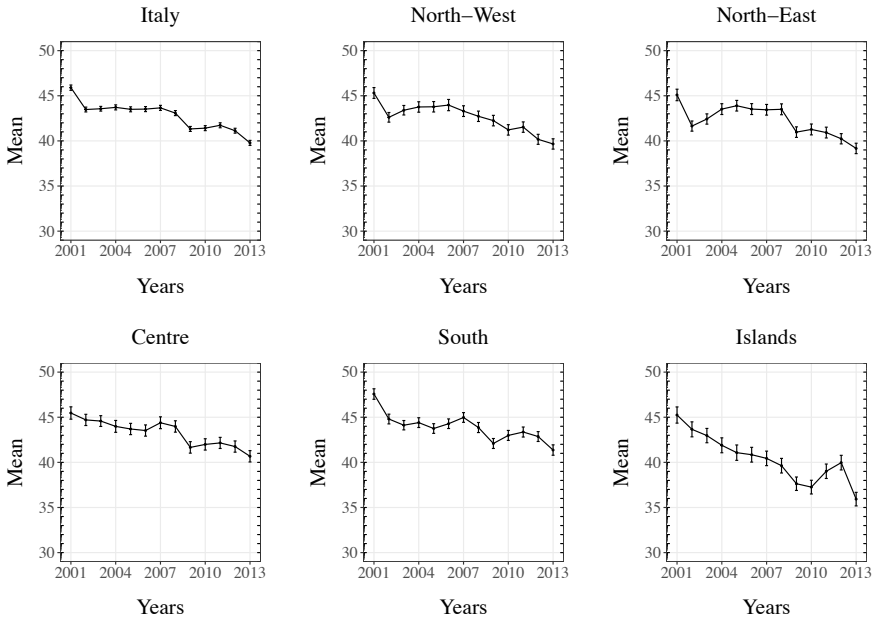


Fig.2.7: Mean number of non-null expenditure categories in Italy and in five macro-areas, from 2001 to 2013. The error bars indicate the three times standard error of the mean.

Figure 2.7 shows an overall decreasing trend of the mean number of non-null expenditure categories throughout the macro-regions that confirms the non-stationarity of consumptions outlined through figure 2.6. It means that, during the considered period, overall all the Italian households reduced the number of goods and services purchased, probably as a consequence of specific exogenous and endogenous factors that negatively affected their consumption behaviour. Although such a negative trend is common for all the macro-areas in which the sample has been stratified, it is worth to note that households living in islands (that are Sicily and Sardinia) reveal a reduction of their purchases stronger than the expenditure contraction of families living in the other geographic areas[21]. We may argue that political, social and economic changes have an impact on the evolution of Italian families' consumption patterns, although with a different magnitude.

The different expenditure's patterns in relation to the Italian macro-regions can be further investigated by considering the amount of income that households, living in different areas of Italy, allocate for purchasing goods and services. In this regard, we calculate the annual expenditure of households, stratified according to the macro-regions in which they live, for every year of the survey. To detect if the expenses vary among the five macro-areas, we apply a bootstrap technique, creating 10000 random samplings with replacement of every pair of vectors of expenses with regard to the two macro-areas considered, and we perform a two-sample t-test. The bootstrap procedure allows us to deal with the fact that data do not satisfy the normality assumption (Efron and Tibshirani 1993). The pairwise-comparisons reveal that the null hypothesis of t-test (the means of the expenditures are equal among two macro-regions) cannot be rejected at the 1% significance-level for the couplings 1) North-West and North-East (for 7 years); 2) North-West and Centre (for 9 years); 3) North-East and Centre (for 4 years); 4) South and Islands (for 4 years). It means that among such pairs of macro-areas we can detect similar patterns of expenditure, while the purchasing habits of households living in areas as North-East and Islands, strongly differ. This evidence can be confirmed by the density plots showed below:

[21] A linear regression model revealed appropriate to fit data on the average values of non-null expenditure categories in Islands. By considering the mean number of expenditure categories as dependent variable, and the years as independent variable, the slope is -0.61626, the p-value is 0.0000175.

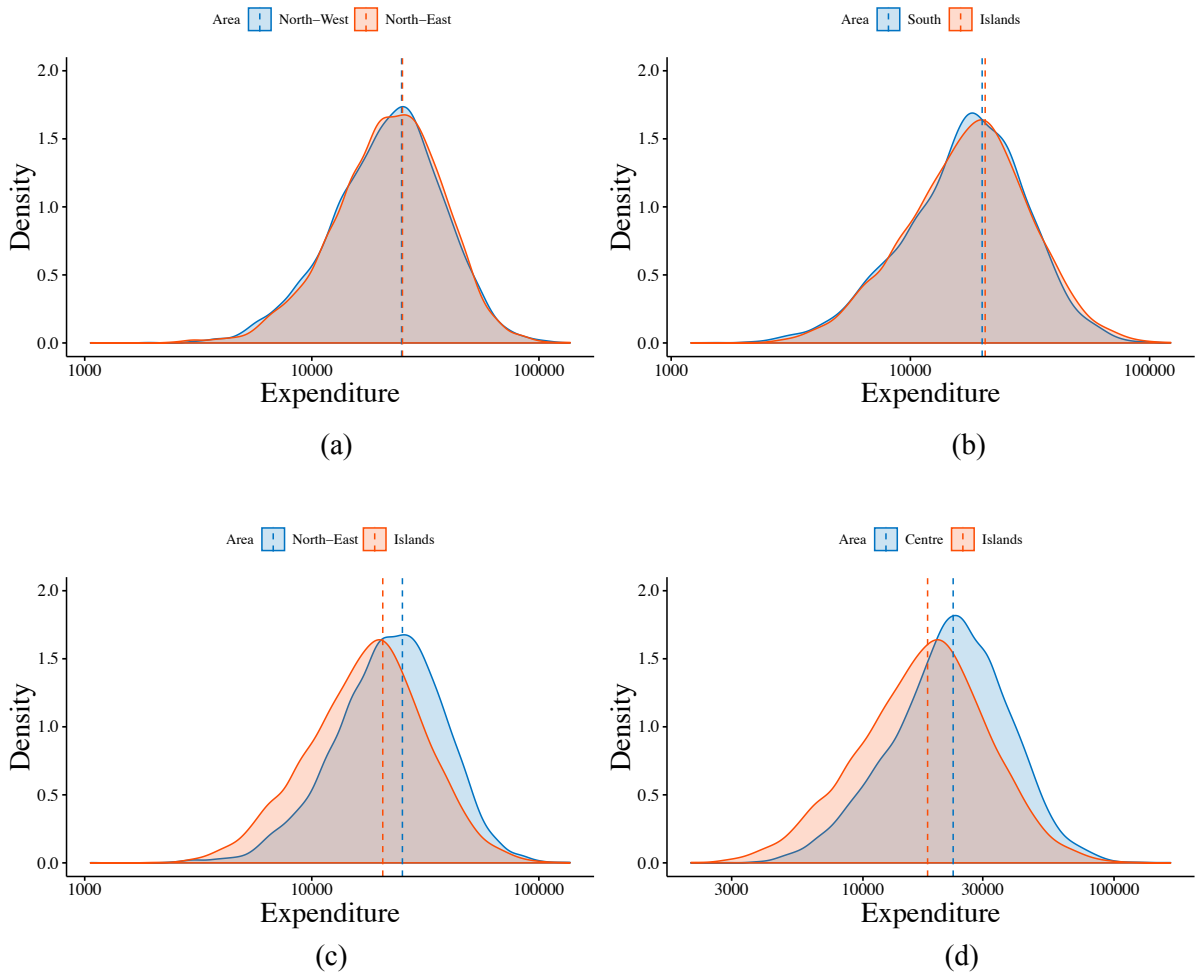


Fig.2.8: Density plots of the annual expenditure of households in four pairs of macro-regions (year 2003): North-West and North-East (a); South and Islands (b); North-East and Islands (c), Centre and Islands (d). Horizontal axis in logarithmic scale. The dotted lines indicate the mean values.

Therefore, the differences on consumption patterns across Italian macro-regions allows one to investigate how and to what extent the regional inequalities (in terms of income, resources, economic growth, local policies and so on) reflect on the differentiated types of expenditure behaviour throughout Italy. In this regard, the study of Bono et al. (2007) focuses on detecting Italian territorial disparities in terms of consumption patterns, with the aim to outline specificities in households' consumption choices, according to the macro-area in which they live. The authors group households' expenses in three macro-categories, namely "food", "living" and "luxury", and consider the northern and central regions as high-income regions, and the southern ones as low-income regions. The results highlight an evident fragmentation of consumers' choices among the Italian macro-areas. More in detail, the study reveals that households living in northern and central regions spend less on food, compared to southern families. On the contrary, they tend to allocate their budget for expenses related to luxury goods and services more than households living in southern regions. Finally, the expenditures on housing are greater in the northern regions than in the central and southern ones. The specificities of consumption behaviours of Italian macro-areas have been also investigated in order to detect similar reactions to the Great Recession of families living in the same macro-regions (Bono et al. 2016; Celidoni et al. 2016; Lucadamo et al. 2019). The studies reveal that, although in general all the Italian households have experienced a severe decrease in purchasing power (that has led to an overall reduction of consumptions), spending profiles characterizing different macro-regions remain. Finally, the regional inequalities in terms of consumption behaviour are widely analysed also by the Italian Institute of Statistics, that yearly draw up a report on Italian households' expenditure,

differentiating between Northern, Central and Southern areas. The results confirm the homogeneity of consumption within macro-regions, both in terms of total expenditure that households allocate for products, and in terms of differentiation among the types of goods and services purchased[22].
In summary, we may conclude that the community structure of the complex social system composed by households and their expenditure reflects on the heteroscedasticity of consumption, that one can observe both at lower level (that is the households' composition) and at higher level (the regional context).

4.6. Extreme events and tipping points

The heterogeneity of system's elements and their interactions, the mutual influence among different systems, the feedbacks' processes and the other characterizing features that determine the dynamicity of complex systems, may led to quick alterations in systems' behaviour. As we introduced in 4.4 section, throughout the considered time-window of thirteen years, the consumptions have been affected by different social, economic and political changes, occurred both at international and national level. Such crucial events can have a strong impact of households' purchasing patterns.
In this regard, analysing the expenditures of Italian households, that will be further discussed in Chapter 3, we detected that, in specific years, all the family types in which we grouped our sample reduced, on average, the number of items purchased with respect to the previous year. Such phenomenon has been observed in 2002, 2008 and 2013, by calculating the rate of change of the mean number of products purchased with respect to the previous years (then with respect to 2001, 2007 and 2012). Possible explanations to the contraction of households' expenditures in these years may be lead back to the events occurred in the previous periods. In this regard, we consider the Euro introduction in 2001, the global financial crisis in 2007 and the austerity policies introduced in Italy in 2012, as possible causes of the overall reductions of households' consumptions. Such events may have altered the Italians' perception of financial security, improved the feeling of uncertainty and, as a consequence, pushed households to reduce the amount of goods and services purchased. Moreover, it is worth to note that in 2013, on one hand, we assist to the reduction of the amount of products purchased, on the other hand, we also observe a reduction of Theil concentration index (not observed in 2002 and 2009)[23]: it means that, although families allocate their income to a reduced number of goods and services, their total expenditure is more equally distributed among the items purchased compared to the previous years. In a complex systems' theoretical framework, such events are considered as tipping points, in which a change in the behaviour of the social system is observed, leading to a shift of the system into a new equilibrium state. In this regard, the impact of social, political and economic events on Italian households' consumptions has attracted the interests of social scientists in the last years, aimed at detecting the strategies adopted by families in order to deal with such critical periods (Bosio et al. 2011; Cappellini et al. 2014; Bono et al. 2016; Secondulfo and Tronca 2016).

[22] The yearly reports on Italian households' expenditures contain the results both at country-level and at macro-regional level. They can be found at: https://www4.istat.it/en/archive/consumption+expenditure (years: 2009-2016).
[23] Theil index has been performed on the expenditures of each household. Then the mean value of the index has been calculated for every family type in which the sample has been classified. It will be further discussed in the next chapter.

4.7. Information cascades, herd behaviour and consumers' adaptation

As pointed out above, the reduction of the average amount of goods and services purchased by Italian households in 2009 may be due to the effects of global financial crisis. Nevertheless, while the possible explanations of tipping points observed in 2002 and 2012 (that are the Euro introduction and the austerity policies, respectively) are not directly connected to the family consumption, the reason why households reduced their expenses (as a consequence of the American financial crisis) can be detected within the system composed by families and their consumptions. Although the American crisis had catastrophic consequences that interested European economies in the long-run, we did not observe instantaneous effects on Italian economy and on households' income in 2008. In this regard, the reduction of families' consumptions observed in 2009 can be considered as an effect of information cascades and herding behaviour. Indeed, we may argue that the global spread of information about the negative consequences of American financial crisis had a strong impact on the Italians' perception of their economic security and on their sense of impoverishment, pushing them to save money in view of a cascade of negative economic downturn affecting also European countries. In this process, a key role has been probably played by the worldwide media coverage that American financial shock had. Indeed, it is broadly recognized that media play a prominent role in shaping reality: they have the potential to influence audience attitudes, expectations and views of the world (McCombs and Shaw 1972; van Raaij 1989). One may argue then that the information cascade on the local effects of American economic collapse generated a shared alarmism about the imminent global consequences. The growing concern about the vulnerability of the middle-class, stressed in the public debate, may have contributed to the Italians' perception of an upcoming worsening of their own financial situation and of the economic conditions of the country, resulting in a reduction of the number of goods and services purchased.

Phenomena of massive changes in consumption habits may even be detected with regard to specific expenditure's categories. For example, the smartphone, introduced in the marketplace at the beginning of the new century, has impacted both the number of purchased mobile phones–it is calculated that, in Italy, the penetration rate of mobile is 85%, and of mobile subscriptions is 128% (We are Social 2017)–and the way in which consumers conceived them. Nowadays, people use smartphones for a wide range of different activities that go beyond the basic functions of traditional mobile phones, such as sending email, watching television, taking pictures, purchasing goods, controlling bank records and so on. Together with its variety of functions, smartphone replaced many products usually purchased by consumers, having a strong negative impact on sales of such items (let's think about fax, cameras, music players and so on). People did not take long time for adapting to technological changes that involved mobile industry, as data confirm: from approximately 17 millions of devices sold in 2006, to almost 410 millions sold ten years later[24]. In this regard, the change in technological consumption habits of individuals may be read as the interplay between consumers' adaptation and herding behaviour. On one hand, everyone (except for digital natives) has been forced to modify his habits in order to deal with a marketplace constantly evolving; on the other hand, we have to consider now the generalized attraction towards new fashionable items. The crowds of people at the entrance of Apple stores, or the long lines of individuals waiting the release of the late-model of iPhone, are examples of herd behaviour of consumers whose purchasing decision are based on trends and social emulation rather than rational choices that may consider the high cost of device or its utility.

Finally, processes of adaptation in consumption habits can be detected in the strategies that consumers adopt to face the financial crisis. Indeed, it is worth to note that, starting from 2010, we

[24] Source: http://lab24.ilsole24ore.com/cellulari/. Language: Italian.

assist in an increase of Italian families that affirm to make expenses for food products in hard discounts with a constant attention on the price of items. While such changes initially arise as an exigence to save money, they gradually become part of purchase habits over time. In this regard, Censis Report (2017) reveals how Italian consumers deeply changed as a consequence of the economic crisis. First of all, they lost their loyalty towards both products and places in which they purchase: the study highlights that, especially for food products, people are more oriented to go to different shops, according to the special offers or to the discount of specific products. In order to do this, consumers are constantly informed and, at the same time, they provide information on consumption's experiences. Moreover, they adapt to the new technologies in order to accomplish their goals of saving money and maintaining a good quality of purchased products, being able to combine traditional (e.g. flyers) and digital information channels and, if necessary, to purchase online.

5. The Survey on Household Consumption

5.1. Objective and sampling strategy

The empirical works of the present thesis, presented in chapters 3 and 4, have been carried out by using data collected from the survey on Italian Households Expenditure, administered by the Italian Institute of Statistics from 1997 to 2013[25-26]. It is aimed at describing the Italian families' consumptions in relation to the different socio-economic variables and family composition that may affect households' lifestyles. Such a survey is also used to estimate the poverty rate and to give a yearly snapshot of Italian families' situation. Moreover, the annual analysis of households' consumption allows one to compare the Italian purchasing choices in different years, by evaluating the impact of exogenous and endogenous factors in consumption behaviour (Bono 2016).
ISTAT collects data on the expenditure for goods and services of a representative sample of the Italian population, through a two-phases sampling strategy. In the first stage, the Italian territory is divided in about 230 layers (from 227, in 2005, to 232, in 2002 and 2003), according to the type of municipality, the number of residents and the region to which the municipality belongs. Specifically, 107 strata correspond to single municipalities (all of them are involved in the survey every year), and the remaining strata are composed by smaller municipalities belonging to the same region, that are grouped together in order to obtain the same population size of the other layers. Thereafter, three municipalities are extracted among the grouped strata, in order to participate to the first, the second and the third quarter of the survey, respectively. In the second phase of the sampling process, the households are randomly extracted from the registry of residents in each selected municipality. In table 2.2, the number of strata and the total amount of Italian households stored in the database each year are presented[27-28]:

[25] For further details on survey, metadata can be downloaded from the ISTAT archive: https://www.istat.it/it/archivio/4021 (language: Italian). Additional information on phases of production process and data dissemination can be found at http://siqual.istat.it/SIQual/visualizza.do?id=0021002 (language: English).
[26] From 2014, substantial changes have been introduced in the survey. As a consequence, data concerning the survey on households' consumption, conducted from 1997 to 2013, are not comparable with the data of the survey on household expenses, conducted since 2014.
[27] Although the survey has been carried out from 1997 to 2013, we present the total amount of families involved in the surveys from 2001 to 2013, since our empirical works will focus on this time-window.
[28] The number of observations in the database differs from the original total amount of sampled households. Such a difference may be due to multiple factors related, among all, to the unavailability

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Strata	228	232	232	231	227	230	228	228	228	230	230	230	230
Obs.	23.918	27.499	28.006	24.853	24.107	23.639	24.400	23.423	23.005	22.246	23.158	22.933	20.680

Tab. 2.2: Number of strata and sampled households from 2001 to 2013.

Households that participate to the survey are required to daily fill out a diary for seven days, by indicating the expenditure (in Euros) on a wide range of goods and services purchased. It includes the expenditures for food and for non-durable goods, such as transport (e.g. bus tickets and fuel), healthcare, leisure time (e.g. tickets for cinema, museum and/or theatre) and household items. Moreover, in the event that a family produces some products for own consumption, it receives a further diary in which the quantity and the corresponding value in Euro of the product have to be registered every day (for seven days). After one week, the interviewer collects the socio-demographic information of all family members, together with other expenditures made for specific goods and services in the last month, three months or during the year (such as utilities, house renovation, insurance, clothing, trips and durable goods).

5.2. Expenditure categories and macro-categories

The means used to collect information about the expenditures of Italian households (both the diary and the final interview) contain a wide range of products for which families may decide to allocate their income. Indeed, ISTAT collects about 280 different variables of goods and services, that proposes to aggregate according to the following categories:

Food expenses	
	Bread and cereal
	Meat
	Fish
	Milk, cheese and eggs
	Oils and fats
	Tubers, fruit and vegetables
	Sugar, coffee and other grocery products
	Beverages
No-food expenses	
	Tobacco
	Clothing and footwear
	Housing
	Electricity, gas and other fuels
	Furnishings, household equipment and routine household maintenance
	Health
	Transport
	Information and communication
	Education services
	Recreation, sport and culture

Tab. 2.3: Meso-categories for data grouping (Source: ISTAT methodological notes).

As table 2.3 highlights, the 279 expenditure categories at micro-level can be grouped at different levels of aggregation (e.g. food and no-food expenditures, durable and non-durable goods and so on). For the purposes of the present work, the empirical studies have been carried out by maintaining the expenses for goods and services at micro-level. Nevertheless, the hierarchical structure of the system allows us to group the expenses in macro-categories that differ from the ones presented by ISTAT

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of sampled families or to serious anomalies in collecting data process that led to questionnaire invalidation.

(table 2.3) and are more in line with our scientific purposes. The macro-categories that we use to pre-process the data, to investigate the trend of expenditure in the selected time-window (from 2001 to 2013), and to discuss the results of our analysis are the following:

N.	Macro-category
1	House
2	Food
3	Health
4	Insurance
5	Transport
6	Pets
7	Education
8	Children care
9	Technology
10	Look style
11	Leisure time
12	Other

Tab. 2.4: Macro-categories adopted for grouping expenditures in the empirical studies of the present work.

Specifically, the macro-categories highlighted in table 2.4 are used to pre-process data and to discuss the results of the first empirical work (Chapter 3). In the same study, macro-categories named *house*, *food*, *leisure time* and *look style* are adopted in order to investigate the evolution of the expenditure patterns throughout time. The second empirical work (Chapter 4) focuses on the specific expenditure macro-category of leisure time and on the related expenditures at the micro-level.

5.3. Classification of family members

The definition of *households* for the Italian Institute of Statistics includes people that live together, linked by different kind of ties. For its purposes, ISTAT groups the sampled families according to a classification strategy mostly focused on the age of respondent and on the presence or absence of offspring, as reported in table 2.5:

N.	Family type
1	One adult (age < 35)
2	One adult (age 35-64)
3	One adult (age 65 and over)
4	Couple without children (reference person's age < 35)
5	Couple without children (reference person's age 35-64)
6	Couple without children (reference person's age 65 and over)
7	Couple with one child
8	Couple with two children
9	Couple with three children
10	Single parent
11	Other family types

Tab. 2.5 ISTAT households' classification (Source: ISTAT methodological notes).

Nevertheless, the classification described above is not appropriate for our scientific purposes, since we are interested in detecting if and to what extent some dimensions (such as the family life-cycle and the generation of children) influence households' purchasing choices. In this regard, since the survey stores a wide range of socio-demographic information of all family members, (e.g. gender, age, marital status, education, activity status etc.), in the empirical studies of the present thesis, we propose to differently aggregate households, in line with the different dimensions affecting households' consumption that we aim to investigate. Although the classifications adopted will be further explained

in the next chapters, we anticipate that two different classifications have been adopted in the first study: one allows to take into account both the family structure (in terms of age of components–singles or couples–and presence or absence of offspring) and the stage of family life cycle; the other one focuses on couples with children, stratified according to the generation of children (Y- or Z-generation), educational level and working status of the parents. The latter classification, together with the age of children, has also been adopted to stratify the sample for the purposes of the second empirical study, which is focused on the impact of teenagers belonging to different generations (Y or Z) on family expenditure for leisure-time activities.

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CHAPTER 3

Household Expenditure and Stage of Family-Life Cycle: an Empirical Study of Italian Households

Abstract

Household expenditure and consumption behaviour are domains strongly investigated through a variety of approaches in Social Sciences. In the present study, we empirically investigate whether and how family structure, stage of family life-cycle, and generation of children influence the expenditure patterns of households. We analyse secondary data collected through the Survey on Household Consumption that the Italian Institute of Statistics administered in the period 2001-2013. The dataset includes detailed socio-demographic information about an annual sample of more than 20,000 Italian households, as well as their annual expenditure on 279 categories of goods and services. Looking at households and their expenditures as a Social Complex System, we generalize the method of Statistically Validated Networks to three-partite networks, and use this technique to elicit the expenditure patterns of different family types from data. Results show that the presence or absence of children, and, eventually, their age influence the budgetary allocation of households on the considered expenditure categories, whereas the generation of offspring does not allow, alone, to discriminate between expenditure patterns. Furthermore, the stage of family life-cycle turns out to be the key to interpret the consumption adopted by elderly households–who are mostly oriented to the purchase of few and necessary goods–, as well as the different consumption profiles of "young families" and "consolidated families". Indeed, families with babies and little kids tend to orient their expenditure to face the needs of a new-born family unit, while "consolidated families", those with older children (teen-agers or young adults), show more varied expenditure patterns. Finally, our analysis indicates that some dimensions associated with the household's income, such as the number of working parents and their level of education, represent prominent factors to interpret consumers' choices.

Keywords: household expenditure, family structure, family life-cycle, generation, Statistically Validated Network.

1. Introduction and literature review

Consumption choices are influenced by different factors, not necessarily all related to the economic dimension (Uusitalo, 1980). Indeed, "consumption style" can be defined "as the whole of consumption activities and interests of a person or a group living under certain living conditions" (Uusitalo 1980, 451). In this study, the living conditions have been identified in the family structure of households (Laslett 1972), the stage of family life-cycle (Solomon et al. 2006), and the generation of children (Mannheim 1928; tr. en. 1952). Consumption is not just a mean to cope with everyday needs, but it is the result of a set of practices and decisions more or less mediated by different dimensions at both individual and class level. According to Bourdieu (1979), the different practices of consumption are embedded in human social structure and they become an instrument through which people recognize themselves as part of a social group and differ from the others.

Applying the concept of "budgetary unit"[1] used by Max Weber to the family unit (McDonnel 2013) allows to analyse household consumption choices without invoking (complicated) internal mechanisms of negotiation in the decision making process. Indeed, according to Weber's definition, a budgetary unit is a group oriented to the acquisition of resources, services and goods with the aim to meet the needs and tastes of its members. This view contrasts with the individualistic idea of consumption, but it does not exclude the existence of a non-uniform distribution of decision power among the members of a budgetary unit, and of forms of negotiation in decision making processes. Each component of a budgetary unit, depending on her influence, acts in light of specific goals that might also involve other members, e.g., the parents' choice to invest in their children's education. Considering the main characteristics of a budgetary unit, McDonnel (2013) suggests to apply the concept of budgetary unit to modern families, in order to interpret expenditure patterns of households as the result of group decisions. In this view, family identity is different from individual identity, because it is the sum of different attitudes, tastes, needs and choices of different household components that merge together, and are oriented to the benefit of the family unit (Epp and Price 2008). Although the family is now considered as a consumption unit, the needs and the choices of the family can depend on its structure, on member characteristics, decision power and tastes, and on the stage of family-life cycle (Solomon et al. 2006). In light of this assumption, the present paper aims to empirically investigate how and to what extent family composition, stage of family life-cycle, and children generation affect the choices of consumption of households.

1.1. Family structure influence

Several studies on household consumption behaviour focused on family structure as determinant of spending patterns. Such an interest includes the composition of the family unit–e.g. number of members, socio-demographic information of the components, presence or absence of offspring etc.– and the relationship between its members. In the last decades, particular attention has been devoted to the influence of women and children on household consumption choices (Filiatrault and Brent Ritchie 1980; Martinez and Polo 1999; Soberson-Ferrer and Dardis 1991; Cotte and Wood 2004; Thomson et al. 2007). The research highlighted that working women are more influential than housewives. In fact, in the first case, there is a higher level of co-decision on purchasing. Studies on children influence reveal that, since their decision power is weaker than the one of other family members, they tend to form alliances with parents or siblings, in order to exert greater influence. Moreover, parents confirm that knowledge that children add to the purchase decisions is taken into account and perceived as beneficial.

1.2. Family life-cycle influence

The original family life-cycle theoretical approach (Lensing and Morgan 1955; Lensing and Kish 1957; Kain and Quigley, 1972) aims to demonstrate that specific needs and behaviours correspond to

[1] See the analysis of the concept of "budgetary union" in *The Max Weber Dictionary* by Swedberg and Agevall (2005). They insert the concept of Budget management (translation of Haushalt) not "budget units" as in weberian sense, because, in weberian sense these are the financial units in place budget management strategies, such as the family, the *oikos* and the planned state economy (Swedberg, 18). The semantic referent, from the point of view of the boundaries of the group referred to, seems to be the same, so much so that McDonnell highlights how both terms are repeatedly used by the second chapter of *Economy and Society* in opposition to the management of capitalist enterprise (*ibidem*, 315). However, in the Italian translation, Bagiotti, Casablanca and Rossi (1995 (1961), 57 et seq.), the authors use the term "domestic economy".

different phases in family life-cycle, that is, the set of developmental steps that households experience over time–as the birth of a child, the departure of offspring from the house, the retirement etc. (Carter and McGoldrick 2005). Changes in household structure, eventually related to specific events, strongly modify priorities, attitudes, needs and, as a consequence, styles of consumption (Solomon et al. 2006). Indeed, the study of Arndt (1979) already revealed, for instance, that single-young people spend much on restaurants, entertainment, transport and recreation, while they spend little for food and housing. On the contrary, new-born families and families with offspring show patterns of expenditure more oriented to cope with the primary needs, such as food, housing and childcare. Finally, elderly households tend to spend a lot for food and medical care, and to save on clothing, recreation, and other goods and services.

1.3. Generational influence

People belonging to the same generation share specific tastes, attitudes, values and representations of the world that are different from those of the previous generations and that differentiate them from their parents (Mannhaim 1928, tr. En. 1952; Kahle 1996). Therefore, consumption choices can also be considered as distinctive of a particular generational group (Leventhal 1997; Solomon et al. 2006). In fact, research reveals some specificities in consumption that are distinctive of new generational groups, such as the attitude towards shopping (Brosdahl and Carpenter 2001), the interest towards new forms of leisure–related to internet, theme parks, rock concerts and fast-food restaurants– (Chhetri 2014), and the inclination to the novelty–experiencing new brands and products–and to be more influenced by advertising (Moore-Shay and Lutz 1988). Nevertheless, a recent research (Diliberto et al. 2019) on expenditure patterns of Italian households with children indicates that "the role of the generation of children in determining consumption patterns on leisure is significant only when the time difference between generational cohorts is long enough that social, economic, political and technological changes occurred in between can affect people's lifestyle."

1.4. Complex Systems and Complex Networks

In the present study, Italian households and their expenditures are considered as a Social Complex System (Castellani and Hafferty 2009). The term "Complex System" has its roots in the second half of the last century (von Bertalanffy 1968) and describes a system composed of many interconnected elements. The connections between the elements of a complex system are typically non-linear, can hardly be predicted individually, may determine non-trivial, non-random, and non-deterministic patterns of evolution, and generate emerging phenomena. All of these characteristics make it almost useless the classical reductionist approach, in order to analyse a complex system, and adopting a holistic approach is, usually, recommended (Castellani and Hafferty 2009), for instance, a network approach. In the present study, we represent the complex social system of households and their expenditures as a tripartite (complex) network, in which the sets of nodes represent 1) family types (defined according to the family structure and its stage in family life-cycle), 2) single households, and 3) expenditure categories. Such a representation allows us to generalise the Statistically Validated Network methodology (Tumminello et al. 2011) to tripartite systems, in order to reveal patterns of expenditure typical of each family type.

The existing literature focuses on several different aspects that could influence households' consumption style. Nevertheless, as far as we know, there is still a lack of studies that consider the interplay between multiple dimensions as influencing factor of household's consumption behaviour, and, generally speaking, that treat households and their expenditures as a complex social system. Moreover, the current research in family purchase decision mainly considered the decision for a

single expenditure or for aggregated expenditure categories (Bono 2016; Raper et al 2002; Toivonen 1992; Wagner and Soberon-Ferrer 1990), while, here, we consider a comprehensive and heterogeneous set of about 280 categories of goods and services.
In summary, the contribution of the present study is to take into account simultaneously family structure, stage of family life cycle, generation of children, which we discuss below in detail, and two proxies of households' income, namely, number of working parents and their educational level, in order to analyse the influence of such dimensions on the consumption choices of households over a wide range of expenditure categories, and a rather long period of time.

The remainder of the chapter is organized as follows: section 2 describes the data and provides an overview of temporal patterns; section 3 describes the network methodology used to investigate the patterns of expenditure; in section 4, the main results of the analysis are reported and discussed; finally, in section 5, we draw our conclusions.

2. Data

2.1. Data description

We analyse secondary data collected by the Italian Institute of Statistics (ISTAT) through the Survey on Household Consumption, in the period 2001-2013[2]. The survey considers a stratified sample of households, which is representative of the Italian population. Specifically, ISTAT collects data about households' expenditures on a variety of goods and services–279 expenditure categories related to food, furniture, clothing, housing, health, transport, leisure time, etc. Some variables that concern ordinary purchases, such as fuel and food products are daily collected, for seven days, and weighted by means of a temporal coefficient, in order to report the estimated monthly expense on the final database. Extraordinary expenditures–as home maintenance, purchase of private transports, travels etc.–are collected with reference to different temporary scales (in the last 1, 2 or 3 months, or during the year). According to such a survey procedure, the final database contains households' expenditures referred to different ranges of time. Finally, socio-demographic information is collected for each member of the family. Here, we use socio-demographic information–family composition, sex, age, job status, and education of members–to group together households that present similar characteristics with respect to family structure and stage of family life-cycle. The sample size ranges between 20,680 households in 2013 and 28,006 in 2002.
The decision to use such a database for the purposes of the works reported in both this chapter and the next one relies upon multiple reasons. First of all, the Italian Institute of Statistics collects data that are representative of Italian families and, therefore, our results are viable at the national level. Moreover, considering micro-data allows us to aggregate families and expenditure categories according to specific scientific purposes (e.g., to group families with regard to their internal structure and expenditure categories with respect to the macro-category they belong to), also in consideration of the rather large size of the surveyed sample. Secondly, the databases covers a rather long time window (from 2001 to 2013), which allows us to investigate the evolution of patterns of consumption of Italian families, by also taking into account the exogenous factors that may have had an impact on consumption patterns, such as the introduction of euro currency in 2001, the financial crisis in 2008, and the austerity policy in 2012-2013. Finally, it is worth to note that the considered data adapt very well to the overall purpose of the thesis, that is, to analyse households and their purchasing patterns as a complex social system. Indeed–as we deeply highlighted in Chapter 2–micro-data allow us to

[2] For more details on the survey design, metadata and methodological notes can be downloaded at: https://www.istat.it/it/archivio/4021 (language: Italian).

demonstrate that the system composed by families and their expenditures shows several characterizing features of complex systems, such as the heterogeneity of households and expenditure categories in both qualitative and quantitative terms, the non-stationarity of the expenditures, and the heteroscedasticity of consumptions.

2.2. Households' classification

In the first part of the study, the categorization of households is based on the model of family structure proposed by Laslett (1972) with some modifications, in order to fit with the objectives of this work. Families have been grouped together in 14 categories considering: 1) family structure (in terms of presence/absence of children); 2) age of the members of families without offspring, and 3) generation of children. The decision to distinguish between families with Y- and Z-generation offspring allows us both to consider the generational influence[3] and to investigate the evolution of expenditure patterns of households with children, starting from two different initial stages of the family life cycle. Indeed, families with Y-generation children (born between 1981 and 1994) can already be considered as consolidated families at the beginning of the investigated time window, given that the age of children lies between 7 and 20 in 2001. On the contrary, families with Z-generation children (born between 1995 and 2010) are in the early stage of family life cycle in 2001, with children between 0 and 6 years old, that is, pre-schoolers.
Although the Laslett's classification also includes multiple and extended families, we just focus on families with a nuclear structure and families without structure (see Table 3.1), in order to limit the heterogeneity of households grouped together in the same category and avoid the proliferation of family types, which, both, might impair the statistical power of the analysis. Nonetheless, the average proportion of sampled households that fall in each family type may vary significantly, ranging from a minimum of 0.4% for family type 6 to a maximum of 12.5% for family type 9. Such heterogeneity of family types is one of the reasons why Statistically Validated Networks are appropriate to investigate the present system. Indeed, the null hypothesis involved in the network construction exactly takes into account that heterogeneity.

[3] While scientific research deeply focused on intergenerational differences between Baby Boomers, X and Y generations (Jackson et al. 2011; Gurău 2012; Moore 2012; Kolnhofer-Derecskei et al. 2017), there is still a lack of studies on the distinction between Y and Z generation in terms of styles of consumption. Such a gap in the sociological discourse is probably due to the fact that people belonging to Z generation represent a recent and uprising consumer group. Nevertheless, nowadays, marketers are focusing on such a new generational cohort by demonstrating that, for example, people belonging to Z generation are, with respect to their predecessors, more sensible to sustainable consumption (Kamenidou et al. 2019), more influenced by technological innovation (Özkan and Solmaz 2017), more oriented to online purchases and less interested in luxury brand, with respect to the quality and originality of the items they purchase (Visioncritical 2016). Therefore, we decided to stratify the sample according to the Y and Z generation of children, in order to detect possible differences in the consumption choices of the corresponding family units.

Categories	Family type according to household composition	Average % of families
1	Couple with Y-generation children	12.0
2	Couple with Z-generation children	11.6
3	Couple with Y- and Z-generation children	4.7
4	One adult and Y-generation children	1.9
5	One adult and Z-generation children	1.0
6	One adult and Y- and Z-generation children	0.4
7	One adult (age 18-39)	4.1
8	One adult (age 40-65)	8.2
9	One adult (age 65 and over)	12.5
10	Couple without children (both age 18-39)	2.4
11	Couple without children (both age 40-65)	6.0
12	Couple without children (both age 65 or older)	8.3
13	Couple without children (mixing age categories 10, 11, and 12)	4.0
14	Others family types	22.8

Tab. 3.1: Household's categories based on: the presence/absence of offspring, the generation of children and the age of members of families without children[4].

In the second part of the analysis, we only focus on family types 1 and 2, i.e., consolidated families (couples with children belonging to the Y-generation) and families in the early stage of family life-cycle (couples with Z-generation children), and further stratify the sample according to the educational level and the number of parents working. Such a stratification allows us to deeper investigate the extent to which stage of family life cycle affects the consumption patterns of families, in comparison with other relevant dimensions, such as the level of education of the parents and the number of working parents, which, together, represent a proxy of the household's income. The size of the reduced sample (family types 1 and 2) ranges between 4,654 in 2013 and 6,070 in 2007.

[4] Although the analysis is performed considering all family types presented in table 3.1, the results for family types 13 (couples without children–mixed age) and 14 (other family types) are not shown in the remainder of the paper. The reason of such a choice is that family type 13, and, at a larger extent, family type 14 are difficult to classify in a specific phase of the family life-cycle, which reflects in the presence of negligible patterns of consumption in the SVN for these family types.

Categories	Family type according to the household composition	Average % of families
1 (Y2H)	Y-generation children, both parents working and high level of education	4.9
2 (Y2L)	Y-generation children, both parents working and average/low level of education	17.5
3 (Y1H)	Y-generation children, one parent working and high level of education	2.2
4 (Y1L)	Y-generation children, one parent working and average/low level of education	20.7
5 (Y0)	Y-generation children, both parents unoccupied	6.0
6 (Z2H)	Z-generation children, both parents working and high level of education	8.0
7 (Z2L)	Z-generation children, both parents working and average/low level of education	18.3
8 (Z1H)	Z-generation children, one parent working and high level of education	2.7
9 (Z1L)	Z-generation children, one parent working and average/low level of education	17.9
10 (Z0)	Z-generation children, both parents unoccupied	1.7

Tab. 3.2: Household's categories based on: the generation of children, the highest educational level among parents and the number of working parents.

In the classification reported in Table 3.2, high level of education indicates a college degree or a higher educational achievement, and average/low everything else. Educational level has been determined as the higher level of education among the parents. Households with both parents are unoccupied have not been further stratified by level of education, because of the limited sample size (1.7% of the sample, on average, as reported in Table 2). Besides providing indirect information on the income (a dimension excluded from the survey), the classification reported in Table 3.2 presents some intrinsic advantages with respect to the objective of the present study, since, educational level is also strictly related to individual tastes and choices (Chan e Goldthorpe 2007; Katz-Gerro 2002).

2.3. Concentration of expenditure over time: first classification of households

The database is extremely heterogeneous, since it includes 279 different categories of expenditure, across several macro-categories ranging from house to cookies, from look style to healthcare, from leisure time to insurance. Moreover, the total budget that households allocate annually for the purchase of goods and services can vary by several orders of magnitude across the sample. Finally, a drawback of the richness and heterogeneity of the set of expenditure categories considered in the survey is that each family, on average, concentrates its annual expenditure on less than 20% of the categories. In other words, the dataset is very sparse, displaying more than 80% of null entries. The concentration of expenditure can vary across family types, depending, for instance, on the stage of family life cycle, and over time. To give a clearer view of the concentration of expenditure, Fig.3.1 shows the number of expenditure categories in which, on average, households belonging to each family type from 1 to 12 (Table 3.1) spend in the period 2001-2013.

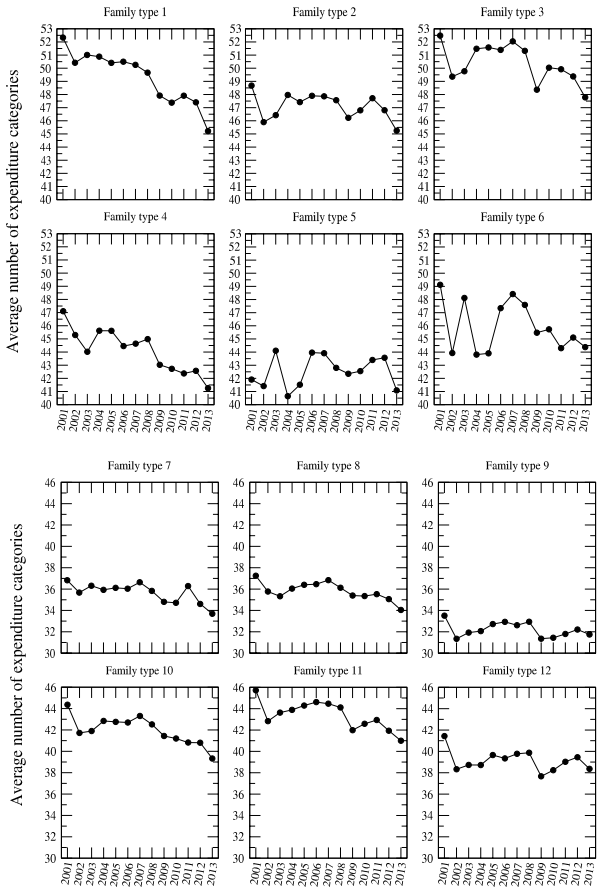

Fig. 3.1: Average number of the expenditure categories in which a household allocates its annual budget over time. According to classification reported in Table 3.1, top panels show the results obtained for family types 1 through 6, while bottom panels report results for family types 7 through 12[5].

Besides the negative trend displayed in Fig.3.1 for most of the family types, as detailed in the caption of the figure, which indicates an increasing trend in the concentration of expenditure over time, it's also worth looking at the annual rate of change of the average number of expenditure categories in which households allocate a share of their budget. Indeed, though the annual rate of change (R) varies from negative to positive values across the set of family types, there are three years when the rate of change is negative for all of the considered family types (tab. 3.3): 2001/2002 (average R = -5.4), 2008/2009 (average R = -3.7%), and 2012/2013 (average R = -3.1%). We may argue that the observed reduction, on average, of the number of expenditures for all family types can be due to political, social and economic factors that had an impact on households' consumption choices, such as 1) the Euro introduction in Italy in 2001; 2) the global financial crisis in 2008; 3) the crisis of sovereign debt and the austerity measures introduced in 2012.

[5] The trend of the mean number of expenditures reported in the figure is significantly decreasing (5% threshold) for family types 1 (slope -0.4747, p-value 0.000004), 3 (slope -0.2105, p-value 0.044), 4 (slope -0.3772, p-value 0.00005), 7 (slope -0.1689, p-value 0.0062), 8 (slope -0.1453, p-value 0.012), 10 (slope -0.2576, p-value 0.0021), and 11 (slope -0.2453, p-value 0.0049).

		Family type											
Year	**Year+1**	1	2	3	4	5	6	7	8	9	10	11	12
2001	2002	-3,7	-5,7	-6	-3,8	-1,2	-10,6	-3,1	-4	-6,5	-6	-6,3	-7,5
2002	2003	1,2	1,2	0,8	-2,8	6,5	9,5	1,8	-1,2	1,8	0,4	1,9	1,0
2003	2004	-0,3	3,3	3,4	3,6	-7,9	-9	-1,0	2,1	0,4	2,3	0,6	0
2004	2005	-0,9	-1,1	0,2	0	2,2	0,2	0,5	1,0	2,0	-0,2	0,9	2,4
2005	2006	0,2	1,0	-0,4	-2,5	5,9	7,9	-0,2	0,2	0,6	-0,1	0,7	-0,8
2006	2007	-0,5	-0,1	1,3	0,4	-0,1	2,3	1,6	1,0	-1,0	1,4	-0,3	1,1
2007	2008	-1,2	-0,6	-1,4	0,8	-2,5	-1,7	-2,2	-1,9	1,0	-1,8	-0,8	0,2
2008	2009	-3,5	-2,8	-5,8	-4,3	-1	-4,4	-2,9	-2	-4,8	-2,6	-4,8	-5,5
2009	2010	-1,1	1,2	3,5	-0,7	0,5	0,5	-0,2	-0,1	0,3	-0,6	1,4	1,5
2010	2011	1,1	2,0	-0,2	-0,8	2,0	-3,1	4,5	0,5	1,1	-0,9	0,8	2,1
2011	2012	-1,0	-1,9	-1,1	0,5	0,4	1,8	-4,6	-1,3	1,3	0	-2,3	1,1
2012	2013	-4,6	-3,3	-3,2	-3,1	-5,7	-1,6	-2,7	-2,9	-1,4	-3,6	-2,2	-2,8

Tab. 3.3: Rate of change of mean number of non-null expenditures for each family type. Percentage values.

The inequalities among the amount of goods and services purchased by family types in the considered time-window can be quantified through the concentration indices. In this regard, we calculate the Theil index (Theil 1967) and the Gini coefficient (Gini 1912) on the expenditures in which every household allocates part of the family income: both the measures of statistical dispersion reveal similar trend in the observed time-window[6]. Therefore, we calculate the average value of the index for each family type (from type 1 to type 12, according to table 3.1) in which the sample has been grouped. Figures 3.2 shows the trends of mean values of Theil index calculated for each family type according to the first classification (table 3.1).

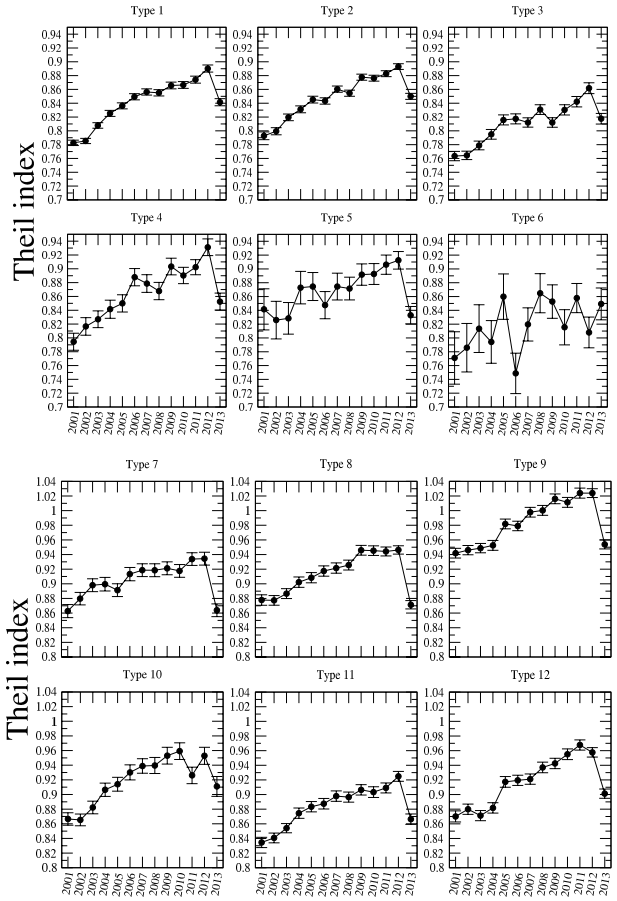

Fig. 3.2: Mean values of Theil index for each family type over time. Index calculated on all the expenditure categories greater than 0. Error bars indicate the standard error of the mean.

[6] The trends of Gini coefficient are reported in Appendix.

We observe that the trend of Theil index increases over time for all the family types. Such a result indicates that, among the items purchased, the households tend to spend more for specific products than for others. Families composed of one adult with Y- and Z-generation children (family type 6) reveal a more unstable trend compared to the other family types, it can be due to a noisy signal resulting from the reduced number of observations that compose the group. Despite the overall increasing trend over the years, we observe in 2013 a sudden decrease of the mean values of the concentration index for all the family types: it means that, in this year, their total expenditures become more democratically distributed among the products purchased. In view of the overall decrease of the mean number of items purchased (fig. 3.1), we may argue that families quantitatively reduce their consumption of goods and services, but, at the same time, they allocate more equally their income in the few selected products. Such phenomena can result from multiple related factors that invested Italy in 2011-2012, as the crisis of sovereign debt, the increase of the unemployment rate, the austerity policies, the increase of VAT and the general feeling of uncertainty and impoverishment of households. Although the reduction of the number of expenditures in which families allocate their income is also observed in 2002 and in 2009 (fig. 3.1) and confirmed by the rate of change R, these tipping points do not generate an evident concentration of the expenses on specific items (fig. 3.2, same years). Nevertheless, we may suppose that the further selection of the products and services purchased in 2013 forces households to maintain only the necessary expenditures (as utilities, food, rent or loan etc.). Among these primary goods, they have to distribute their income more equally compared to the previous years. Figure 3.2 also highlights that households with children (family types from 1 to 6) show lower values of concentration compared to households without offspring (family types from 7 to 12): this evidence reveals that the presence of children (despite their ages), leads to a more democratic distribution of total expenditure on the different goods and services purchased. Finally, Theil index reveals to be higher for family type 9, in which single adults over 65 are grouped. It means that, among the small number of items purchased (as highlighted in figure 3.1), they are more "loyal" or probably more "accustomed" to specific ones, for which they spend more than for other products.

Thereafter, we group the variables of expenditure in 5 macro-categories, namely House, Food, Transportation, Look Style and Leisure, in order to detect how the concentration of households' expenses varies among family types in relation to different kind of products and services. We observe that the Theil index is: 1) higher for the macro-category concerning the expenditures on housing than for the other macro-categories; 2) quite high and stable over time for the food products; 3) low for the macro-categories related to secondary needs, as transportation, look style and leisure time activities[7].

2.4. Concentration of expenditure over time: second classification of households

The mean number of non-null expenditures, together with the Theil and Gini indices have been also calculated for the second classification of households, that concerns nuclear couples with children belonging to Y- or Z-generation, stratified according to the number of working parents and the highest educational level (tab. 3.2). Figure 3.3 shows the mean number of items purchased by households, according to the family type they belong to. We observe that families with Y-generation children reveal mean values of non-null expenditures higher than households in which Z-generation offspring are present. Such an evidence probably is related to the different family needs that parents of Y- and Z-generation offspring have to cope with. Indeed, the former are consolidated families with offspring that are adolescents or adults, and already faced with the expenditures related to home purchasing, maintenance and childcare. They have now variegated consumptions, depending also on

[7] Theil indices and Gini coefficients calculated for the macro-categories are reported in Appendix.

the age of children, oriented, for example, to private and public transportations, leisure activities, clothing, travels etc. On the contrary, families with Z-generation offspring, that are younger in terms of composition, have a less heterogeneous consumption, mainly oriented to children (toys, clothing for babies, diapers, nursery etc.) and house (loan, furniture, renovation etc.). It is worth to note that a general negative trend in the average number of items purchased is observed for all the family types. Nevertheless, by looking at the mean values at the beginning and at the end of the considered time-window (2001 and 2013, respectively), the reduction of expenditures appears more marked for families with Y-generation children and one or both working parents compared to households with Z-generation children. Instead, families in which both parents do not have a job show the lowest contraction of the mean number of item purchased, probably due to the fact that, since these family types have no income, their number of (necessary) expenditures is already strongly limited.

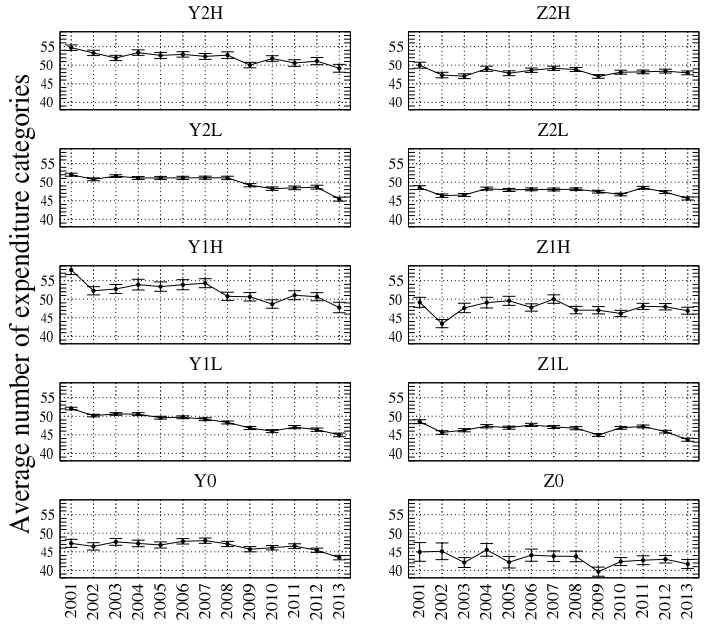

Fig. 3.3: Average number of the expenditure categories in which a household allocates its annual budget over time. According to family classification reported in Table 3.2, top panels show the results obtained for families with Y-generation children, while bottom panels report results for families with Z-generation children[8].

As regards the concentration of the expenditures[9], fig. 3.4 highlights that in families in which only one parent works and the educational level is low (Y1L, Z1L), and in households in which both parents do not have a job (Y0, Z0), the Theil index is lower at the beginning of the investigated period with respect to the other family types. Nevertheless, for these family types, the concentration of expenditures increases over the years. Households in which only one parent works and the level of education is high (Y1H and Z1H) and in which both parents work, despite the level of education achieved by family members (Y2H, Z2H, Y2L, Z2L), reveal more stable trends, with high values of concentration index over time, especially families with Z-generation children.

[8] The trend of the mean number of expenditures reported in the figure is significantly decreasing (1% threshold) for family types Y2H (slope -0.32986, p-value 0.000266), Y2L (slope -0.41302, p-value 0.000204), Y1H (slope -0.5474, p-value 0.000899), Y1L (slope -0.52935, p-value 2.34e-07), Y0 (slope -0.2154, p-value 0.01068). Therefore, although the trend is negative for all family types over time, such a decrease is statistically significant only for households with Y-generation children.

[9] Theil index calculated for the macro-categories, together with Gini coefficient calculated for all the expenditures and for the macro-categories are reported in Appendix.

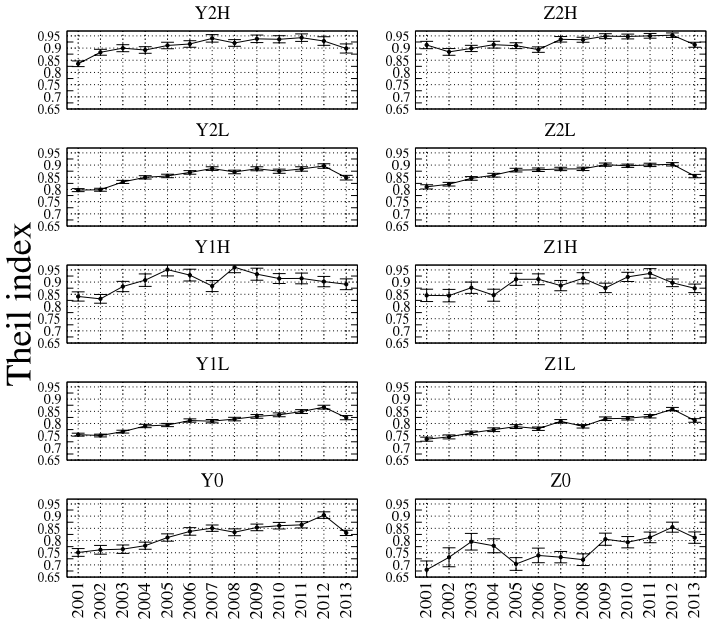

Fig. 3.4: Theil index for family types with children. Error bars indicate the standard error of the mean.

3. Methodology

3.1. Data pre-processing

Considered the ISTAT survey method, the heterogeneity of both expenditure categories and annual expenditure per household, the sparseness of data, and the trend of expenditure concentration, expenditure data were suitably pre-processed, independently for each year of the survey. The pre-processing consisted of the following steps:

- Step 1. Since ISTAT collects households' expenditures referred to different temporary scale (1, 2, 3 months or annual), all the data have to be reported to the same scale before to perform the analysis. In this regard, according to the period in which each variable has been collected, we set a value that we use to divide the considered expense in order to obtain its annual amount[10]. For ten variables, since they include both ordinary and sporadic expenses, we decide to attribute 0 if the household did not make the considered purchase, 1 otherwise. These expenditures are not considered in the following steps of the pre-processing procedure.
- Step 2a. For each household, the total annual expenditure is calculated. Every expenditure category is then divided by the total amount of the family expense. The result is the quota of expenditure that each household allocates for a specific good or service.
- Step 2b. Expenditure categories are grouped in 12 macro-categories, namely, house, food, healthcare, insurance, transport, pets, education, children care, technology, look style, leisure, and others. For each household, the total amount of expenditure on each macro-category is calculated and, then, the actual expenditure of that household for a specific good or service is divided by the total expenditure on the corresponding macro-category. The result is the quota of expenditure that each family allocates for a specific good with respect to the total expenditure in the macro-category the good belongs to.

  Steps 2a and 2b represent two different ways to pre-process raw data. In step 2a, we consider the "weight" that a single expenditure has on the overall family budget (e.g. the proportion of

[10] A table with the expenditure categories, the values used to obtain the annual amount of each expense, and the macro-categories in which the expenses have been grouped is provided in Appendix.

expenditure on home maintenance with respect to the proportion of expenditure on a generic food product). In step 2b we "contain" the heterogeneity of the expenditure variables (that concern occasional, ordinary, affordable and expensive products or services), within the macro-categories the items belong to.

- Step 3 The quotas of expenditure resulting from step 1 are now categorized, independently for each expenditure category. Specifically, a categorization on six categories is used. Let's indicate with *xij(t)* the quota of expenditure of family *i* on expenditure category *j* over the year *t*. Sample quintiles are calculated independently for each expenditure category *i* in year *t*, by excluding the *0s*. Finally, a categorization of *xij(t)* is attained according to the following rule:
    - if *xij(t)*=0, then the corresponding categorical value is 0;
    - if *xij(t)*>0, then *xij(t)* is categorized into the associated quintile (1,2,3,4,5) of expenditure *i* in year t.

The output of the categorization process is a matrix with the same dimensions of the original data matrix for each year *t* and categorical entries that take values in the support {0, 1, 2, 3, 4, 5}.

3.2. Statistically Validated Bipartite Network

The methodological approach used in present study is a generalization of the Statistically Validated Network (SVN) method, which has been introduced in 2011 (Tumminello et al. 2011) to analyse bipartite networks. A bipartite network is composed of two sets of nodes–e.g. actors and movies (Tumminello et al. 2011), criminals and crimes (Tumminello et al. 2013), mobile users and phone calls (Li et al. 2014) etc., in which links connect elements of the first set two elements of the second set (e.g., an actor to a movie if that actor played in that movie) and no link is allowed to connect elements of the same set. Here the method is generalised to the case of a tripartite system. Specifically, we consider three sets of nodes, namely, 1) family types (12 in the first analysis and 10 in the second one); 2) sampled households (more than 20,000 every year); 3) categorical values (quintiles and 0s) of each expenditure category. A link is set between a household and a family type if that household belongs to that family type, whereas a link connects a household to a categorical value of an expenditure category if its share of expenditure on that category fells in that quintile (or 0). No direct link exists between family types and values of expenditure categories. In contrast to the classical representation of a social network, in which links typically represent social interactions between the actors (e.g. kinship, co-authorship, neighbourhood, friendship etc.), the complex network that we present here does not involve any primary interaction between families. Indeed, the fact that two or more households are linked to the same set of goods and services (since they purchased them) does not imply the existence of any social tie among them. Nevertheless, it indicates a certain degree of similarity between their expenditure patterns. Similarly, if two or more households are connected to the same family type in our network, then the considered households are similar with respect to structure (e.g. couples with Y-generation children), or stage of life-cycle (e.g., young couples without offspring), or educational level of the parents (e.g., high-school and post-graduate studies), or number of working parents, or a combination of such family features. We may argue that the specificities of the connections in our system (namely, connections between a family type and a household and between a household and an expenditure category) can be fruitfully used to investigate the similarity between households' patterns of expenditure from the comprehensive perspective of complex systems.

In the present work, the final objective is to elicit preferential patterns of expenditure of each family type from data. Therefore, according to the SVN method, we study the association between a family type (*f*) and a categorical value (*j*) of an expenditure category (*i*) joined together in the single node *i-j*,

according to the number of households $\hat{n}_{ijf}(t)$ connected to both node *f* and node *i-j* in the tripartite network for the year *t*.

More formally, let's consider an expenditure category, *i* (*i=1,...,279*), jointly with one of the possible categorical values, *j* (*j=0,...,5*), and a family type, *f* (*f=1,...,12*, in the first part of the study; *f=1,...,10*, in the second), for a given year, *t* (*t=2001,...,2013*). The following notation is introduced: $n_{ij}(t)$ is the total number of households with a quota in the categorical value *j* of expenditure category *i*; $n_f(t)$ is the number of households belonging to category *f* in the data, for the year *t*; *F(t)* is the total number of households sampled in year *t*; $\hat{n}_{ijf}(t)$ is the total number of households of family group *f* with a quota that belongs to the categorical value *j* of the expenditure category *i*. According to the introduced notation, a binary Pearson's correlation coefficient, Eq. 3.1, and the associated p-value, Eq.3.2, can be used to evaluate the association and its significance, respectively, between family type *f* and categorical value *j* for expenditure category *i*, at time *t*.

(3.1)

$$\rho_{ijf}(t) = \frac{\hat{n}_{ijf}(t) - \frac{n_{ij}(t)n_f(t)}{F(t)}}{\sqrt{n_{ij}(t)\left(1 - \frac{n_{ij}(t)}{F(t)}\right) n_f \left(1 - \frac{n_f}{F(t)}\right)}}$$

;

(3.2)

$$p - value\left(\hat{n}_{ijf}(t)\middle| n_{ij}(t), n_f(t), F(t)\right) = \sum_{n_{ijf}(t)=\hat{n}_{ijf}(t)}^{\min\left(n_{ij}(t), n_f(t)\right)} \frac{\binom{n_{ij}(t)}{n_{ijf}(t)}\binom{F(t) - n_{ij}(t)}{n_f(t) - n_{ijf}(t)}}{\binom{F(t)}{n_f(t)}}$$

.

The p-values provided by Eq.2 have been corrected through the Bonferroni correction (Miller 1981) in the first phase of the study, and through the False Discovery Rate (FDR) correction (Benjamini and Hochberg 1995) in the second part of the study, with a threshold of univariate statistical significance equal to 0.01. Indeed, the Bonferroni correction is the most conservative correction for multiple hypothesis testing with respect to the number of false positives, and, as a consequence, it appears to be the most appropriate in the first analysis, where the sample size, i.e., *F(t)*, is large (more than 20,000 per year), which guaranties the statistical power of the hypothesis test. Instead, in the second analysis, the sample size is much smaller, since we only focus on households with children. Therefore, using the FDR correction appears more appropriate in this case, since, being less conservative than the Bonferroni correction, it reduces the number of false negatives.

4. Results and Discussion

4.1. Family types and their expenditures

With respect to the first classification of households (tab. 3,1), the Bonferroni networks have been generated for every year of the investigated time-window. The graphs reported in figures 3.5 and 3.6 show a stylized fact, which is observed throughout the time-window, namely, the dependence of spending patterns from family composition. They present the connections among family types and expenditure categories according to the different categorical values of expenditure, highlighted

through the colour of links. It means that, for a given family type, we may observe multiple links that connect the household to the over-expressed expenditure with respect to the different categorical values[11]. The graphs have been constructed considering the persistence in the SVNs of over-expression of a value of an expenditure category for any given family type greater than 7 years[12]. The differences in figures 3.5 and 3.6 rely upon the second step of the pre-processing procedure: in the first case, raw data have been pre-processed by calculating the quotas of expenditures of each household with respect to the *total amount* of his expense (step 2a); in the second case, the quotas have been calculated with respect to the total amount of family expense *within each macro-category* in which the expenditures have been grouped (step 2b). The links' colour indicates the quintile of the over-expressed expenditures (orange=1, yellow=2, light green=3, green=4, blue=5), and the size of links indicates the amount of years (greater than 7) in which the specific connection has been observed. The circular black nodes represent family types, while the blue square nodes indicate the expenditure categories. Such a graphical representation allows us to present, in the same graph, the main results of the SVNs.

Graphs show a clear dichotomy in the spending patterns between couples with children, that are indicated with letter "C", followed by the generation of offspring, and families with a single member, that are indicated with letter "S", followed by the age class of member. Couples with children show a varied spending profile, mostly in the lower quintiles of the distribution of spending (orange and yellow links), that varies from food products to schoolbooks, from accommodation to footwear and clothing for children, from sport to lottery, from tickets for buses to life insurance. Instead, the spending profile of families with a single member is concentrated on a few goods and services (such as tobacco, food away from home, clothing, tickets for cinemas, theatre and concert, pay-tv subscription and so on), mainly in the highest quintiles of the distribution (green and blue links). Couples without children show spending patterns similar to singles, with few differences that rely upon households' different stages of family life-cycle. For example, singles tend to spend for renting house and leisure time activities, whereas young couples are oriented to the purchase of the primary home and food products. It is worth to note that similar expenditure profiles can be detected among households with Y-generation children and singles aged 18-39 and 40-65 (e.g. tobacco, café and bakery, menswear, gasoline, beer, pay-tv subscription, tickets for cinema, theatre and concerts, newspapers). Such an evidence can be explained by the presence of young adults in families (Y-generation offspring) that have tastes, needs and purchasing habits likened to young (and less young) singles living alone. On the contrary, to some extent the purchasing patterns of households with Z-generation children are similar to the spending profiles of elderly singles and couples. Indeed, these family types share a lot of over-expressed expenditure categories related to food products, although with very different quintiles (high for elderly people–blue links–and more heterogeneous for families with children).

[11] For example, in fig. 3.5, singles aged 40-65 (S_40-65) show the over-expressed expenditure category "rent" in both quintile 4 (link colour=green) and quintile 5 (link colour=blue).

[12] In the graphical representations, the over-expressed null expenditures have been removed from the figure for the sake of readability.

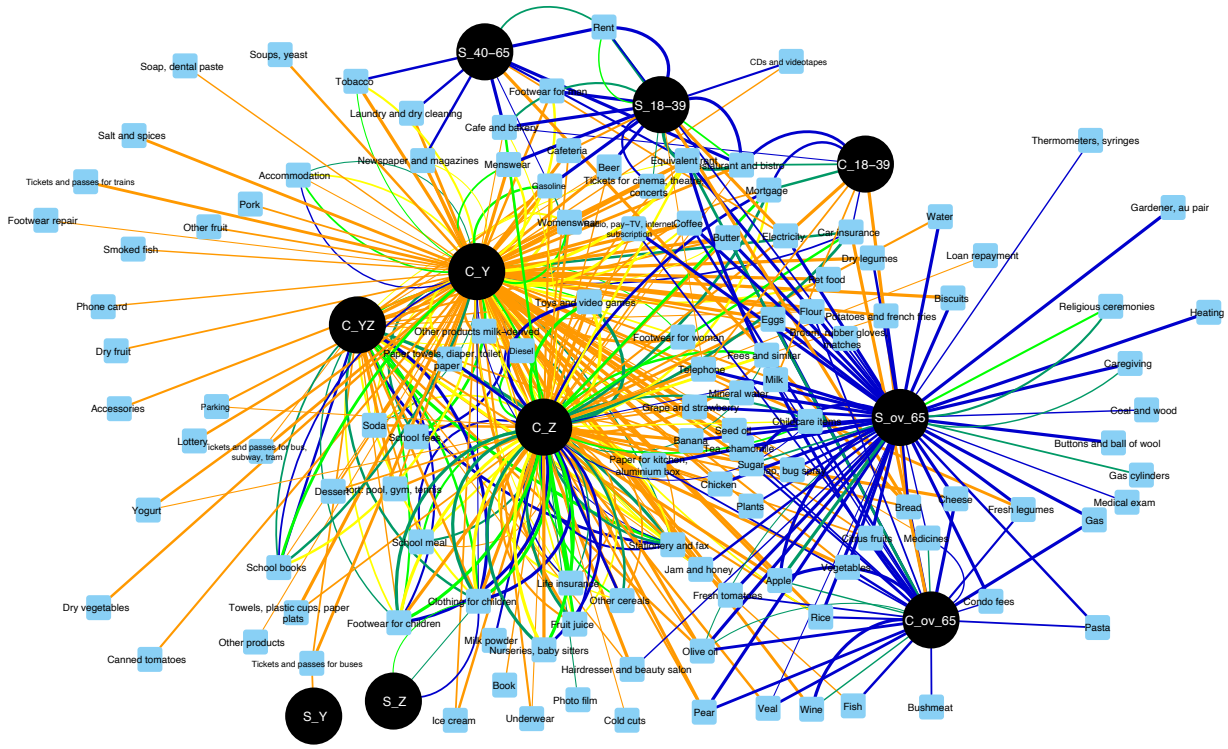

Fig. 3.5: Summary of SVNs outputs, constructed by calculating the quotas of expenditure in accordance with step 2a. Bonferroni correction, threshold=0.01. The circular black nodes represent family types, the blue square nodes represent the expenditure categories. The size of link indicates the amount of years (greater than 7) in which the tie between family type and expenditure category has been observed. The colour of links indicates the quintile of the over-expressed expenditure category: orange=1, yellow=2, light green=3, green=4, blue=5). The over-expressed null expenditures have been removed from the figure.

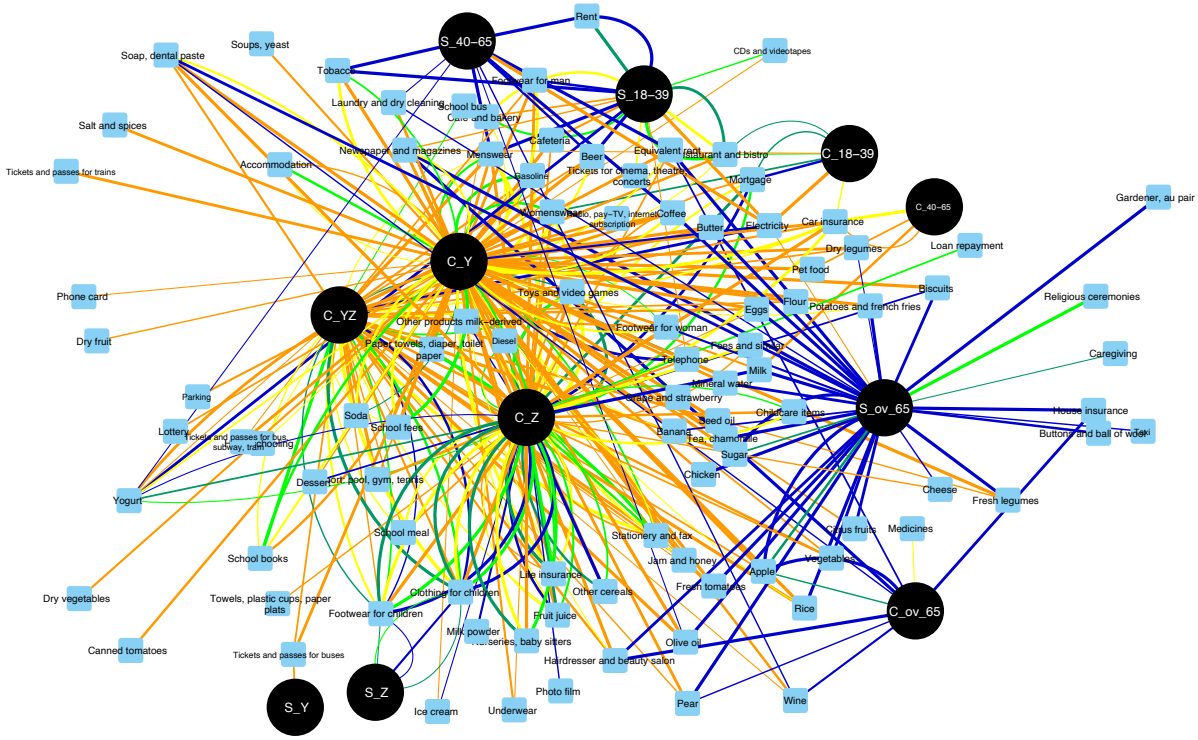

Fig. 3.6: Summary of SVNs outputs, constructed by calculating the quotas of expenditure in accordance with step 2b. Bonferroni correction, threshold=0.01. Nodes and links described in fig. 3.5.

The heatmap reported in Fig. 3.7 summarizes all the information of the thirteen SVNs (constructed on data pre-processed by calculating quotas of expenditures within the macro-categories, step 2b) at once. On vertical axis, we report family types from 1 to 12 (table 3.1) and, for each of them, lines represent the years from 2001 to 2013. On horizontal axes, all the expenditure categories are reported, grouped in accordance with the macro-category they belong to (e.g. house, transport, health etc.). For each year and category of household, we selected the over-expressed expenditures with the respective quintiles (or zeros) and we calculated the mean value of quintiles for every expense. Such values are reported in the heatmap as small squares, coloured with respect to the legend near the figure.

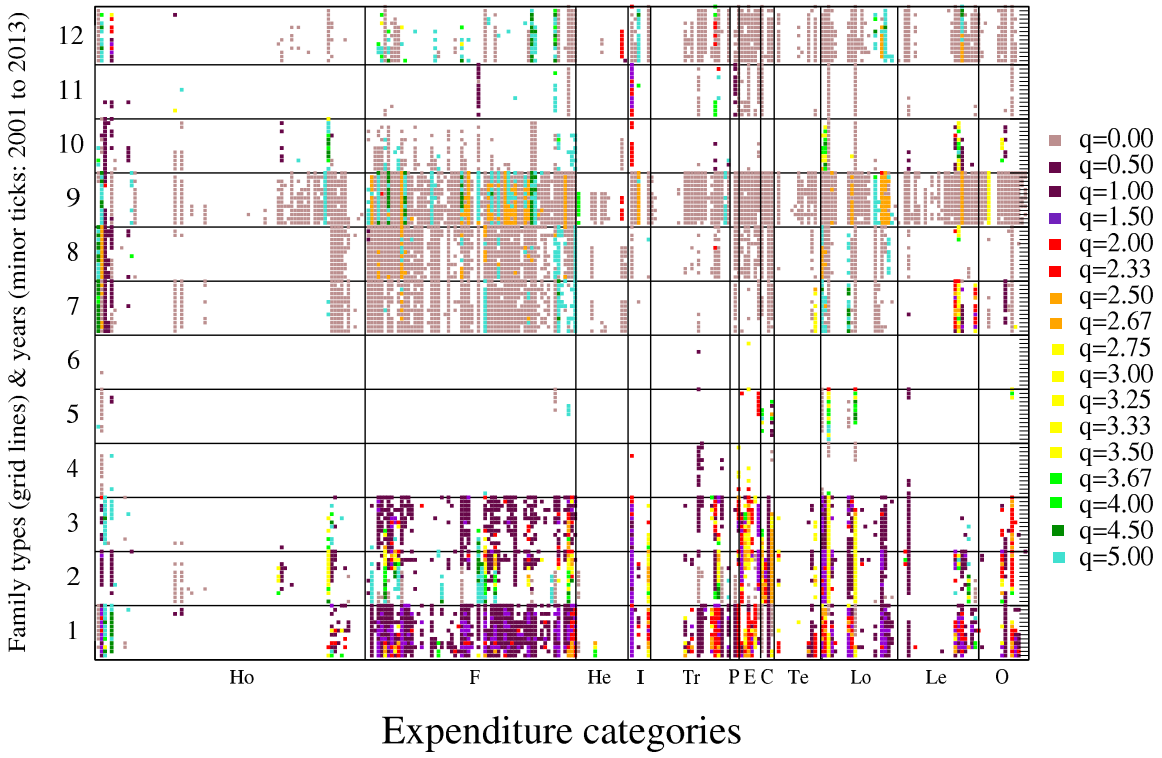

Fig.3.7: Heatmap of average over-expressed quintiles of expenditure for each family type reported in Table 3.1 and expenditure category over time. Expenditure categories are sorted according to macro-categories: Ho=house, F=food, He=health, I=insurance, Tr=transport, P=pets, E=education, C=children care, Te=technology, Lo=look style, Le=leisure time, O=other. On the vertical axis, the types of family considered in the study are reported (from 1 to 12) and, for each of them, the expenditure profiles over the thirteen years of the survey are reported, from bottom to top. Data stratified within the macro-categories. Bonferroni correction.

Overall, families without children clearly show spending profiles only in macro-categories related to food and house, although this evidence is weaker for younger one-component families (types 7 and 8), which also show expenditure's patterns in categories such as "look style" and "leisure time".

Considering the expenditures on food products, households with children (family types from 1 to 3) show variegated expenditures on different kind of food with low quintiles. On the contrary, single people (family types from 7 to 9) reveal a huge amount of null expenditures over-expressed, and few expenditures with high quintiles: the youngest singles probably eat away from home often (e.g. at restaurants and bistros or at parents' home), the oldest ones are probably accustomed to specific brands and products.

Focusing on elderly families, some health-related expenses are persistently over-expressed for type 9 (single elder) and 12 (elderly couples). These two types of families show very similar patterns of spending on most of macro-categories, especially, food, look style, and leisure time, however single elders appear to be more selective (many categorical values equal to 0 are over-represented in the network for this family type) than elderly couples.

Fig. 3.7 also shows the similarity between the spending patterns of family types 1, 2, and 3–i.e., couples with Y-generation children, couples with Z-generation children, and couples with Y- and Z-generation children, respectively. Such a similarity raises over time, which might be a mere consequence of the fact that the age of the Z-generation children increases during the investigated period and, as consequence, the three types of family gradually become more similar in composition. The main differences between family types 1 and 2 depend on the stage of family life cycle. Indeed, family type 2 (young family) shows expenditure patterns on the macro-categories house (Ho) and food (F), which are concentrated on the highest quintiles of a few categories, while family type 1 (consolidated family) shows an over-expression on the lowest quintiles within both macro-categories. Households with children also reveal their similarity with respect to technological expenditures. Indeed, such family types, together with young singles (family type 7), are more inclined to consume technological products. In this regard, we may argue that it is an age effect: being young adults living alone or with their parents, the result is orienting households' expenditure towards technological products.
Focusing on look style, fig. 3.7 shows heterogeneous over-expressed expenditure categories, with low quintiles, for family types in which children are present (categories 1-2-3-5). It can be due to the impact of children (especially the younger ones, see categories 2 and 5) on purchases of clothing and footwear, that are frequent but not very expensive. Look style of family units without children is prominent for young adults (both singles and couples, family types 7 and 10) that reveal high quintiles (probably resulting from a particular interest in body care), and for elderly people (both singles and couples, family types 9 and 12), whose over-expressed quintiles are medium or high, on average, but concern different expenditure categories.
In fig. 3.7, according to the macro-category "Leisure", we observe that variegated expenditures are evident among households with children (family types from 1 to 3) and young family units, that are single and couples whose members have from 18 to 39 years old (family type 7 and 10). Such an evidence can be due to the fact that the former have expenses on leisure activities related to offspring (such as sport, musical instruments, camping, classes etc.), the latter can be interested to spend their free time for travelling abroad, eating away from home and going to cinema, theatre and sporting events.

4.2. Families with Y- or Z-generation children and their expenditures

This section focuses on the SVNs of families with children–further stratified according to the educational level and the number of parents working (Table 3.2). The graphs in figures 3.8 and 3.9 have been realized following the same method adopted for the first classification of family types (fig. 3.5 and 3.6), with the exception of the threshold of persistence, that we set at 5 years, since the overall network is sparser. In general, households with Y-generation children reveal expenditures oriented to food products (especially in families in which the educational level is low and only one parent works, probably the father, whereas the mother is housewife), public transportation and education. Moreover, high-income families (in which two parents work and the educational level is high) show over-expressed expenditures related to secondary house, leisure time and domestic workers (e.g. au pair and gardener). Families with Z-generation children have expenditure profiles mostly concerning childcare, although the expenditures are over-expressed with different quantiles according to the family type. In this regard, we may observe that households in which only one parent works and the educational level is low, and families in which none of the parents works (that is, likely, households with a limited income), reveal higher quintiles (blue links), as compared to the other family types.

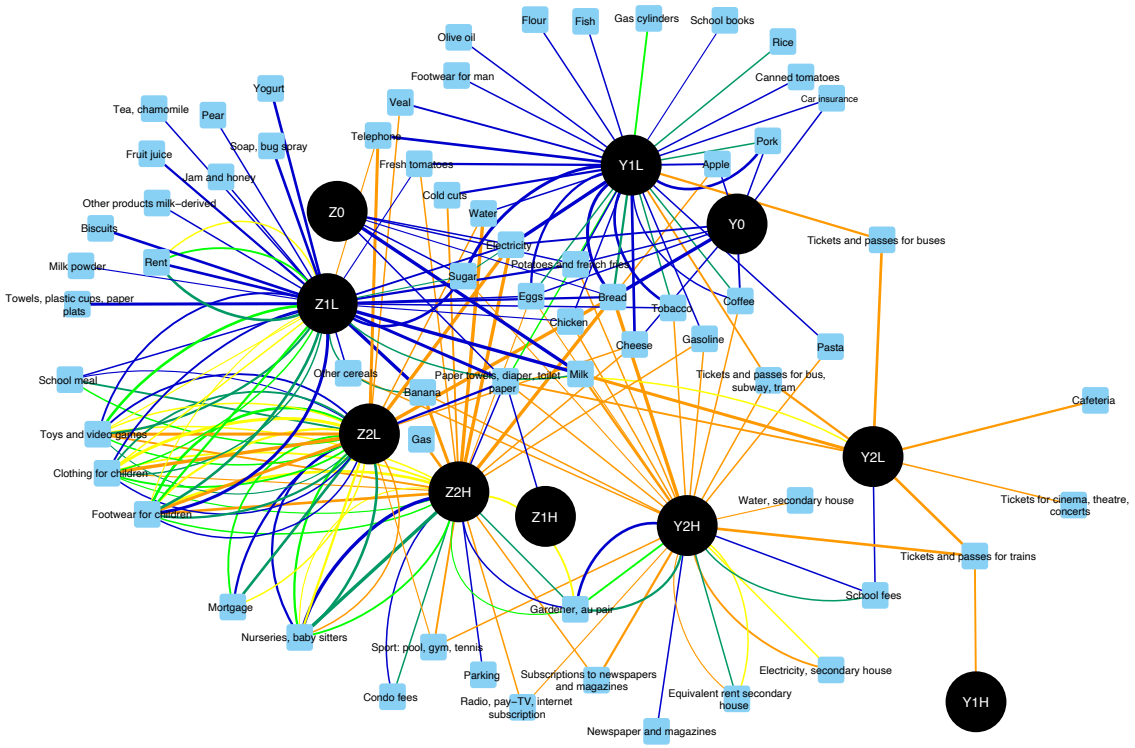

Fig. 3.8: Summary of SVNs outputs, constructed by calculating the quotas of expenditure in accordance with step 2a. FDR correction, threshold=0.01. The circular black nodes represent family types, the blue square nodes represent the expenditure categories. The size of link indicates the amount of years (greater than 5) in which the tie between family type and expenditure category has been observed. The colour of links indicates the quintile of the over-expressed expenditure category: orange=1, yellow=2, light green=3, green=4, blue=5). The over-expressed null expenditures have been removed from the figure.

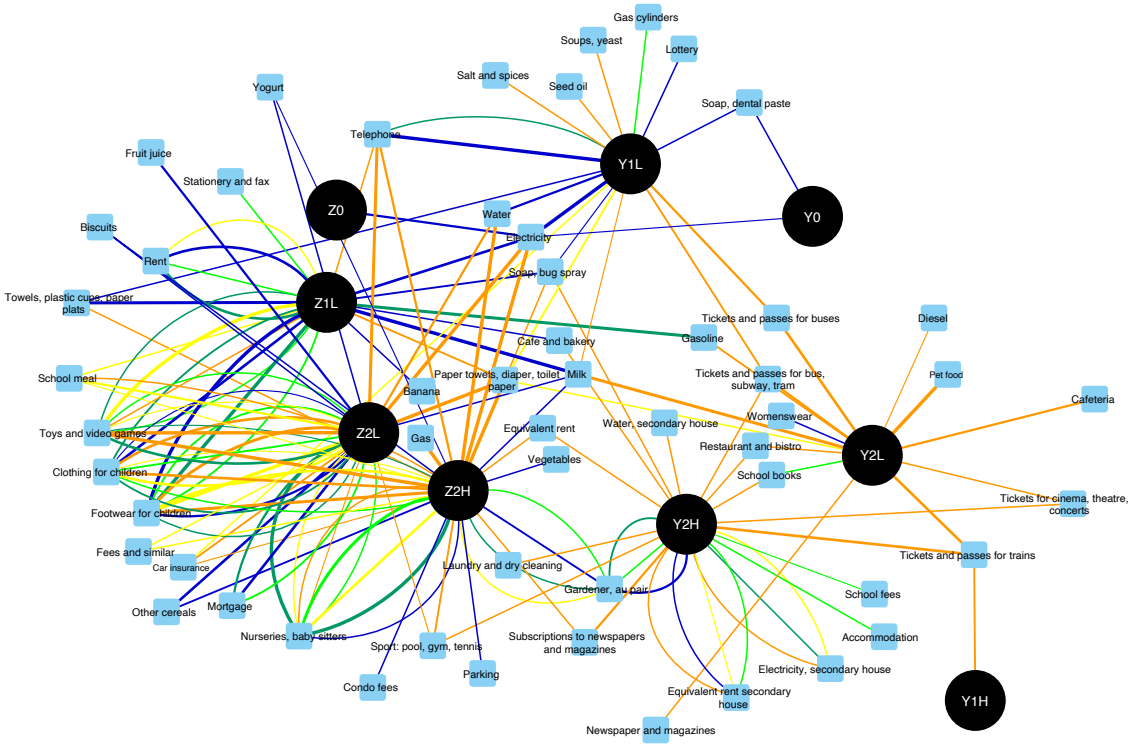

Fig. 3.9: Summary of SVNs outputs, constructed by calculating the quotas of expenditure in accordance with step 2b. FDR correction, threshold=0.01. Nodes and links described in fig. 3.8.

The heatmap in figure 3.10 summarizes the results of SVNs constructed on data pre-processed by calculating quotas of expenditures within the macro-categories (step 2b):

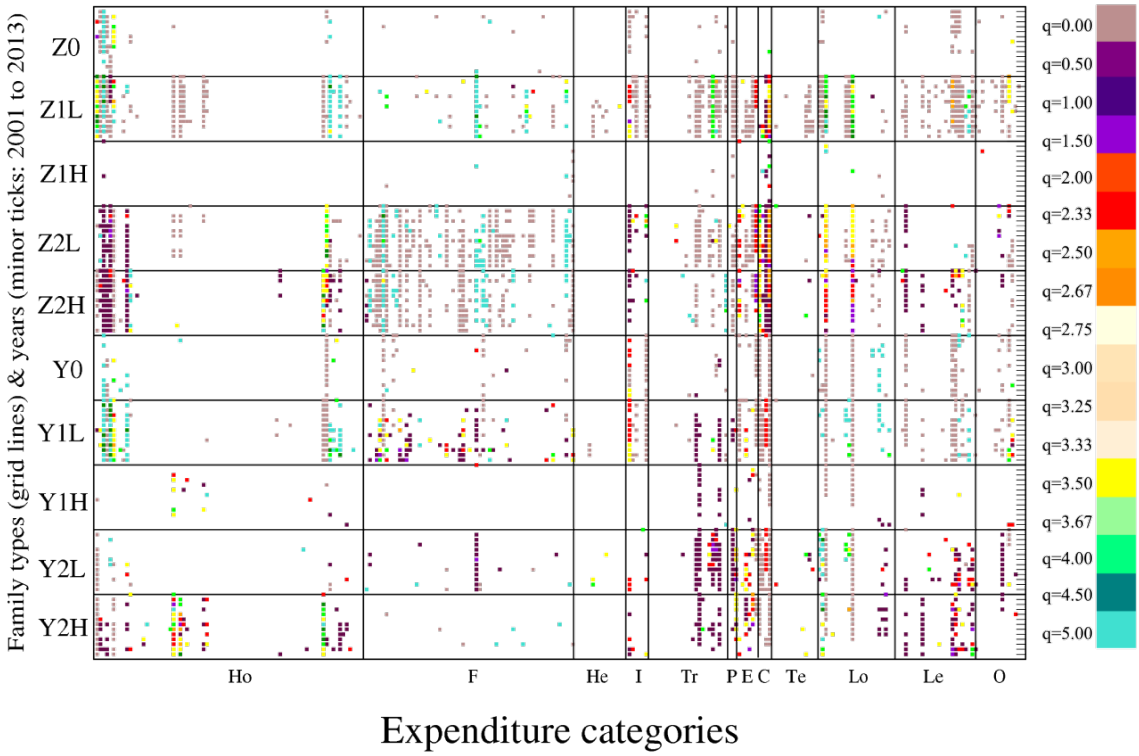

Fig.3.10: Heatmap of average over-expressed quantiles of expenditure for each family type reported in Table 3.2 and expenditure category over time. Expenditure categories and sampling years are reported as in Fig. 3.7. Data stratified within the macro-categories. FDR correction.

Considering the expenditures related to the macro-category "house" (see Fig.3.10), it is worth to note the presence of expenditure profiles that make it possible to distinguish between families with Z-generation children (initial stage of the family life-cycle) and families with Y-generation children (mature stage of the family life-cycle) In fact, excluding Z1H and Y1H families–which don't show over-expressed patterns, probably due to the small sample size–, families with Z-generation children show the typical expenditure patterns of a young family unit, focused on the primary house: indeed, the over-expressed expenditures on house are largest and constant over the years with respect to the ones of families with Y-generation children, that show more varied patterns of consumption. The macro-category "food" also clarifies that families with Z-generation children tend to concentrate their expenditure on specific food categories, in order to satisfy the needs of children (high quintiles over-expressed for specific expenditure categories and 0 for others), while the spending profile of households with Y-generation children is much more heterogeneous. Macro-categories such as "transport", "look style" and "leisure" also show the difference between consolidated families and young families. In fact, the presence of offspring belonging to the Y-generation pushes families to orient their expenses towards goods and services that can satisfy the needs of children now approaching adult life, whose needs are no longer limited as those of childhood, but become multiple and varied (as owning a car, traveling, hobbies, etc.). However, income related dimensions, such as the number of working parents and, to a lesser extent, the level of education of the parents also appear to play a prominent role. Indeed, for instance, for the macro-category "house", the profiles of the family types Y2H, Z2H and Z2L (two working parents) are much more similar to each other than they are, respectively, with the expenditure profiles of the family types Y1L and Z1L (only one working parent). In this regard, also the expenditure patterns on leisure time seem to be associated to the number of working parents. Indeed, they are over-expressed especially for families in which both

parents have a job and despite the educational level. Nevertheless, also the stage of family life cycle and the generation of children seem to play a prominent role: we may observe that households in which there are two working parents and Y-generation offspring (Y2H and Y2L), have a more stable and variegated consumption related to leisure activities with respect to the same family structures with Z-generation children (Z2H and Z2L).
Finally, it is worth to note that family types Y1L and Z1L, in which only one parent works and the educational level is low, reveal the most heterogeneous consumption among the expenditures related to the macro-category of food. We may argue that such an evidence relies upon the fact that families in which only one parent has a job are mainly composed of working men and housewives. The presence of a housewife in the family unit may play a prominent role in shaping family expenditures related to house care, food and childcare.

4.3. Comparison of family types: complementary over-expressed expenditure categories

Tables from 3.4 to 3.8 can be used to highlight the main differences between the expenditure patterns of families with Y- and Z-generation children, when the number of working parents and the level of education are the same. The tables have been constructed by looking at families with the same level of education and number of working parents, and selecting, for each investigated year, the over-expressed quintiles (from 1 to 5), and the category 1 (that indicated the purchase made) for the dichotomized expenses, of each expenditure category for households with Y-generation children that were not over-expressed for (the corresponding) households with Z-generation children and the reverse. Among the selected quintiles and category 1 of the expenditures, the top ten, according to the number of years in which they were selected, are displayed in the table, provided that the number of years of over-expression is larger than one. The number of expenditure-category quintiles and category 1 reported in the table can either exceed ten, if there is a degeneracy in the number of years of over-expression for some expenditure categories, or be smaller than ten, if the overall list of over-expressed expenditure quintiles and category 1 includes less than ten entries. Over-expressed expenditure's values have been grouped as follows: quintiles 1 and 2 = low expenditure (L); quintile 3 = average expenditure (A); quintiles 4 and 5 = high expenditure (H); category 1 = purchase made (P).
Table 3.4 highlights that families with both parents working and high level of education have very different spending profiles, depending on the generation of their children (Y2H VS Z2H). In particular, households with Y-generation offspring are consolidated families, they typically own the primary house, in some cases they also own a secondary house and they mainly spend for public transport, children' education, and food away from home. Instead, the patterns of consumption of households with Z-generation children, that can be considered "new-born" families, are mostly focused on childcare and on the expenditures related to primary house (in terms of utilities). For these families, the fact that both parents work implies that they have to allocate part of their income for day-care services or babysitting.

Family type (Y)	Expenditure	Macro-category	Quintiles (time persistence)	Family type (Z)	Expenditure	Macro-category	Quintiles (time persistence)
Y2H	Tickets and passes for trains	Transport	P(11)	Z2H	Diaper, toilet paper etc.	Childcare	L(13)
	Equivalent rent - primary and secondary houses	House	L(10), H(7)		Toys	Childcare	L(13)
	Electricity - secondary house	House	L(7), H(6)		Day-care, babysitter, etc.	Childcare	H(13), A(12), L(11)
	School fees	Education	A(7)		Electricity	House	L(12)
	Restaurant and bistro	Leisure	L(7)		Child footwear	Look style/Childcare	L(12)
	Newspapers and magazines	Leisure	P(6)		Telephone bill	House	L(12)
	Buses, subway and trams	Transport	P(6)		Child clothing	Look style/Childcare	L(12)
	School books	Education	L(6)		Other cereals and products	Food	H(9)
	Cafe and bakery	Leisure	L(6)		Gas	House	L(9)
					Water	House	L(9)

Tab. 3.4: Most time-persistent expenditure's categories over-expressed for family type Y2H and not for family type Z2H (on the left), and vice versa (on the right).

In table 3.5 we may observe that, as soon as the level of education decreases, but the number of working parents is still two (Y2L VS Z2L), the costs for transportation, both private and public, become very relevant for families with Y-generation children, together with the expense for cafeteria, probably due to the fact that parents (that have a low educational level) work all day long and usually have lunch at the workplace. Moreover, other expenditure categories related to leisure time, food away from home and women's clothing seem to play a prominent role in shaping patterns of consumption of family type Y2L with respect to family type Z2L. The expenditure of households with Z-generation children remains oriented to the childcare, in particular to look after children while the parents are at work, even if some new categories of expenditure appear in the "house" macro-category, e.g. the loan.

Family type (Y)	Expenditure	Macro-category	Quintiles (time persistence)	Family type (Z)	Expenditure	Macro-category	Quintiles (time persistence)
Y2L	Food for pets	Pets	L(13)	Z2L	Telephone bill	House	L(13)
	Milk	Food	L(12)		Toys	Childcare	L(13), H(11)
	Coaches etc.	Transport	P(11)		Day-care, babysitter	Childcare	H(13)
	Trains	Transport	P(11)		Child footwear	Look style/Childcare	L(13), H(11)
	Gasoline	Transport	L(10)		Child clothing	Look style/Childcare	L(11)
	Buses, subway and trams	Transport	P(10)		Loan	House	H(11)
	Cafeteria	Other	P(9)		Electricity	House	L(13)
	Diesel	Transport	L(8)		Other cereals and products	Food	H(11)
	Newspapers and magazines	Leisure	L(7)				
	Womenswear	Look style	H(6)				
	Cinema, theatre,concerts	Leisure	L(6)				
	Restaurant and bistro	Leisure	L(6)				

Tab. 3.5: Most time-persistent expenditure's categories over-expressed for family type Y2L and not for family type Z2L (on the left), and vice versa (on the right).

When only one parent works and the level of education is high (Y1H VS Z1H), table 3.6 shows that the spending profiles of families with Y-generation children appear more heterogeneous and, therefore, less characteristic, with a few over-expressed categories of expenditure, which are mainly linked to public transport, information (in terms of newspapers and magazines purchased), and children' s education (in terms of home-schooling): this last expenditures suggest that households with high level of education are inclined to guarantee a good education to their children, in spite of the costs. The expenditures of families with Z-generation children are still focused on childcare, however, when only one parent works, the management of children (babysitters, nurseries, etc.) observed in the previous comparisons disappears, probably due to the fact that the working parent is the man, and the childcare is one among the housewife' tasks.

Family type (Y)	Expenditure	Macro-category	Quintiles (time persistence)	Family type (Z)	Expenditure	Macro-category	Quintiles (time persistence)
Y1H	Trains	Transport	P(9)	**Z1H**	Toys	Childcare	L(3), H(2)
	Gas	House	L(9)		Diaper, toilet paper etc.	Childcare	L(2)
	Equivalent rent (primary and secondary houses)	House	A(3)		Electricity	House	L(2)
	Newspapers and magazines	Leisure	P(3)				
	Home-schooling	Education	L(2)				

Tab. 3.6: Most time-persistent expenditure's categories over-expressed for family type Y1H and not for family type Z1H (on the left), and vice versa (on the right).

Table 3.7 reveals that when only one parent works and the level of education is low (Y1L VS Z1L), for households with Y-generation children the expenditures related to the macro-category of food become prominent. It is probably due to the fact that the presence of a housewife has a significant impact on the purchasing habits concerning food products. Moreover, such a family type tends to spend in utilities for primary house, private and (mainly) public transports. The expenditure of families with Z-generation offspring, instead, remains concentrated on the childcare, although, two important expenditure categories appear: the rent for the primary house, and the gasoline. Such expenses, that are persistent over time with average and high quintiles, play a prominent role in the consumption patterns of this category of household, that we could consider low-income families.

Family type (Y)	Expenditure	Macro-category	Quintiles (time persistence)	Family type (Z)	Expenditure	Macro-category	Quintiles (time persistence)
	Telephone bill	House	H(13)		Milk	Food	H(13)
	Coaches etc.	Transport	P(10)		Child footwear	Look style/Childcare	H(13), A(9)
	Water	House	H(9)		Toys	Childcare	L(13), A(8), H(8)
	Buses, subway and trams	Transport	P(9)		Child clothing	Look style/Childcare	H(12)
	Gas cylinders	House	A(7)		Monthly rent	House	H(12), A(8)
Y1L	Milk	Food	L(7)	**Z1L**	Gasoline	Transport	H(11)
	Soap, dental paste etc.	Look style	H(5)				
	Soups, yeast etc.	Food	L(5)				
	Salt and spices	Food	L(5)				
	Other oil	Food	L(5)				
	Car insurance	Insurance	L(5)				

Tab. 3.7: Most time-persistent expenditure's categories over-expressed for family type Y1L and not for family type Z1L (on the left), and vice versa (on the right).

Finally, when both parents do not have a job (Y0 VS Z0), in table 3.8 we observe the over-expressed expenditures of households with Y-generation children indicate very heterogeneous purchases, from utilities to leisure time, from transportation to clothing. Such a result is quite interesting since we expect that not wealthy households, since no parent works, should allocate their limited expenditure mostly on products and services aimed to deal with family primary needs. Nevertheless, in tab. 3.8 (left side), we also observe the presence of expenses related to body-care–as hairdresser, beauty salon and clothing for men–that lead us to suppose that, despite the economic constraints, the desire to show a greater social status than one has, plays a prominent role in shaping consumption. On the other hand, families with Z-generation children are no longer able to concentrate their expenditure on their children, since they are forced to allocate their income on expenditure categories related to the sustainability of the family, mainly belonging to the macro-category "house" (that is, utilities and monthly rent).

Family type (Y)	Expenditure	Macro-category	Quintiles (time persistence)	Family type (Z)	Expenditure	Macro-category	Quintiles (time persistence)
	Soap, dental paste etc.	Look style	H(5)		Electricity	House	H(6)
	Car insurance	Insurance	L(4), A(2)		Gas cylinders	House	A(3),H(3)
	Newspapers and magazines	Leisure	H(3)		Towels, paper plats etc.	House	H(2)
	Electricity	House	H(3)		Monthly rent	House	L(2)
Y0	Hairdresser and beauty salon	Look style	H(2)	**Z0**			
	Menswear	Look style	H(2)				
	Buttons and ball of wool	Look style	H(2)				
	Water	House	H(2)				
	Buses, subway and trams	Transport	P(2)				

Tab. 3.8: Most time-persistent expenditure's categories over-expressed for family type Y0 and not for family type Z0 (on the left), and vice versa (on the right).

5. Conclusions

Presented findings support the theoretical assumption according to which consumption behaviour is affected by endogenous factors, such as family structure and stage of family life-cycle. Besides that, overwhelming exogenous factors, such as social change and economic trend, clearly impact all of the households, as the analysis of trend and tipping points in the concentration of household expenditure over time shows.

The main differences between the patterns of consumption of family types empirically observed in this study can be summarized as follow:

- **Family structure.** The presented empirical analysis shows a clear difference between the consumption patterns of households with offspring, varied and focused on the needs of children, and those of households without offspring, especially single-component households, which display very narrowed patterns of expenditure.
- **Stage of family life cycle**.
  - *Difference between young couple without offspring and elderly couples without offspring*. Elderly couples tend to concentrate their expenditure on a few goods and services belonging to specific macro-categories (mostly house, food, insurance and leisure). The results suggest that the consumption choices of the elders become a routine. Younger couples, on the contrary, show more variegated behaviours. Such a difference is even stronger for one-component families.
  - *Difference between households with Y-generation children (consolidated families) and households with Z-generation children (young families)*. The main differences between the expenditure profiles concern the macro-categories "food", "house" and "transport", and can be attributed to the different stage of family life-cycle these family types belong to. In fact, the observed expenditure profiles are consistent with the fact that families Y-generation children are "consolidated families"-maintenance and renewing of the primary house, and, possibly, of a secondary house, whereas families with Z-generation children are "young families", and, therefore, their expenditure are more oriented to the essential needs, such as buying the primary house (loans) and childcare.
- **Income.** Though information about household income is missing in our data, the number of working parents and their educational level were used as a proxy of socio-economic status, in order to compare the expenditure patterns of (homogeneous) families with children at different stages of family life cycle. Our analysis indicates that the focus of young families on childcare decreases when the number of parents working and their level of education decrease, which is progressively replaced by a focus on fundamental needs, mostly related to the sustainability of the family itself. Under the same conditions, instead, consolidated families significantly reduce the variety of their expenditure patterns.
- **Generational influence.** According to our empirical analysis, none of the revealed patterns of expenditure could be solely attributed to the different generation of offspring: age of children, stage of family life cycle, and income related dimensions all contributed to hide the generational impact on household expenditure in our analysis.

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CHAPTER 4

Household Expenditure on Leisure: a Comparative Study of Italian Households with Children from Y- and Z-Generation[1]

Abstract

The intrinsic complexity of post-materialist society makes it challenging to investigate the connection between social changes and generations. However, the study of consumption might help in the analysis of such a connection. In this paper, we analyse empirical data of consumption on leisure of Italian households, and focus on families at a very precise stage of family life-cycle, that is, couples with teenager children. We look at consumption of households at different points in time, 2001, 2007, and 2012, in order to investigate the impact of both social change and generation of children–Y-generation in 2001 and 2007, and Z-generation in 2012–on the leisure expenditure patterns of families. Specifically, we consider secondary data of yearly expenditure on a wide range of different leisure activities, and use hierarchical clustering and logistic regression to highlight specificities in family consumption patterns on leisure, depending on both the generation of offspring and the inter-time between sampled cohorts, 2001–2012 and 2007–2012. Our analysis indicates the presence of differences between the consumption patterns on leisure of families with Y- generation children and families with Z-generation children. However, our results also point out that such differences cannot be explained by solely invoking the different generation of offspring, and that social changes should also be taken into account.

Keywords: Leisure, Generations, Family with adolescents, Household consumption, Classification, Multivariate Analysis

1. Introduction

The complexity achieved by contemporary societies in both the so-called *Global North*, and, although in very different conditions, the *Global South*, makes every kind of sociological analysis of social change very difficult. In fact, even recently, there have been many sociological approaches, among the most varied paradigms, that have attempted to explain the dynamics of social change and find a unitary interpretive framework, at least for the systems of societies that show comparable socio-economic and socio-cultural characteristics (Noble 2000; Vago 2003; Weinstein 2010).
Recently, studying social change with the meaning of "a change in human interactions and interrelations", scholars felt that the approach of the sociology of the generations could have greater heuristic capacity than other theories. Although sociology of the generations is a theoretical approach that has its roots already in the works of Mannheim (1928; tr. En. 1952), and it has been invoked in many studies over time (Eisenstadt 1956), only recently it has taken on new epistemological vigour in sociological research (Gilleard 2004).

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According to many scholars, the generationalist approach provides a very effective theoretical framework to systematically study social changes. Indeed, within such a framework, it is possible to analyse various aspects of social change by comparing the *cultural reference system* and *the training model of the opinions of the different generations* that live in the same historical epoch and share *the same representation of significant historical events*. In this regard, it is necessary to make a distinction between the terms *cohort* and *generation*. The term *cohort* refers to a group of individuals who were born in the same year and share the same age. Although they live in the same historical period and are exposed to the same social, political and economic changes, this is not enough to define them as a generation (Bagnasco et al. 1997). Indeed, as Mannheim argues (1928; tr. En. 1952), a *generation* is composed by people born in the same period who experience strong social modifications (as revolutions, wars, cultural and economic changes etc.) and are affected by them to the point of breaking with previous habits, styles of life and values transmitted from the main socialisation agents (as the family and the school). Therefore, for a cohort can be described as a generation, it is necessary that the social modifications or historical events occurred have a strong impact on people, pushing them to adopt new attitudes and behaviours that are different from those of their parents and, at the same time, are shared by the members of the same generation. In light of this, a cohort of people born in the same period of time cannot automatically be considered as a generation, in spite of the amount of social changes they experienced, unless such changes deeply influenced people lifestyles, attitudes and views of the world. Such a consideration allows one to assume that, under a generational perspective, people belonging to the same generation tend to adopt specific styles of consumption that characterise them with respect to the others.

Therefore, belonging to the same generation is determined by such a *sharing of evaluation of historical events* and cultural representations, (Eyerman and Turner 1998; Edmunds and Turner 2002a; Edmunds and Turner 2002b; White 2013). Moreover, studies on consumption have been of great importance in the study of social change, as consumption is a way in which individuals and groups construct their identity and representation and the meanings of social world in contemporary society. In particular, scientific research focused on differences in consumption in terms of "generational differences". Recently, the analysis of consumption trends (in a generational key) has been carried out with the aim of identifying specific life choices that define and differentiate contemporary consumption with respect to that practiced by previous generations (Kahle 1996). Some scholars argue that the "post-materialist values" and their patterns of consumption are linked to age classes and to specific generations (Corsten 1999; Rawlins 2006), although little research has been done on this topic. Consumers, generally choose different products and services during the course of their lives, and such preferences–whether it is clothing, furniture, or leisure activities–change significantly over time and from a generation to another (Leventhal 1997; Solomon et al. 2006).

Despite the fact that scholars have given considerable importance to the difference in the different phases of the individual and family life cycle (Solomon et al. 2006), the focus of consumer research aimed, for a long time, at developing marketing and communication strategies to attract younger cohorts (Grant 2004; Lindstrom and Seybold 2004). In any case, it is above all the notion of "post-materialist values" that scholars consider very relevant to understand changes in the styles of consumption that occurred in recent years, especially among young people. This concept is useful to interpret the slippage of consumer interest from the consumption of *material goods* to other forms of consumption, those with a high symbolic value. This type of value orientation places the possibility of expressing people's identity at the centre of consumption dynamics, by focusing on the quality of life beyond economic security, which leads to a *symbolic* consumption rather than a *functional* consumption. As for Italy, a progressive orientation of Italian households towards a post-materialist consumption has been observed in the last decades. Indeed, according to a report published by the Italian General Confederation of Enterprises, Professions and Self-Employment in 2014

(Confcommercio 2014), the decrease of families' income has led to an overall reduction of households' expenditure in Italy. However, such a reduction has been more pronounced for goods than services: it has been observed a 1.4% decrease of the average annual expenditure on goods in the period 2008–2011, whereas, a 0.7% increase for services has been observed in the same period of time (Confcommercio 2014, 3). Such an empirical evidence suggests that Italian consumers are becoming more oriented to spend their (reduced) income on services rather than goods, and, therefore, they seem to attribute a greater relevance to the symbolic value of life experience (such as the leisure time) than the one they associate with essential goods (such as food and clothes). A clear example of this orientation towards a symbolic appropriation of practices and non-material goods can be observed in both the increase of sport activities and the new role that such activities assume within people's lifestyle. Starting from the eighties, sport has become widespread in Italy (although with regional differences), and the value that people confer to sport activities has radically changed since then (Lo Verde 2015). Indeed, it can be observed a shift from an idea of sport as merely intended as an agonistic activity to an idea of sport as a practice oriented to body and health care. This way, sport activities have quickly become an integral part of modern lifestyles, interpreted by consumers as a "socialisation mean" as well as an activity that improves the psycho-physical wellbeing ("individualist value").

Obviously, this change has involved above all the generations that have appeared after *Baby Boomers* (born between 1945 and 1964), however, highlighting how each generation undergoes a different mix of cultural influences that *produces* and *determines* the relative consumption behaviour of people.

Furthermore, it should be noted that each generation determines and articulates its *social practices* within–and influenced by–social groups, one of which is the family unit. Then, it is conceivable that generational sub-groups may appear within a family, e.g., adolescents or young adults among the children, besides other sub-groups formed on the ground of a shared role, e.g., parents or children. Therefore, a family *negotiation process*, which brings to the decision of purchasing a certain type, brand, and quantity of a good, is also influenced by the various subcultural sets of tastes, needs and attitudes that characterise the different generations of family sub-groups. In such a scenario, it is necessary to take into account that social influences in adolescents' styles of life are not only transmitted by the families, and consumption choices are not just reflecting the sense of belonging to a family unit, rather they depend on horizontal pressure from peers as well. The idea is that the reference group, outside of the family unit, plays a significant role in decisions of consumption of young people, and pushes them to adopt particular tastes and styles of consumption with the aim of recognising themselves as a part of the group. In line with this view, peer influence on adolescents' behaviour is a domain of strong interest for several disciplines, and it is investigated from different perspectives, with the objective of analysing the effects of peer selection and influence on different aspects, such as, for instance, adolescent alcohol use and abuse (Mundt et al. 2012), college choice (Bhayani 2015), prosocial behaviour (Choukas-Bradley et al. 2015).

Therefore, the aim of this paper is to illustrate what the most evident differences are in the consumption dynamics of Italian families with children who belong to Y (born between 1981 and 1994) and Z (born between 1995 and 2010) generation[2].

[2] Most of the social research work as well as of the popular publicity identifies the Y-generation with those born between 1980 and 2000. In this context it was decided to use the categorisation of Nielsen because it was considered more coherent with the literature concerning the identification of different generational groups as consumer actors. Nielsen ranks the Millennials as those born between 1981 and 1994.

The empirical basis of the present work consists of microdata on household consumption (multi-purpose survey) collected by the Italian Statistics Institute (ISTAT). First, we tried to identify the relationship between the categories of goods purchased, more generally, for and during leisure time and the types of households based on family structure. Secondly, the relationship between quantity and types of goods consumed and the presence of young people in the age group under analysis are investigated. The attempt is to identify a model of consumption that can be considered a *style* as compared to the type of family described by Italian domestic aggregate models, on the basis of the theoretical perspective that classifies the types of family cohabitation, according to a typology founded on the basis of domestic aggregates, i.e., the "who lives with whom" (Laslett 1972).

2. Literature Review

Scholars (Eyerman and Turner 1998; Edmunds and Turner 2002a; Edmunds and Turner 2002b; White 2013) argue that the generationalist approach is one of the possible ways through which sociological knowledge builds analytical categories.

These categories can be understood as "systems of recognition of specific social objects" that, in their definition, allow both the analysis of the defined social object–a *social group*, in this case–and, at the same time, as Bourdieu argues (1991), exclude other possible forms of categorisation and, therefore, of "grouping" (class, ethnic group, religious group, professional group, etc.). According to Bourdieu, what becomes decisive in sociological analysis is precisely the *process of social recognition* that some social objects receive as they are considered as a group. Therefore, the concept of *generation* itself takes two meanings: (i) an "analytical" meaning, as it allows one to distinguish and study a specific group, and (ii) an "ontological" meaning, since people belonging to the same generation recognise themselves as "belonging to a group" with shared attitudes and social practices. In summary, the generationalist approach, on the one hand, allows us to analyse a part of the social phenomenon that we take into consideration for comparative purposes; on the other hand, it records the "objective"–in a sociological sense–existence of groups of people born in the same period of time, which they shared as *experiences* and, later, as *a memory of experiences*, including certain phases of historical change, and some *epochal events*.

Those who belong to the same generation may recognise themselves as the protagonists of a symbolic, cultural and value production, responsible for recognisable practices as a specific cultural experience shared in a particular epoch. Moreover, they may recognise themselves as people who share a *collective imagination*, that is, a set of values, attitudes, symbols and a representation of the world, which they consider as specific to their generation. As claimed by Mannheim (1928, tr. En. 1952), there is not necessarily an "interchange" or a "group interaction" among the members of the same generation, since it is a category that encompasses individuals who do not necessarily share membership in a *social circle*. But there is the belonging to a shared imaginary that generates a real "complicity", as it happens for other forms of aggregation of individuals. Mannheim defined the generation as *a group of individuals born in the same historical period* and in the *same geographical position* who interact under *the influence of the same social forces* and the *same events*. Furthermore, the characterising properties of a generation are attributed to collective memory, rather than to the age of the members (Costanza et al. 2012). A collective memory derives–and it is formed by–significant political, cultural, economic events.

However, it is not possible to consider only shared experiences as elements capable of creating a generation. Only a concrete link that has "formative force" can cause external events to turn individuals into members of a generation.

What are the social connotations of consumption of Generation Y and Generation Z? And, more specifically, the consumption associated with leisure time? To highlight its characteristics, we will try

to read the dynamics of leisure consumption of households with children in a *generationalist way*. If we con- sider the family unit as a *budgetary unit* (McDonnell 2013) composed of members belonging to different generations, as well as of different ages, we can see how, in different historical periods, the members of a family in a specific phase of family life-cycle have allocated the different resources for different consumption modes of leisure time. According to McDonnell (2013), in fact, budgetary units are:

> "[…] relatively durable social collectives where a substantial portion of collective activity is devoted to consumption–the selection, procurement, or enjoyment of goods, services, or experiences valued for their nonpecuniary benefits. Budgetary units are composed of members with some intersubjective orientation to each other, possessing a minimal collective identity and norms for enforcing group behavior" (McDonnell 2013, 309).

According to that definition, consumption-oriented budgetary units are characterised by a *specific ethos*, i.e., a *consumption ethos*, which is different from the one of organisations that operate in the market, which are driven by a *profit-oriented ethos*. On the contrary, the consumption ethos of a budgetary unit is oriented to the purchase of goods and services that meet the needs of group members. Such a consumption attitude is different from the individual action whose usefulness, according to classical economy, can only be calculated "individually". In fact, in the budgetary units (McDonnell 2013),

> "There are multiple, potentially conflicting, benefits and logics of usefulness: multiple members, with various desires for different objects, and various uses, outcomes, or functions of any given object. […] the multiple logics of usefulness in the budgetary unit are co-present but not stably ordered because they are not derivative of a single concrete master "utility"" (McDonnell 2013, 325).

Therefore, since family units are groups of individuals who primarily share the resources they consume, it is necessary to understand that leisure practices change on the basis of many variables, but most of all on the basis of three essential elements: the budget constraint, the constraint determined by the phase of family life-cycle, and the influences determined by belonging to a generation that, in general, affects the consumption styles of each family member. In short, the income constraint remains a fundamental variable that influences consumption choices. But, on the other hand, it is equally evident the symbolic value assumed by the consumption practices that end up to be, in many cases, as it happens for families of the Italian middle class, strategies of social positioning (Sassatelli et al. 2008).

Between 1981 and 2010, when Generation Y and Z were born, there have been considerable socio-economic, cultural and technological changes that have influenced the differences between generational cohorts, not only in terms of values and beliefs, but also of preferences in consumption. Within the family, consumption can be considered as a *negotiation activity*, the result of interaction processes that concern, not only the *type and quantity of goods* to be consumed, but also the *ways of consumption* and the *distribution of goods among the family members*. Access to a more structured labour market, with more equal-opportunities, such as the one experienced by the generation of Baby Boomers, which removed the monopoly of earning of the "male breadwinner", has made family more democratic. Such a change deeply influenced the decision making process within the family unit, in particular for what concerns the allocation of resources, and, therefore, the activity of choosing consumer goods, especially of unproductive goods. Furthermore, the acquisition of innovative habits and ways of life that erupted in the 1990s, thanks to the ever-increasing diffusion of digital

technologies, has led to a progressive *libidinization*[3] (Morin 1962) of the family economy. Such an attitude can be more apparent on members of the Y-generation, always poised between the traditional family values and the external influences they are exposed to, above all, in reference to the ways in which leisure time might be spent.

In the past, scholars thought that economic mobility was so high that the effects of any kind of change in income would have "dispersed" over three generations (Becker and Tomes 1986). However, recent studies (Waldkirch et al. 2004) based on longitudinal panels have shown that the intergenerational mobility of income is less fluid than Becker and Tomes (1986) imagined. The economic stratification across generations is equally pronounced if we analyse, for example, consumption data, which show that only 8% of adult children with parents belonging to the lowest quintile with regard to consumption data, moves to the highest quintile (Waldkirch et al. 2004). In other words, in that particular segment of the population, only 8% of children consume more than their fathers. Still, at the same time, the costs of access, for some modes of consumption of leisure time, decreased and so children can consume free time by carrying out practices that their fathers were not able to carry out because they were too expensive for them. Such a difference is also reinforced by the formation of modalities of use of the free time that did not exist at the time when their fathers were young. But what generates the change in the styles of leisure consumption are mainly the so-called "styles of family consumption", which express different "family tastes" that are a function of the income, the social position of the family unit, and the generation different members of the family belong to.

The expression of different family tastes and styles of consumption would seem to emerge much more significantly in families whose life-cycle phase is characterised by the presence of adolescents, young people and young adults, that is, individuals belonging to the Y- and Z-generations (Funches et al. 2017) who consume leisure time in a way that can be interpreted in a *generationalist way*. In short, the adoption of a generationalist approach, even in the selection of the cohorts of households–families with adolescent children belonging to Y-generation in 2001 and 2007, and families with adolescent children belonging to Z-generation in 2012–allows us to analyse the impact of generation on the consumption patterns of families, and effectively mitigate the impact of age.

In fact, if we consider the spending behaviour of households at three different times in the period 2001-2012 (2001, 2007, and 2012), we can observe differences between families at the same stage of family-life cycle, that is, consolidated families with adolescent children, but sampled at different historical moments. Such a choice allows us to investigate the effects of both the general economic conditions (the macro-level) and the (different) generation of children (the meso-level, or the "generational" level) on consumption of leisure time. Also the way to allocate free time with respect to the total time spent in family commitments is an important variable (Rowland et al. 1986). But even at this level the different "consumption styles" become variables that are certainly determined by the age of those who consume time, by the constraints determined by the phase of the life cycle, and by the generational belonging of the different components of the family unit.

Do families with Y-generation children and families with Z-generation children show different preferences for leisure activities? Does that can be deduced from the expenditure shares of families for different types of leisure goods or services in different years? What are the reasons that determine such differences? Are they due to the education of parents, or to the number of parents who work? Is it possible that different expenditure patterns on leisure just reflect the difference between the generation of children?

[3] According to Morin (1962), *libidinization* is a continued interest and appetite for new goods that satisfy transitory and nonessential needs.

3. Data Description

We analyse secondary data collected by the Italian Institute of Statistics (ISTAT) through the Survey on Household Consumption, in the years 2001, 2007 and 2012. The survey considers a stratified sample of households, which is representative of the Italian population. The survey aims at detecting the expenditure patterns of Italian households[4] and their dynamics. Specifically, the ISTAT collected data about households' yearly expenditure on a variety of goods and services–more than 280 different expenditure categories. According to the European guidelines on Classification of Individual COnsumption by Purpose (COICOP), recorded expenditure includes: food, furniture and fittings, clothing, health, transportation, leisure, education and other goods and services. In this paper, we focus on the dimension of leisure, which includes 25 expenditure categories, as detailed in Table 4.1.

N.	Description	Innovation influence
1	Boat, canoe, windsurf	NOT IETI
2	Musical instruments	NOT IETI
3	Sport equipment	IETI
4	Sport	NOT IETI
5	Sport events subscription	IETI
6	Painting and dance class	NOT IETI
7	Bricolage	NOT IETI
8	Other	NOT IETI
9	Newspapers subscription	IETI
10	Concerts subscription	IETI
11	Trip abroad	IETI
12	Meals and accommodation abroad	IETI
13	Overnight accommodation abroad	IETI
14	Trip to Italy	IETI
15	Meals and accommodation in Italy	IETI
16	Overnight accommodation in Italy	IETI
17	Travel equipment	NOT IETI
18	Cafe and bakery	NOT IETI
19	FAFH[5]	NOT IETI
20	Newspapers	IETI
21	Books	IETI
22	Analog photography	IETI
23	Gambling	IETI
24	Cinema, theatre, concerts	NOT IETI
25	Museum and sport events	NOT IETI

Tab. 4.1: Expenditure categories associated with leisure time. Second column provides a description of expenditure category and last column indicates whether an expenditure category is Influenced by Economic and Technological Innovation (IETI) or not (NOT IETI).

Moreover, socio-demographic information is collected for each member of the family, including sex, age, parental relationship with the respondent, education level, job status etc.[6] Here, we use socio-demographic information–age, relationship between family members, job status, and education–to group together households that present a similar composition according to the aim of the present

[4] According to ISTAT, a household is defined by people that live together, linked by emotional ties, relationship, marriage, affinity or adoption.

[5] Food Away From Home (FAFH) category includes restaurants, fast foods and all kind of meals consumed outside the home.

[6] For more details on the survey design, the methodological note for years 2001, 2007 and 2012 can be downloaded at: https://www.istat.it/it/archivio/4021 (language: Italian).

study. Expenditure data for each family on a specific year are used here to calculate the percentage of the total expenditure on leisure that each household allocates on each expenditure category reported in Table 4.1. Specifically, for each family *f*, the total spending in euros on the 25 selected leisure time categories, *TSf*, is calculated, (e.g., *TSf* = 1000 EUR for family *f*). Then, the expenditure of family *f* on each expenditure category (e.g., 150 EUR on category "Books") is divided by the total expenditure *TSf* and multiplied by 100, in order to obtain the percentage of total spending on leisure time that each family *f* allocated on a given good or service (e.g., a 150/1000 × 100 = 15% of total spending on books for family *f*). The result of the procedure is a matrix, one for each year considered in the study (2001, 2007 and 2012), where an entry represents the relative expenditure of a household on a specific expenditure category, expressed as a percentage. Concerning families, we consider households only including a couple (the parents) and children age 13-17. Such a choice allows us to compare families with Y-generation children, as sampled in 2001 and 2007, and families with exactly the same structure but with Z-generation children, as sampled in 2012. This way we avoid that possible differences between expenditure patterns may be attributed to the different age of children. Sampled families have been further stratified according to the number of working parents (1 or 2[7]) and the highest educational level of the parents, college or higher degree (H) or a lower level (L). Table 4.2 reports summary statistics of the different types of families considered in the upcoming sections of the paper.

Year (Generation of children)	Number of working parents	Highest educational degree of parents	Number of sampled households
2001 (Y-generation)	1	L	227
	2	L	251
	1	H	26
	2	H	83
2007 (Y-generation)	1	L	202
	2	L	274
	1	H	23
	2	H	79
2012 (Z-generation)	1	L	132
	2	L	181
	1	H	20
	2	H	65

Tab. 4.2: Summary statistics of family types

4. Results and Discussion

4.1. Cluster Analysis

In this section, we compare the choices of consumption for leisure activities of families with the structure described in the previous section. At first, we shall focus on families with Y-generation children sampled in 2001 and families with Z-generation children sampled in 2012. According to the classification of households based on generation of children, number of working parents and highest educational degree of the parents, eight types of families shall be considered. The percentage of expenditure (share) on each one of the 25 categories detailed in Table 4.1, with respect to the total expenditure on goods and services associated with leisure time, has been calculated for each household. Then, the average of expenditure shares for any given expenditure category has been

[7] A few families with both parents unoccupied have been removed from the analysis, as well as the few families that showed no expenditure at all among the 25 considered expenditure categories.

calculated for each family type. Such an averaging allows us to deal with the sparseness of the dataset, in order to reduce the effect of expenditure concentration on the comparison between different family types.

Table 4.3 shows the relative variation of the average allocation of spending in each expenditure category and for each family type from 2001 to 2012. The table shows some variations that are negative for all the family types, e.g., trip abroad, newspapers, newspapers subscription, analog photography, and meals and accommodation in Italy. Such a negative change can be due to the impact of the economic downturn on some expenditure categories, for instance, trip abroad (probably replaced by trip to Italy, as positive variations suggest, except for families with one working parent and high educational level), while others likely reflect technological changes, which, as clarified later in the paper, are quickly absorbed by households with Z generation children, which is the cohort considered in 2012.

Expenditure category	**YZ_1-L**	**YZ_2-L**	**YZ_1-H**	**YZ_2-H**
Sport*	24,6	20,4	31,8	199,8
Cinema, theatre, concerts*	−62,0	2,4	132,1	−31,5
Gambling*	−27,6	−40,1	142,6	−82,8
Books*	27,5	−33,6	5,0	103,0
Trip to Italy	19,0	105,6	−71,8	127,4
Meals and accommodation in Italy	−18,1	−32,8	−34,0	−27,2
Museum and sport events	−20,5	−23,0	333,3	−66,3
Overnight accommodation abroad	NA	63,4	NA	NA
Painting and dance class	185,3	133,2	NA	19,2
Sport events subscription	−56,5	73,6	NA	44,0
Meals and accommodation abroad	NA	12,1	NA	−5,4
Concerts subscription	189,6	−66,3	−9,0	−91,1
Musical instruments	NA	NA	NA	NA
Other	258,3	360,9	NA	78,8
Bricolage	2356,7	−44,7	NA	NA
Overnight accommodation in Italy	70,9	−7,1	NA	117,4
Travel equipment	−0,8	−47,3	NA	50,9
Sport equipment	−83,1	61,5	77,9	113,8
Trip abroad	−45,5	−42,3	NA	−78,4
Boat, canoe, windsurf	NA	−85,3	NA	NA
Analog photography*	−80,4	−70,7	−96,1	−63,5
Newspapers subscription	−85,0	−68,6	−74,8	−58,5
Newspapers*	−43,7	−15,1	−72,9	−43,3
FAFH*	20,2	14,5	14,1	20,7
Cafe and bakery*	43,6	34,5	23,5	3,5

Tab. 4.3: Relative change of the average percentage of expenditure on leisure categories between 2001 and 2012, for each family type (1-L, 2-L, 1-H, and 2-H). NA indicates that in either 2001 or 2012 (or both) the expenditure of all the households of the corresponding family type is zero. Values in percentage.

* Expenditure categories for witch at least 10 % of all the households in the sample display an expenditure other than zero. Such categories are, actually, those used in the logistic regression analysis.

The positive change of spending observed for all family types on sport, might reflect, instead, a social change towards hedonism and culture of the body that leaded people to attribute an increased value to sport activities (Lo Verde 2015). Such a consideration is confirmed by the overall positive variation of spending on sport equipment, which is mostly apparent for families with both parents working and a high educational level. Indeed, such family type shows an increase of more than 100% of spending on sport equipment, as well as an increase of almost 200% of the expenditure on sport activities. Moreover, according to Table 4.3, between 2001 and 2012, a rise in interest towards more "creative" activities, such as painting and dance class, is observed. Such a positive result, together with the increase of expenditure on leisure category "other", suggests that Z-generation children are oriented towards a more variegated leisure consumption than Y-generation teenagers. It's also interesting to note that households with only one parent working and a low level of education (1-L) show an increment of more than 2000% of their relative expenditure on bricolage, which might be interpreted as a consequence of the expansion of IKEA on the Italian territory[8] (Blackshaw 2010). Indeed, looking at the expenditure category "furniture" (not included in the set of leisure time expenditure categories, but present in our database), a significant negative slope is observed over the same period of time. Finally, Table 4.3 shows a positive increase of relative expenditure on FAFH and cafe and bakery categories for all family types, although such variation is slightly smaller than the others. The fact that changes of spending on some expenditure categories are either positive or negative for all family types suggests that there might be a difference in the expenditure patterns of families on leisure time that only depends on the generation of children and the decade that separates matched samples, and it is less affected by other dimensions, such as education and number of parents working.

To better investigate the latter conjecture, we performed an agglomerative hierarchical cluster analysis of the described average expenditure data. Hierarchical clustering is a method of multivariate statistics suited to reduce the complexity of a dataset by detecting groups of sampled variables that show similar patterns and creating clusters more homogenous within them than between them (Anderberg 1973). Specifically, starting from the original dataset, we calculated the Euclidean distance between the objects–family types in the vertical axis of Fig. 4.1 and expenditure categories in the horizontal axis–and hierarchically grouped them through the Complete Linkage Clustering Algorithm (CLCA)[9].

Figure 4.1 reports the results of cluster analysis performed both on the sampled households (vertical axis) and on the 25 categories of expenditure (horizontal axis). Family-type labels, associated with the rows of the data matrix displayed in Fig. 4.1, incorporate full information about the considered family types: the first letter in the label indicates the generation of children (Y or Z); the following number represents the number of working parents (1 or 2), and the last letter indicates the highest level of parents' education (H in case of college degree or a higher educational achievement, L in case of a lower degree). We adopt such a further categorisation of families with the aim to detect if and to what extent working status and educational level affect the choices of consumption expenditures. Expenditure categories have been divided in two groups: expenditures influenced by economic and technological innovation (IETI) in the period 2001-2012 and expenditures not influenced by innovation over that decade (NOT IETI). The idea is that such a classification might help to interpret results. Indeed, some expenditure categories, such as, for instance, those related to travelling, have

[8] See, for instance, https://www.ikea.com/ms/en_JP/about_ikea/facts_and_figures/ikea_group_stores/italy.html.

[9] Average Linkage method of hierarchical clustering was also performed, giving a similar partitioning of the families in the data set to the Complete Linkage algorithm.

been greatly affected by major changes occurred in the period 2001-2012–e.g. the burst of low-cost flight companies.

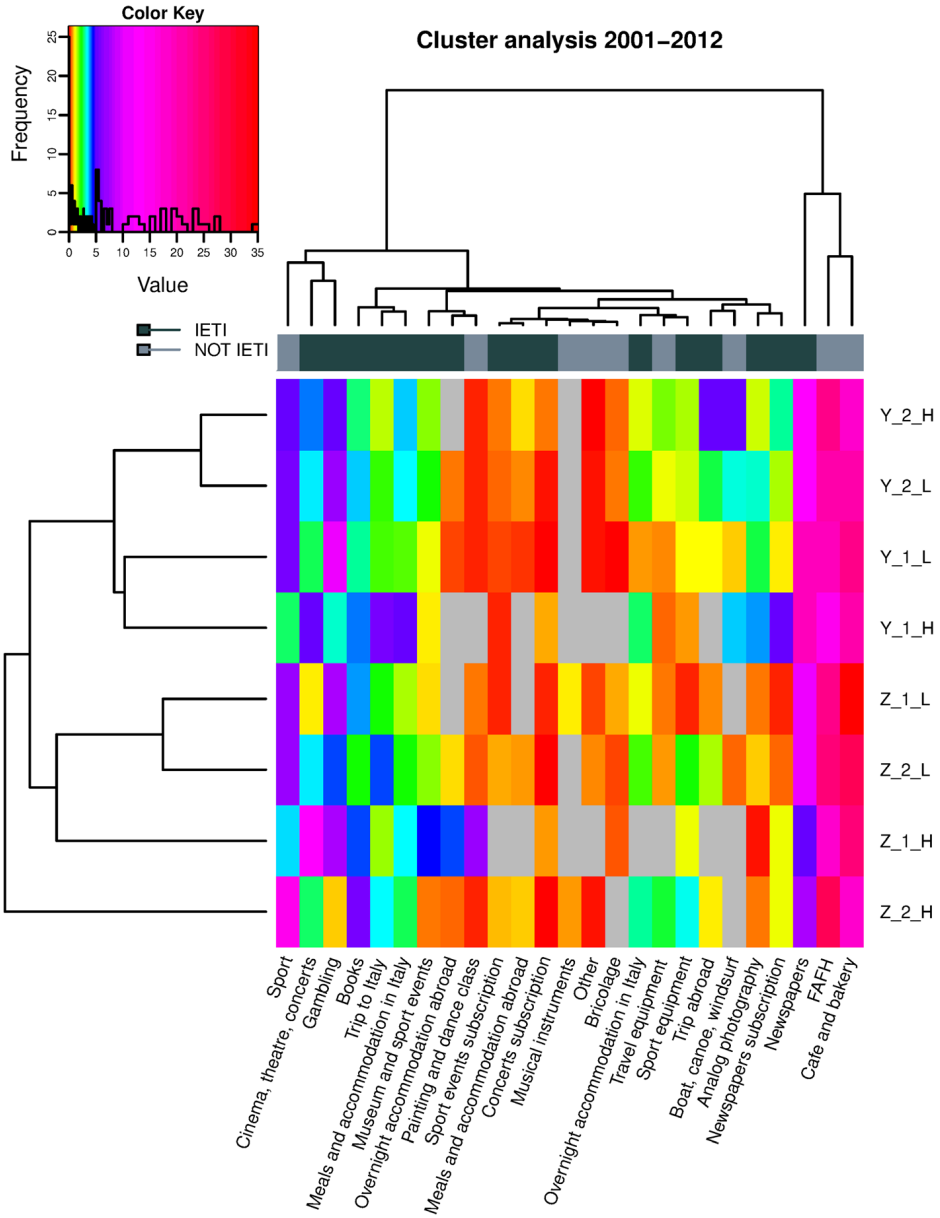

Fig. 4.1: Cluster analysis of households' expenditures with children belonging to Y- or Z-generation, stratified according to number of working parents and level of education. Null spending is in grey colour. Years 2001– 2012.

Cluster analysis clearly highlights a dichotomy between the different types of families. In fact, we observe two main groups, one composed by households with Z- generation children, and one composed by households with Y-generation children. The only exception regards families with Z-generation offspring, both parents working and high educational level (Z_2_H) that merge together with all the other categories of households at the highest distance level in the dendrogram, probably due to the high values of some specific expenditure categories, such as Sport. In this respect, sport frequency expenditure category deserves further attention. As Fig. 4.1 reveals, although both families with Y- and Z-generation children show quite high shares for sport activities, households with Z-generation offspring tend to allocate more income in such leisure expenditure with respect to households with Y-generation offspring. A possible explanation of such a phenomenon can be related to a new emphasis in the culture of the body erupted at the end of the first decade of 2000s (Bauman 2000; Sassatelli 2010; Lo Verde 2014). In these years, sport frequency has become a leisure activity

oriented to the aesthetic body care and aimed at the achievement of common standards of beauty. Such a new interest in appearance care, might imply that Z-generation adolescents go to the gym, make fitness, and play sports more than Y-generation teenagers. According to this view, it is not surprising that families with Z-generation children belonging to the high socio-economic position (two working parent and high educational level), who care even more than other family types of health, well-being and appearance, reveal higher shares of expenditure for sport activities than other types of families with Z-generation offspring.

Figure 4.1 also shows that there are some leisure expenditures that are present for families with Z-generation children and either null or negligible for families with Y-generation children. Half of households with children belonging to Z-generation reveal expenditures related to painting and dance class, musical instruments, and other kind of leisure that are, instead, either null or marginal for families with Y-generation teenagers. It seems that Z-generation children determine more variegated consumption patterns and heterogeneous interests than Y-generation children do, although playing sport remains the favourite leisure activity, as confirmed by high values of the corresponding shares for all kinds of families with Z-generation offspring. On the contrary, the purchase of boats, canoe and windsurfs is more typical of households with Y- generation offspring, and it is null or almost null for the others. It is conceivable that such a result could depend on a progressive loss of interest in outdoor activities among adolescents belonging to Z-generation. Indeed, the technological innovations and the increased availability of digital devices might have had a strong impact on lifestyle of young children, pushing them to spend more and more time indoor, engaged in sedentary and possibly alienating leisure activities (e.g. instant messaging, social networks, video games etc.). It's also possible to interpret the loss of interest in the purchase of boats, canoe and windsurfs by households with Z-generation children as a result of the different socio-economic phases experienced by families with Y- and Z-generation children considered in the present study, which have been sampled in 2001 and 2012, respectively. In fact, several events occurred since 2008–the global financial crisis, the political instability, the austerity policies and the increase of unemployment rate–strongly affected the consumption expenditures and induced families to contract and even suppress expenditures on secondary and luxury goods. Despite the economic crisis and its consequences on the patterns of consumption, it is worth to note that the expenditure for eating out remains stable and proportionally high for both generations, with slightly higher expenditure shares for families with Z-generation children.

It is worth to note that a difference between families with Y- and Z-generation offspring in leisure expenditures can be observed for the purchase of analog photography and newspaper subscription. In fact, cluster analysis reveals that all families with Y-generation children devote a not negligible proportion of their income to such leisure activities, whereas, households with Z-generation offspring show lower expenditure's shares on both analog photography and newspaper subscription. A possible explanation of such a difference lies in the digital revolution started at the beginning of 21-st century and well-established in the following years. In this period, we witnessed the appearance of new technological tools that quickly replaced those of the past: analog cameras have been replaced by digital cameras and smartphones, while printed newspapers have been replaced by blogs, online news, and TV-news h24. It is possible to suppose that the Z-generation teenagers, called "digital natives", adapted quickly to the technological revolution and induced their parents to adopt new digital technologies. Such an explanation can be confirmed by looking at the shares on newspaper's expenditures in Fig. 4.1, which are slightly smaller for families with children belonging to the Z-generation. To better highlight these findings, we set label colours of expenditures according to last column of Table 4.1, which distinguishes between expenditure categories either influenced or not by economic and technological innovation throughout the period 2001-2012. It is worth to note that digitalization processes had different implications depending on the type of leisure category: in some

cases, digitalization processes led to the almost disappearance of the purchase of a good, e.g., the analog photography, and the subscription to newspapers in our study, while, in other cases, they modified the way in which families consume a good or use a service, but they did not affect the portion of income allocated on the corresponding expenditure category. The latter explains, for instance, why we do not observe a negative trend of expenditure shares over time, that is, between 2001 and 2012, in several expenditure categories. For example, for what concerns the rather stable expenditure on books, we suppose that in 2012 people did not reduce the purchase of such a good with respect to 2001, but they just modify their reading habits adopting new digital format and devices (e-books and e-book readers): such a modification in the style of book consumption seems not to negatively affect the quantity of income that families with Z-generation children allocate for the corresponding good; similarly for travel expenditures, reduced costs favoured an increment in the number of trips, keeping the expenditure shares stable over time. It is also worth mentioning that–for some expenditures–the role of the generation is marginal to distinguish between different types of families, whereas other dimensions come into play. This is the case, for instance, of expenditures related to meals and accommodation abroad, which are null or marginal for all families except for households with Y- and Z-generation offspring in which both parents work. Such a result suggests that, in this case, the choice of consumption is more affected by income than by the generation or the level of education of parents.

Figure 4.2 reports the hierarchical cluster analysis performed on the sample of households with offspring belonging to Y- and Z-generation, stratified according to the number of working parents and their highest educational level, for the years 2007-2012. Also in this comparison, families sampled in 2007 have children who belong to the Y-generation. The aim of this second analysis is to detect if there are some differences in families' choices of expenditure for leisure activities as compared to the years 2001-2012, in order to investigate the role played by the difference in time between people belonging to different generations.

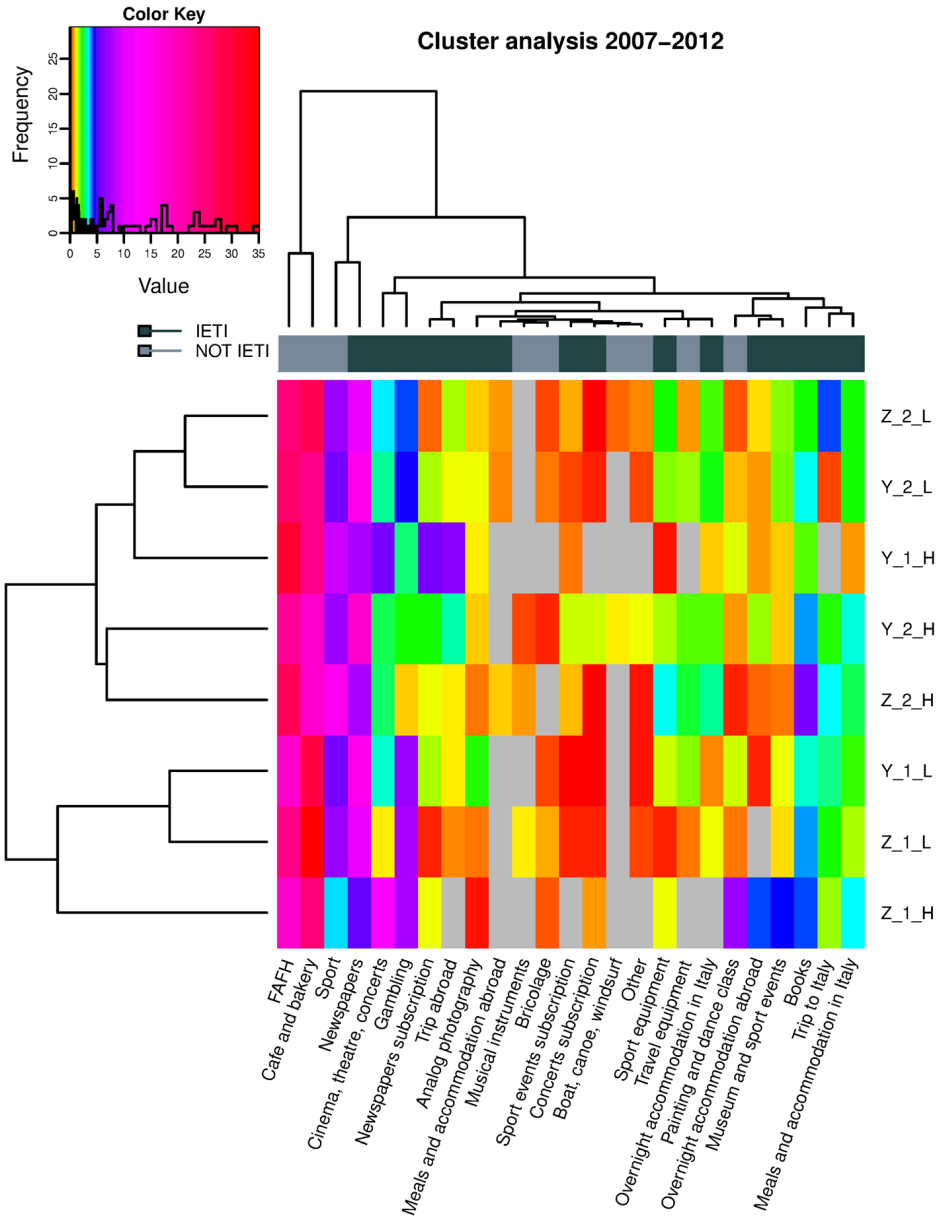

Fig. 4.2: Cluster analysis of households' expenditures with children belonging to Y- or Z-generation, stratified according to number of working parents and level of education. Null spending is in grey colour. Years 2007– 2012.

Cluster analysis reported in Fig. 4.2 shows some evidences that differ from 2001 to 2012. First of all, the composition of the two largest family clusters (see vertical axis dendrogram) is quite heterogeneous with respect to children generation and level of education. In this comparison, it seems that the discriminatory variable for the classification of households is the number of parents working, which better explains clusters as compared to both the level of education of parents and the generation of children. The only exception is related to households with Y-generation children, just one working parent, and a high educational degree, which clusters together with all of the family types in which both parents have a job. This might be due to the higher purchasing power of households with only one parent working and high level of education in 2007 (pre-crisis) with respect to the power of the same households in 2012. Figure 4.2 shows that households with only one working parent are inclined to low cost activities, such as bricolage, painting and dance class, and gambling. Despite all, eating out is a leisure activity in which all family types allocate a significant portion of their total expenditure.

At difference with the 2001-2012 comparative analysis, results from the 2007-2012 comparison cannot reflect the generational difference of offspring. In fact, belonging to the same generation implies the sharing of events (cultural, historical, economic and political) that create a collective memory for all members, different than the collective memory of generations that experienced other events. In case of the limited time window of years 2007-2012, it is possible to suppose that adolescents belonging to Y- and Z-generation (respectively sampled in 2007 and 2012) do not have styles and choices of consumption that strongly differ, one generation with respect to the other, simply because they share similar experiences. The borderline between Y- and Z-generation children in this case is thinner and the generational impact hardly perceived. In this case, the generation does not play a primary role in consumption expenditures, whereas the number of working parents becomes more influential.

4.2. Logistic Regression

In this section, we consider a logistic model to describe the association between expenditure patterns on leisure (explanatory variables) and a binary variable which can be either the generation of children in the families (Y- or Z-generation) or the year when household data were sampled (2001 and 2012).
Logistic regression allows one to evaluate the parameters of a logistic model aimed at estimating the probability that a binary response variable takes one of two values (not necessarily numeric values or even ordered, generation Y and Z in our case) based on the values of a linear combination of a set of predictor variables (Cox 1958).
The dataset used for the regression includes data about 977 households with either Y- or Z-generation children from 2001 (Y-generation) and 2012 (Z-generation). The eight selected explanatory variables, that is, shares of family expenditure on eight expenditure categories, used in the model are such that their entries are different from zero for more than 10% of families in the dataset. To test the overall significance of the logistic regression, 100 training and test sets have been randomly and independently constructed from the whole dataset. Each training set included 80% of data and the test set the remaining 20%. Each training set has been used to perform the regression and obtain parameters' estimates. Then the logistic function has been applied to the test set to predict if households' children were from Y- or Z-generation, according to recorded expenditure patterns. The threshold used on the logistic function is 0.5. The resulting classification has then been compared with the actual one for the test set, by estimating the Standardised Mutual Information (SMI) (Yao 2003; Zhang and Stewart 2016) between actual and predicted classifications (average SMI 0.053), the Matthews correlation coefficient (MCC) (Matthews 1975) (average MCC = 0.22), the percentage of correctly classified families (average value equal to 64%). A *p*-value has been associated with mutual information by independently randomising 1000 times the actual classification of families in each one of the 100 randomly sampled test sets and by measuring the mutual information between the random classification and the predicted one. The *p*-value is calculated as the proportion–with respect to the overall 1000 simulations–of random replicates of the classification that showed a mutual information larger or equal to the actual one, that is the one associated with real classification of households in each specific test set. The average *p*-value over the 100 independent training and test sets considered in this study is 0.037, indicating that the classification obtained according to the logistic regression is statistically significant at 5%. The same level of statistical significance (<5%) has been attained by looking at MCC in place of mutual information.
Three explanatory variables show regression's coefficients that are statistically significant, according to False Discovery Rate correction for multiple hypotheses testing, at 1%, (*p*-values are reported in Table 4.4). More specifically, the regression's coefficients statistically significant concern the expenditures for newspapers, analog photography and gambling. All of the three variables display

negative coefficients in the regression, indicating that the share of (leisure) expenditure of households on the corresponding goods was higher in 2001–Y-generation children–than in 2012–Z-generation children. Variable "gambling" requires further explanation. Indeed, it doesn't refer to casinos, rather to nationally specific types of gambling, namely "totocalcio", which is the official Italian gambling on soccer games, lotteries, and all the other gambling games that share the characteristic of being managed and accessible at an institutional level.

Variable	Estimate	Standard error	z-statistic	*P*-value	Odds ratio unit=1%	Odds ratio unit=10%
Sport	0.0039	0.0034	1.144	0.2524693	1.004	1.040
Café and bakery	0.0034	0.0018	1.821	0.0686343	1.003	1.035
FAFH	−0.0014	0.0017	−0.797	0.4252062	0.999	0.986
Newspapers	−0.0168	0.0032	−5.159	0.0000002*	0.983	0.845
Books	−0.0018	0.0052	−0.343	0.7315561	0.998	0.982
Analog photography	−0.0530	0.0153	−3.469	0.0005216*	0.948	0.588
Gambling	−0.0127	0.0040	−3.141	0.0016858*	0.987	0.881
Cinema, theatre, concerts	−0.0070	0.0065	−1.086	0.2775841	0.993	0.932

Tab. 4.4: Parameters of a logistic regression with 8 explanatory variables, and generation of households' children as binary response variable, that is, Y- or Z-generation.

The results indicate that the main differences between families with Y-generation children in 2001 and families with Z-generation children in 2012 strongly depend on the technological and economic innovation occurred in between and on how fast adolescents belonging to Z-generation adapted to such changes. Indeed, analog cameras diffusion and associated expenditures reduced due to the appearance and subsequent diffusion of mobile phones with cameras–the digital revolution. Similarly, newspapers have been progressively replaced by news websites, as well as institutionally managed gambling games have been replaced by online gambling (also favoured by the progressive liberalisation of the gambling market that occurred in Italy between 2006 and 2011), which are both not included in the sampled expenditure variables above. Therefore, the performed empirical analysis shows us that households with teenager children experienced the digital revolution and modified their expenditure patterns accordingly. Changes on the expenditure patterns on two of the three explanatory variables, namely analog photography and newspapers, are likely a consequence of the direct influence of children on family consumption habits, as pushed by a pressure from peers. Such an influence, could also be at the root of the change in the gambling activity of parents, as children likely induced an increased usage of the internet among the parents. In other words, according to the presented analysis, the difference between Y- and Z-generation teenagers is that Y-generation teenagers and their families show pre-digital expenditure patterns on the leisure dimension in 2001, whereas, families with Z-generation teenagers in 2012 already experienced the digital revolution, and, consequently, show reduced expenditure proportions on pre-digital goods and services. Such a difference suggests that a generational interpretation of the expenditure patterns of people should take into account the social, technological, and economic changes occurred in the time that separates the generations.

Such a conclusion is supported by a logistic regression analysis performed on exactly the same dimensions for households with Y-generation teenagers in 2007 and households with Z-generation teenagers in 2012. The only significant variable in this case turns out to be Newspapers (p-value = 0.000017). However, according to the mutual information analysis already described for the case

* Statistically significant parameters at 1% after false discovery rate correction for multiple hypothesis testing.

2001-2012, the classification model for the years 2007 and 2012 is not statistically significant (mutual-information average *p*-value: 0.67). Although the overall logistic model is not stable enough to changes in the training and test set, the fact that *p*-value of variable "newspapers" is statistically significant suggests that families with Y-generation children display a legacy to pre-digital goods and services that families with Z-generation children don't show.

One might be tempted to claim that the observed differences between families with Y-generation children, as those sampled in 2001, and families with Z-generation children, as those sampled in 2012, just depend on the aforementioned technological change occurred in that decade, and not also on the different generations of children sampled in 2001 and 2012. In line with this consideration, a legitimate question could be: if only the technological changes affected households' consumption, should we observe the same results independently of the different generations of members of the family units? To address such a legitimate question, we have performed a logistic regression, using the same 8 expenditure's categories discussed above, by focusing our attention only on families made of a couple without children and age between 30 and 50 years old–a range of age which is strongly overlapping with the age of parents of teenagers–in 2001 and in 2012. In this way, we investigated the impact of technological change on consumption patterns by only considering the changes occurred between 2001 and 2012, and excluding the possible influence of children's generation. It turns out that the only variable, which is statistically significant after the FDR correction, in the case of couples without children, is, again, Newspapers (*p*-value 0.00006). Furthermore, the mutual information analysis using training and test sets, as previously discussed, indicates that the classification based on the logistic regression is not statistically significant (*p*-value 0.073) at 5%. Such a result suggests that social and technological changes are, alone, not sufficient to determine significant changes in households' expenditure patterns for leisure activities and that the generation of children plays a non-negligible role in determining significant differences.

Finally, some of the results obtained through the logistic regression as applied to 2001-2012 data are also supported by the trend of consumption reported in Table 4.5, according to a survey managed by the ISTAT (2001, 2007, 2012)[10].

Year	**Teenager readings of newspapers and magazines per week**		**Teenager readings of books per year**		
	1–4 times	5 or more times	1–3 books	4–11 books	12 or more books
2001	41.2%	8.2%	29.0%	21.2%	4.3%
2007	36.6%	11.0%	27.7%	23.4%	5.5%
2012	29.0%	4.4%	29.5%	23.0%	7.8%

Tab. 4.5: Statistics about teenager (age 15-17) readings of newspapers and magazines, and readings of books. Percentage of the sample age 15-17. Source: Istat - http://dati-giovani.istat.it/?lang=en.

The table shows that teenager (age 15-17) readings of newspapers and magazines drop in the period 2001–2012, which is in line with the result of a statistically significant negative coefficient in the logistic regression associated with expenditure on newspapers. Similarly, the reading of books remains rather stable over the considered time window, which supports the fact that the coefficient associated with expenditure on books in the logistic regression is not statistically significant.

In summary, the generation of children might have an influence on their ability to adapt to technological advances, and, therefore, be a genuine explanation for the faster acquaintance of their families with new technologies.

[10] More details on the survey design can be found at http://siqual.istat.it/SIQual/lang.do?language=UK.

5. Conclusions

The object of the present study is to explore the role of two different generations–Y and Z–of teenagers in affecting households' consumption behaviour oriented to leisure activities. To explore such a phenomenon, we compare the expenditure on leisure activities of families with adolescents belonging to either Y- or Z-generation, in two different time windows (2001–2012 and 2007–2012), in order to take into account the interplay between the influence of generations and the influence of social, political and economic events occurred in a shorter (2007–2012) and a longer (2001–2012) period of time, and mitigate the influence of the age of children belonging to different generations.

The findings described in the paper have several implications. First of all, they improve the research on consumption choices for leisure activities from the perspective of sociology of the generations. Indeed, although the study of generational differences has its roots already in Mannheim's works (1928; tr. En. 1952), there is still a lack of sociological research that analyses the choices of consumption in relation to the belonging to different generations and, at the same time, are not deeply influenced by the age difference of generational cohorts.

Moreover, considering households as a budgetary unit (McDonnell 2013) allows us to give an interpretation of the empirical results that takes into account the needs of all family members and their influence, more or less pivotal, on the decision-making process. In fact, one of the main findings outlined in this article indicates that house- holds with Z-generation children have already adapted in 2012 to new technologies and modified their styles of consumption as a consequence. We are inclined to believe that such an evidence strongly depends on the consideration that parents have of their offspring's needs, tastes and opinions. In fact, considering the household as a budgetary unit in which the consumption choices are oriented to the benefits of all the family members, the evident decline in purchase of pre-digital goods (such as analog photography and newspapers) may depend on both the children's desire of new digital devices (e.g. digital cameras and smartphones) and the influence that adolescents have on their parents to quickly adapt to new technologies (e.g. reading news and gambling online). Furthermore, the logistic regression performed on families without children and their expenditures for leisure activities in the same time window (2001–2012) does not reveal significant differences between households of the two cohorts, which allows us to exclude that the differences in consumption patterns highlighted for households with children just reflect and depend on the social, technological and economic changes occurred in the period 2001–2012. In other words, the changes occurred in this time period have affected more the expenditure patterns on leisure activities of households with 13–17 years old children than those of families without children, likely due to two dimensions related to family composition: 1) the presence of children that, despite their generation, influence the family's decision-making process, and 2) the key role played by generation in modifying expenditure choices, in line with technological and economic changes. From the generationalist perspective, historical changes have a stronger impact on the lifestyle of adolescents and young adults with respect to older people, since the former are more receptive and inclined to change than the latter. As Mannheim argued (1928; tr. En. 1952), youth is the stage of lifecycle in which young people start to develop attitudes, perceptions and a style of life in a way that is more and more independent of the socialisation agents typical of childhood (family and school). Such an autonomy encourages them to re-define cultural reference models (e.g. greater importance and influence is given to peers) and develop a new awareness of their social position (political views, social class, etc.). Adolescents are, therefore, more inclined to adapt to rapid changes, in contrast to adults that have settled habits, attitudes and consciousness. In this regard, the presence of youths in households assumes a key-role for orienting expenditure choices and pushing the other members to adopt new styles of consumption: as confirmed through our empirical study, adolescents between 13 and 17 years old follow the direction of historical change and accelerate the assimilation of changes

by the whole family. In light of this, the main contribution of the present study is to consider teenagers, that is people of the same age, belonging to different generations. Indeed, some studies already exist that aim at investigating the generational influence on consumption patterns (Brosdahl and Carpenter 2011; Chhetri et al. 2014; Kolnhofer-Derecskei et al. 2017), but the generational effect is mixed with the effect of the different age of generations' members in these studies.

Although the generation of children affects family consumption patterns, our results indicate that its influence cannot be separated from the one of social changes. In fact, as the empirical analysis performed on 2007–2012 data revealed, when a short time window separates Y- and Z-generation offspring, no significant differences between households' consumption patterns are observed, and other dimensions become more influential (e.g. the number of working parents, as cluster analysis highlighted). Such findings are in line with the literature on sociology of the generations (Alwin and McCammon 2003; Bagnasco et al. 1997; White 2013), according to which generations are not just a mere chronological sequence of cohorts, and sharing the same experiences is not enough to create a generation. For a cohort to become a generation, it is necessary that the changes are internalised by people and that such assimilation creates new and shared attitudes and views of reality that could influence the style of life specific to that generation. Although people belonging to Y- and Z-generation share different collective memory, the adolescents in 2007 (Y-generation) and the adolescents in 2012 (Z- generation) act under the influence of similar social changes, and such a reduced time window does not allow them to develop a style of consumption specific of the generation they belong to.

The analysis reported in the paper indicates that, under a generationalist perspective, the observed differences in household consumption patterns on leisure activities can only be explained through the entanglement between the generation of children and the presence of major social changes that occurred in the time window that separates the considered generational cohorts (about a decade, in our case). Nevertheless, it is necessary to note that, in our study, we analysed household's differences in consumption choices within a "generationalist framework", that is, we focused on studying the impact on consumption of belonging to Y- or Z-generation. It is still to be investigated the role played by social changes alone, for instance, by comparing consumption patterns of different cohorts of people (teenagers, possibly) who belong to the same generation at different points in time. However, such an analysis could not be run with our data, which only cover the time period 2001–2013.

In conclusion, the present study makes an important contribution to understand the joint influence of children's generations and social changes on the expenditure patterns of households for leisure activities. The reported analysis indicates that the role of the generation of children in determining consumption patterns on leisure is significant only when the time difference between generational cohorts is long enough that social, economic, political and technological changes occurred in between can affect people's lifestyle.

6. Limitations and Future Directions

We acknowledge various limitations in our study. Our sincerest wish, however, is that such limitations and especially the open questions will lead to future research in leisure consumption from a generationalist perspective.

First, we are aware of the difficulty to empirically frame a labile concept as "generation", especially for the new generational cohorts. In fact, for the previous generations (Traditionalist or Silent Generations, Baby Boomers, and X Generation), it is quite evident to identify which historical events occurred to transform a cohort in a generation and which social changes people experienced (Great Depression and World War II, Cold War and social conflicts in 1968, Fall of Berlin Wall and falling birth rate, respectively). On the contrary, it can be more difficult to frame the generations considered

in the present study, Y generation (so called Millennials) and Z generation, in a more specific historical period. Such a difficulty is due to the rapid sequence of socio-economic changes and epochal events that involved the global population in the last decades. Nevertheless, there are some evidences that allow to distinguish between Y and Z generations in terms of attitudes, view of the world and, as the present study suggests, consumption choices. One might be tempted to interpret the differences between Y- and Z- generation expenditure's patterns revealed in the present work as a mere effect of the different cohorts sampled, 2001 and 2012, without invoking a role played by the generation of offspring. That is indeed also a reasonable interpretation of our results. However, we are not aware of any empirical study that compare consumption patterns of people with the same age, but belonging to different generations in two separated time-windows, which could support or dismantle our interpretation of empirical results. Indeed, all of the studies we are aware of in the vast literature on generational attitudes and consumptions (Brosdahl and Carpenter 2011; Chhetri et al. 2014; Kolnhofer-Derecskei et al. 2017) clearly highlight differences between generational cohorts, but focus on consumption occurred in the same year, by also making it difficult to untangle the effects of age and generation. Unfortunately, empirical studies that could help to better untangle the interplay between generations and the inter-time between sampled cohorts could not be done through our data. In fact, such studies would require one to consider the consumption of teenagers' cohorts (13–17 years old) belonging to the same generation in 2012 and 2023 (Z-generation offspring in both years) or the consumption of teenagers' cohorts belonging to the same generation in 1996 and 2007 (Y-generation offspring in both years). By involving a time difference between cohorts, which is exactly equal to the one considered in this paper, such hypothetical studies would allow to compare the behaviour of cohorts that belong to the same generation. Therefore, if no difference would emerge in these studies between the cohorts, that would support the relevance of the concept of generation to interpret differences in consumption between households, whereas, if significant differences would arise, that would support the reverse, that is, the prominence of the role played by the inter-time between cohorts with respect to the generation.

Second, the list of expenditure's variables used to infer families' style of consumption could be easily enlarged and specified to better highlight the differences between the generations of offspring. On the one hand it's true that our dataset is informative about a wide range of leisure activities–from sport to painting courses, from musical instruments to events–and allows one to distinguish between goods and services that may or may not be affected by economic changes and technological innovations. On the other hand, however, the database does not include items that surely would enrich the analysis, such as goods and services that appeared in the contemporary era and quickly became iconic of leisure time, such as wellness centres, video games, video on demand services etc. Furthermore, our dataset does not include information about relevant features of goods, e.g., brand and typical cost of a unit.

Third, we have focused our analysis on households in a specific phase of family life-cycle, i.e., families with adolescent offspring. Our choice is motivated by the following considerations. Teenagers are more inclined to be affected by social changes–especially the technological ones–and, as a consequence, to quickly adopt new styles of consumption (Mannheim 1928; tr. En. 1952), which may also influence consumption preferences of other family members. Households with adolescents can be considered as "consolidated families" (Solomon et al. 2006) that, on average, already faced with the primary needs of a new-born family (such as buying the family house and children care) and, therefore, can afford to spend more on leisure time activities and related goods. However, this is also an intrinsic limitation of the present study, since it disregards consumption activity of households at other stages of family life cycle, such as new-born families, families with young adult offspring and families without kids.

In light of the above, the future research directions could be oriented towards a greater understanding of the symbolic value attributed to the consumption of free time, perhaps through a qualitative research methodology that brings out the meaning attributed by adolescents to different leisure time consumption practices. For example, it could be interesting to investigate the motivations that push young people to choose specific activities during their free time. Do they depend on a desire for peers' approval? Or do they derive from the constant Fear of Missing Out some crucial experiences (Przybylski et al. 2013)?

An analysis performed on more recent data could allow one to better consider the impact of new technologies on the style of consumption: how are consumer trends affected by the flourish of mobile phone applications for everything (monitoring physical activity, listening to music, watching tv, booking flights, reading news, taking pictures and making videos)? That, indeed, might be at the root of what emerged from our study about, for instance, the reduced expenditure on analog photography and newspapers in the 2012. We are led to think that some consumptions might increase much more, whereas others might even disappear. For example, is it conceivable that, on average, the purchase of several goods for leisure time, including several expenditure categories in our data, has been replaced by just the purchase of smartphones in 2018?

Moreover, we believe that a comparison of cohorts from the same generation across a wider time-window, e.g., Z-generation adolescents in 2012 and in 2022, would allow to clarify if the differences in consumption patterns reflect more a cohort or a generation effect.

Finally, we would conclude the present work with an open question that we hope will lead to future debates and empirical studies. Nowadays, the speed with which major technological changes occur and their (almost) global diffusion is increasing. Moreover, such changes, including social media penetration, digital devices, artificial intelligence, might deeply influence the social behaviour of people belonging to more than one generation, accentuated by the rapidity of information spread in contemporary age. Such a rapidity of change could facilitate the transition from a generation to the next one in a short period of time, but, at the same time, could make it difficult to draw a line that separates consecutive generations. As Kolnhofer-Derecskei et al. clearly argued (2017):

> "This lifetime-long generation transition has become much shorter in the case of the recent generations; the quicker the technological innovations are implemented, the more difficult it is to determine the transition between the generations."

This will probably be the challenge that the sociology of generations will have to face in the near future.

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Conclusions

In the present thesis, we propose to frame the sociology of consumption in the theory of Complex Systems, in order to highlight the opportunities of knowledge provided by such an approach, which represents a new perspective for the study of consumption. This purpose relies upon the fact that 1) sociologists never treated patterns of consumption as emergent phenomena that arise from the interaction between the elements of a social complex system, and, 2) when we approached our system composed by Italian households and their expenditures, we observed some features that identify such a system as "complex".

Households and their expenditures as an Evolving Complex Social System

After a detailed description of Complex Systems and the introduction of a specific methodology derived from Social Network Analysis to analyse them in Chapter 1, we discuss more in detail the system composed by households and their expenditures in Chapter 2. The main aim of the chapter is to demonstrate that several of the features of complex systems introduced in the previous chapter can be detected in the considered social system. Specifically, we observe that:

- From the perspective of complex systems, the widespread phenomenon of young adults that still live at home, also if they have a job, may be interpreted as a consequence of the interplay between multiple dimensions: the economic, socio-political and cultural ones, especially if we consider how the transition to adult life is declined in different ways among European countries. Such a "delay syndrome" has definitely an impact on households' consumptions, since adult children still living at home, especially if they have a job, show specific purchasing attitudes that affect the consumption's patterns of the entire family unit, typically more oriented to meet secondary needs of young adults.
- The system composed by Italian households and their expenditures (that will be deeply analysed in Chapters 3 and 4) reveals a high degree of heterogeneity of its elements that is typical of complex systems. Indeed, both households and expenses are very different among them: we deal with many types of family structures (e.g. couples with children, people living alone, elderly couples etc.) and many different goods and services that families may purchase. Moreover, differences among households are also detected with respect to their total expenditure. Indeed, we observe that family total expenditure follows a log-normal distribution. Such a result suggests the existence of a multiplicative process that determines the total expenditure of a family. An analysis of such a process is left for future research. However, it may be hypothesized that the multiplicative process is a consequence of the symbolic value that people associate with purchased goods and services. Indeed, to reach a higher social status, it is necessary to meet a minimum expenditure on several macro-categories (house, car, etc.), and expenditure categories are extremely heterogeneous. Therefore, spending more on a certain expenditure category may push a household to spend more on several other categories, in the attempt to reach a higher social status.
- Extreme events and tipping points have been observed. In particular, the introduction of the euro currency, the financial crisis and the austerity policies strongly affected family purchasing decisions, pushing households to change their consumption habits. Heteroscedasticity of consumption has also been detected in the considered system. In this regard, we observe that households' consumption is affected by family structure and area of residence. Such multiple influences, together with information cascades and herd behaviour, compete to determine the non-stationarity of consumption.

In summary, the aforementioned features allowed us to conceive households and their expenditures as an Evolving Complex Social System.
In Chapter 3, we generalized the Statistically Validated Networks (SVNs) method–conceived for eliciting significant pair similarities between the elements of a one-mode projection of a bipartite graph–to the case of a tripartite graph, composed by 1) family types (groups in which each household has been classified, according to its characteristics), 2) households, and 3) expenditure categories. The approach allowed us to take into account the high heterogeneity of the system and the sparseness of data in the analysis. Indeed, both households and expenditure categories were extremely heterogeneous, in both qualitative and quantitative terms, and the thirteen available datasets (from 2001 to 2013) were extremely sparse, displaying, on average, 80% of null expenditure shares per household. Through the analysis of the constructed bipartite SVNs, we observed that family types reveal different spending profiles in relation to some structural properties that distinguish them. First of all, the presence or absence of children within the family unit determines variegated or extreme consumption choices, respectively. Secondly, the stage of family life-cycle influences the purchasing habits of households: elderly people are loyal to a limited number of specific goods and services, whereas young singles or young couples are inclined to spend on primary-house rent or purchase, leisure time, and food away from home; new-born families with young children tend to concentrate their budget on coping with children necessities and house primary needs, whereas consolidated families with teenager and/or young adult children display patterns of expenditure spanning a variety of goods and services. Finally, some income-related variables, such as the number of working parents and their educational level, emerged as prominent factors in shaping consumption patterns of households with children belonging to the same stage of family life cycle.
As the adoption of a holistic approach reveals, the consumptions of family units cannot be explained by considering a single aspect that may affect them, such as family structure, exogenous socio-economic factors or generation of family members. Indeed, households' expenditure patterns result from the entanglement among different interacting dimensions. In this regard, in Chapter 4 we observed that the share of spending that families allocate for goods and services related to leisure time activities depends on the combined effects of technological and economic innovations and the generation of children. Indeed, households with Z-generation offspring are more encouraged by young children to adapt to new technologies. Children belonging to Z-generation are "digital natives", it means that they did not adapt to the contemporary digital revolution, changing their consumption habits as a consequence, but they are born in the middle of it. For them, reading news online, making purchases on digital stores, using smartphones to take pictures are part of their lifestyle, and such an evidence clearly has an impact on consumptions, especially the ones related to leisure time. The differences revealed between the expenditure profiles on leisure-time activities of families with Y- and Z-generation adolescent children (sampled in 2001 and 2012, respectively) are not significant when households with adolescent children from the same generation (sampled in 2007 and 2012) and couples without offspring (sampled in 2001 and 2012) are considered. Such results suggest the existence of the entanglement between generation and socio-economic changes that determines the different spending profiles of families with respect to leisure time activities. Moreover, we observed that dimensions that are endogenous to the family unit, such as the educational level and the number of working parents (typically related to income), play a prominent role in shaping consumptions that differentiate households' categories.

Limitations and future research

The present thesis aimed at analysing households and their expenditures as an Evolving Complex Social System, by using the theoretical framework and the methodologies provided by the adoption of

such an approach. On a broader view, we propose to use Complex Systems Theory for the study of different domains of the sociological discourse. Indeed, along with the very different scientific fields in which the complex systems' theoretical framework has been applied in order to achieve a better knowledge of specific phenomena, such an approach may provide useful insights also if applied to the multiple branches of sociology. For example, although our focus here is on the sociology of consumption–that we treat by joining different fields of the sociological discourse, as the concepts of family and the generation–, we argue that the specific sociological interest towards the intergenerational differences might benefit from the adoption of the complex systems' theoretical framework. As research on generational cohorts confirms, the generations are differently conceived across the world, and, especially when a new generation appears, it is a hard task to find clear and shared sets of tastes, attitudes, values, expectations and world views that characterize one generation with respect to the others. In this regard, complex systems' theoretical perspective may improve the knowledge of intergenerational differences, since it allows to consider the interplay between multiple factors that may play a prominent role to give birth to a new type of generation, such as the political and socioeconomic events that shape generational attitudes, the preferences, the value system etc. Nevertheless, one may argue that the emergence of groups of individuals that share similar attitudes, tastes, views of the world etc. depends on age similarity instead of the generation people belong to. However, it might be possible to compare people with same age but sampled at different points in time, i.e., individuals homogeneous by age and not by generation, in order to highlight characteristics of people that are strictly related to the age and do not concern the belonging to a specific generation. Once such features would be detected, one may take them into account in the initial analysis of similarity, in order to distinguish between age effects and generational effects.

The results reported in the present thesis suggest that the Complex System framework can be embraced to manage other kinds of complexity in social systems, by detecting extreme events that alter the system's behaviour, understanding the mechanisms of resilience and adaptation of a society after a shock, modelling possible scenarios of society's evolution, evaluating the impact of environment and so on.

Complex systems' approach can be adopted for the analysis of systems composed by many elements, which reveal specific features of structure and dynamics (e.g., mechanisms such as information cascades, positive and negative feedbacks, self-organizing rules, etc.), and in which emergent phenomena are observed (communities, hierarchical organization, etc.). It implies that if we focus on social issues, such a perspective can be applied to every level of analysis, from the lower one (as the internal dynamic of a family unit) to the higher one (as the alliance among States). In other words, the presented results suggest that several social dimensions may reveal some or many typical features of complex systems, and, such a framework should help to unify different levels of social analysis.

One limitation in the adoption of a complex systems' perspective may be that, although the intellectual landscape on complex systems consists of scholars coming from different scientific domains (biologists, economists, mathematicians, physicists, geologists, computer scientists etc.), there is still a lack of interest towards Complex Systems among sociologists. Indeed, until now, few scholars tried to incorporate complexity science into sociology, especially in the Italian scientific landscape. Such a lack may be due to 1) the difficulty to overcome the dichotomy between micro- and macro-level of analysis that has divided sociologists for a long time, and to 2) the need to adapt to new methodological tools conceived for dealing with complexity. Such a last issue is strictly related to the idea of multidisciplinary research that the adoption of a complexity perspective requires. Indeed, what complex systems' approach highlights is that the collaboration among different disciplines is the key for having a more complete overview of the analysed system and of the elements that compose it at different levels of aggregation. Nevertheless, to make such a fruitful interplay more widespread, some changes in the formation process of researchers, setting a minimal

common ground with respect to both qualitative and quantitative analysis, would be required to favour a smoother and fruitful collaboration.
Finally, it is worth to mention some constraints related to the intrinsic nature of complex systems. In this regard, if, on one hand, the adoption of a holistic approach allows one to simultaneously take into account multiple factors that may affect the patterns of evolution of the system, on the other hand, it might become difficult to untangle the effect of single variables from their joint effect.
In conclusion, we argue that the theory of complex systems as a unifying framework to investigate the structure and evolution of society may provide relevant insights that cannot be obtained by adopting a classical reductionist approach. Moreover, methods and models developed to analyse complex systems may allow the researcher to deal with features of social systems' microdata (available today, thanks to technological innovation) that might be difficult to treat otherwise. Therefore, the expectation is that the sociology opens to the theory of complex systems, and to the methodological tools developed to study complexity, by recognizing the opportunities of knowledge provided by complexity and giving its contribute to such a multidisciplinary approach.

Appendix

- **Expenditure categories**

In table A.1 we show: 1) the expenditure categories; 2) the macro-category in which each expense has been grouped; 3) and the temporal coefficient applied for calculating the annual expenditure of every good or service.

Expenditure category	Macro-category	Temporal coefficient
Nurseries, baby sitters	Children	12
Toys and video games	Children	12
Paper towels, diaper, toilet paper	Children	12
Childcare items	Children	12
School fees	Education	12
Fees and similar	Education	12
School bus	Education	1
Home schooling	Education	12
Accommodation	Education	12
School books	Education	1
School meal	Education	12
Bread	Food	12
Biscuits	Food	12
Pasta	Food	12
Rice	Food	12
Flour	Food	12
Other cereals	Food	12
Dessert	Food	12
Veal	Food	12
Beef	Food	12
Pork	Food	12
Horse	Food	12
Sheep and lamb	Food	12
Chicken	Food	12
Bush meat	Food	12
Cold cuts	Food	12
Potted meat	Food	12
Other meat	Food	12
Fish	Food	12
Smoked fish	Food	12
Seafood	Food	12
Other fish products	Food	12
Milk	Food	12
Milk powder	Food	12
Yogurt	Food	12
Cheese	Food	12
Eggs	Food	12
Other products milk-derived	Food	12
Olive oil	Food	12
Seed oil	Food	12
Butter	Food	12
Margarine	Food	12
Animal fat	Food	12
Citrus fruits	Food	12
Banana	Food	12
Apple	Food	12
Pear	Food	12
Stone fruit	Food	12
Grape and strawberry	Food	12
Other fruit	Food	12
Dry fruit	Food	12
Canned or frozen fruit	Food	12
Fresh tomatoes	Food	12
Canned tomatoes	Food	12

Fresh legumes	Food	12
Dry legumes	Food	12
Vegetables	Food	12
Dry vegetables	Food	12
Other products	Food	12
Potatoes and French fries	Food	12
Sugar	Food	12
Jam and honey	Food	12
Ice cream	Food	12
Salt and spices	Food	12
Soups, yeast	Food	12
Coffee	Food	12
Tea, chamomile	Food	12
Wine	Food	12
Beer	Food	12
Liquor	Food	12
Mineral water	Food	12
Fruit juice	Food	12
Soda	Food	12
Tobacco	Food	12
Caregiving	Health	12
Glasses	Health	1
Prosthesis, hearing aid	Health	1
Wheelchair and leg braces	Health	1
Spa	Health	1
Medicines	Health	12
Thermometers, syringes	Health	12
Rental of health equipment	Health	12
Medical exam	Health	1
Dentist	Health	1
Health services	Health	12
Clinical tests	Health	1
Radiological tests	Health	1
Hospitalization	Health	1
Nursing home	Health	12
Emergency room	Health	1
Rent	House	12
Equivalent rent	House	12
Rent secondary house	House	12
Equivalent rent secondary house	House	12
Equivalent rent secondary house (free use)	House	12
Painting	House	3
Repair of water, sanitary and heating systems	House	3
Repair of electrical system	House	3
Repair of fixtures	House	3
Other work	House	3
External makeover	House	3
Internal makeover	House	3
Makeover of water/sanitary system	House	1
Replacement of fixtures	House	3
Heating and electrical system	House	3
Other work	House	3
Painting, secondary house	House	3
Repair of water, sanitary and heating systems, secondary house	House	3
Repair of electrical system, secondary house	House	3
Repair of fixtures, secondary house	House	3
Other work, secondary house	House	3
External makeover, secondary house	House	3
Internal makeover, secondary house	House	3
Makeover of water/sanitary system, secondary house	House	3
Replacement of fixtures, secondary house	House	3
Heating and electrical system, secondary house	House	3
Other work, secondary house	House	3
Water	House	12

Water, secondary house	House	3
Electricity	House	12
Gas	House	12
Gas cylinders	House	12
Fuel oils	House	3
Coal and wood	House	3
Heating	House	3
Condo fees	House	3
Electricity, secondary house	House	12
Gas, secondary house	House	12
Gas cylinders, secondary house	House	3
Fuel oils, secondary house	House	3
Coal and wood, secondary house	House	3
Heating, secondary house	House	3
Condo fees, secondary house	House	3
Furniture	House	1
Single furniture	House	-
Furniture for bathroom	House	1
Furniture for the outside	House	1
Carpet	House	1
Painting, mirror	House	1
Lamp, chandelier	House	1
Furniture repair	House	1
Blanket, bedsheets	House	1
Tissues repair	House	1
Electric stove	House	3
Non-electric stove	House	3
Refrigerator and freezer	House	3
Dishwasher	House	3
Washing machine	House	3
Cleaning devices	House	3
Stove and boiler	House	3
Air conditioner	House	3
Sewing machine	House	3
Blenders, toaster, iron	House	1
Other items	House	1
Large devices repair	House	1
Small devices repair	House	1
Cutlery	House	1
Glasses, plates, cups	House	1
Items for kitchen and house	House	-
Towels, plastic cups, paper plats	House	12
Equipment for house and garden	House	1
Accessories	House	12
Gardener, au pair	House	12
Paper for kitchen, aluminium box	House	12
Broom, rubber gloves, matches	House	12
Soap, bug spray	House	12
Plants	House	12
Radio, TV, Pc repair	House	1
Telephone	House	12
Telephone, secondary house	House	12
Mortgage	House	12
House insurance	Insurance	3
Secondary house insurance	Insurance	3
Health insurance	Insurance	3
Car insurance	Insurance	12
Insurance and storage of vessels, caravans	Insurance	3
Life insurance	Insurance	12
Boat, canoe, windsurf	Leisure time	3
Musical instrument	Leisure time	3
Sport and camping equipment	Leisure time	1
Bricolage	Leisure time	-
Other expenditures	Leisure time	1

Photo film	Leisure time	12
Sport: pool, gym, tennis	Leisure time	-
Passes for sporting events	Leisure time	1
Painting and dance class	Leisure time	12
Subscriptions to concerts and theatre	Leisure time	1
Lottery	Leisure time	12
Tickets for cinema, theatre, concerts	Leisure time	12
Tickets for museums, sporting events	Leisure time	12
Subscriptions to newspapers and magazines	Leisure time	-
Newspaper and magazines	Leisure time	12
Book	Leisure time	12
Bags and luggages	Leisure time	1
Cafe and bakery	Leisure time	12
Restaurant and bistro	Leisure time	12
Trip abroad, all inclusive	Leisure time	1
Full board abroad	Leisure time	1
Accommodation abroad	Leisure time	1
Trip in Italy, all inclusive	Leisure time	1
Full board in Italy	Leisure time	1
Accommodation in Italy	Leisure time	1
Menswear	Look style	12
Womenswear	Look style	12
Clothing for children	Look style	12
Underwear	Look style	12
Other clothing items	Look style	12
Fur	Look style	1
Tissue	Look style	1
Handmade clothing	Look style	1
Buttons and ball of wool	Look style	12
Clothes repair	Look style	1
Footwear for man	Look style	12
Footwear for woman	Look style	12
Footwear for children	Look style	12
Footwear repair	Look style	12
Needle, crochet	Look style	12
Laundry and dry cleaning	Look style	12
Soap, dental paste	Look style	12
Hairdresser and beauty salon	Look style	12
Devices for personal care	Look style	1
Silverware	Look style	1
Jewellery	Look style	1
Other	Look style	1
Other	Look style	1
Other items for house	Other	12
Moving expenditure	Other	3
Other	Other	12
Other	Other	12
Stationery and fax	Other	12
Phone card	Other	12
Stamp	Other	12
Fees for accountants, tax consultants	Other	3
Fees for lawyers, notaries, architects	Other	3
Religious ceremonies	Other	3
Annuities	Other	12
Loan repayment	Other	12
Other	Other	3
Cafeteria	Other	-
Pets	Pets	1
Pet food	Pets	12
Television	Technology	3
Video recorder	Technology	3
Radio, microphones, headphones	Technology	1
Stereo	Technology	3
Personal computer, printer	Technology	3

Camera, video camera	Technology	1
Calculator, typewriter, pc accessories	Technology	1
CDs and videotapes	Technology	12
Telephone	Technology	3
Mobile phone	Technology	3
Voice mail	Technology	3
Fax	Technology	3
Telephone repair	Technology	1
Radio, pay-TV, internet subscription	Technology	12
New car	Transportation	3
Second-hand car	Transportation	3
New motorbike	Transportation	3
Second-hand motorbike	Transportation	3
New scooter	Transportation	3
Second-hand scooter	Transportation	1
New camper	Transportation	3
Second-hand camper	Transportation	3
New bike	Transportation	3
Second-hand bike	Transportation	3
Spare parts	Transportation	1
Oil	Transportation	1
Maintenance and repair	Transportation	1
Private garage	Transportation	12
Driving lessons	Transportation	3
Gasoline	Transportation	12
Diesel	Transportation	12
Parking	Transportation	12
Tickets and passes for buses	Transportation	-
Tickets and passes for trains	Transportation	-
Flight tickets	Transportation	1
Tickets and passes for ferries	Transportation	-
Tickets and passes for bus, subway, tram	Transportation	-
Taxi	Transportation	12

Table A.1: Expenditure categories, macro-category in which the expenditure categories have been grouped, and temporal coefficient for calculating the annual expense on each expenditure category.

- **Gini coefficient. First and second classification of family types.**

The average of Gini coefficient has been calculated for the expenses greater than 0 of all the family types in which households have been classified (tab. 3.1 and 3.2, Chapter 3). It confirms the trends highlighted by Theil index (fig. 3.2, Chapter 3), with a slightly difference for households' categories from 7 to 9. We observe an overall increase of the mean values and a sudden decrease in 2013, indicating a more equal distribution of the expenses for all the family types.

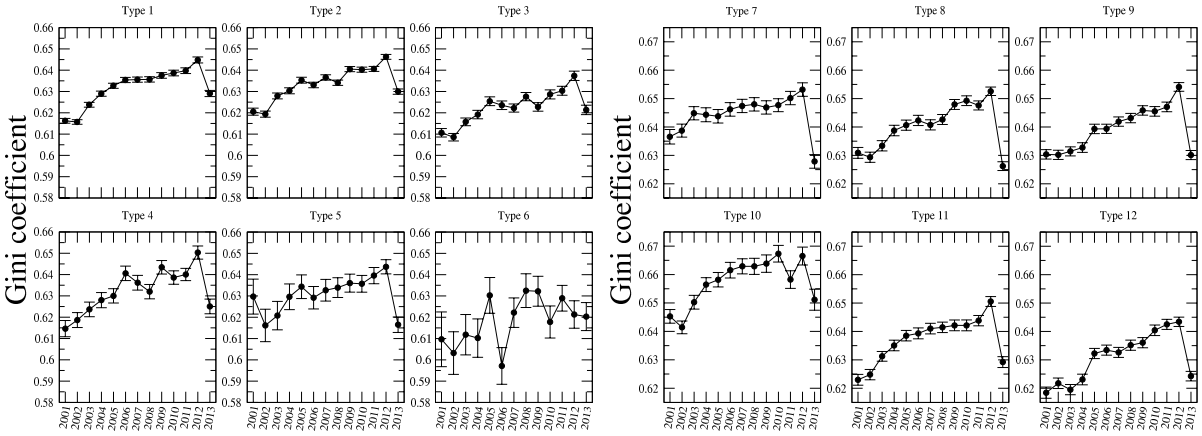


Fig. A.1: Mean values of Gini coefficient for each family type over time. First classification. Coefficient calculated on all the expenditure categories greater than 0. Error bars indicate the standard error of the mean.

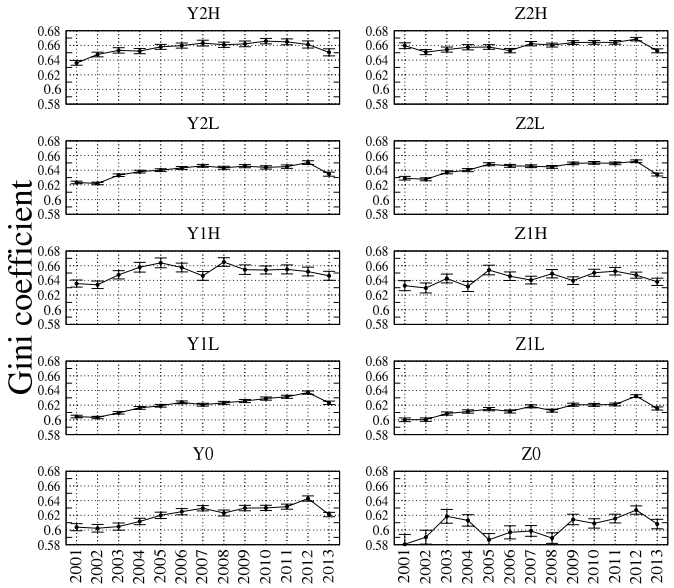


Fig. A.2: Mean values of Gini coefficient for each family type over time. Second classification. Coefficient calculated on all the expenditure categories greater than 0. Error bars indicate the standard error of the mean.

- **Theil index and Gini coefficient for 5 macro-categories of expenditure. First classification of family types.**

Expenditures have been grouped in 5 macro-categories, namely “House”, “Food”, “Transportation”, “Look Style” and “Leisure time”. Both the Theil index and the Gini coefficient have been calculated for each family types. The trend of Theil index for the expenditures related to the house (fig. A.3 a-b) is in general more stable for families with children than for families without children. The index concerning the expenditure-category “Food” (fig. A.4 a-b) seems quite stable over time. Nevertheless, the concentration of expenses on food products increases in 2010, decreases in 2011 and increases again in 2012. Such a trend is more evident for some categories of households, as singles (despite the age) and young couples without offspring (from family type 7 to 10). In contrast to the overall stability of the concentration index related to expenditures for house and food, the trends of Theil index performed on macro-categories “Transportation”, “Leisure” and “Look Style” seem more unstable and decreasing over time (fig. A.4 a-b). The instability can be due to the fact that the items related to the macro-categories of leisure and look style are secondary goods that concern temporary needs or desires (such as the purchase of a fashionable but very expensive bag, a holidays abroad, the car purchase etc.). The categories of look style and leisure activities seem more stable for households with offspring compared to families without children. It can be due to the fact that within households with children multiple desires and different needs coexist, leading to a continuous negotiation process among family members that results in a more democratic distribution of the total expenditure. Also in these cases, the Gini coefficient confirms the trends highlighted by the Theil index (figures A.3 c-d and A.4 c-d), although the trends of the coefficient related to transportation are higher than the Theil index ones.

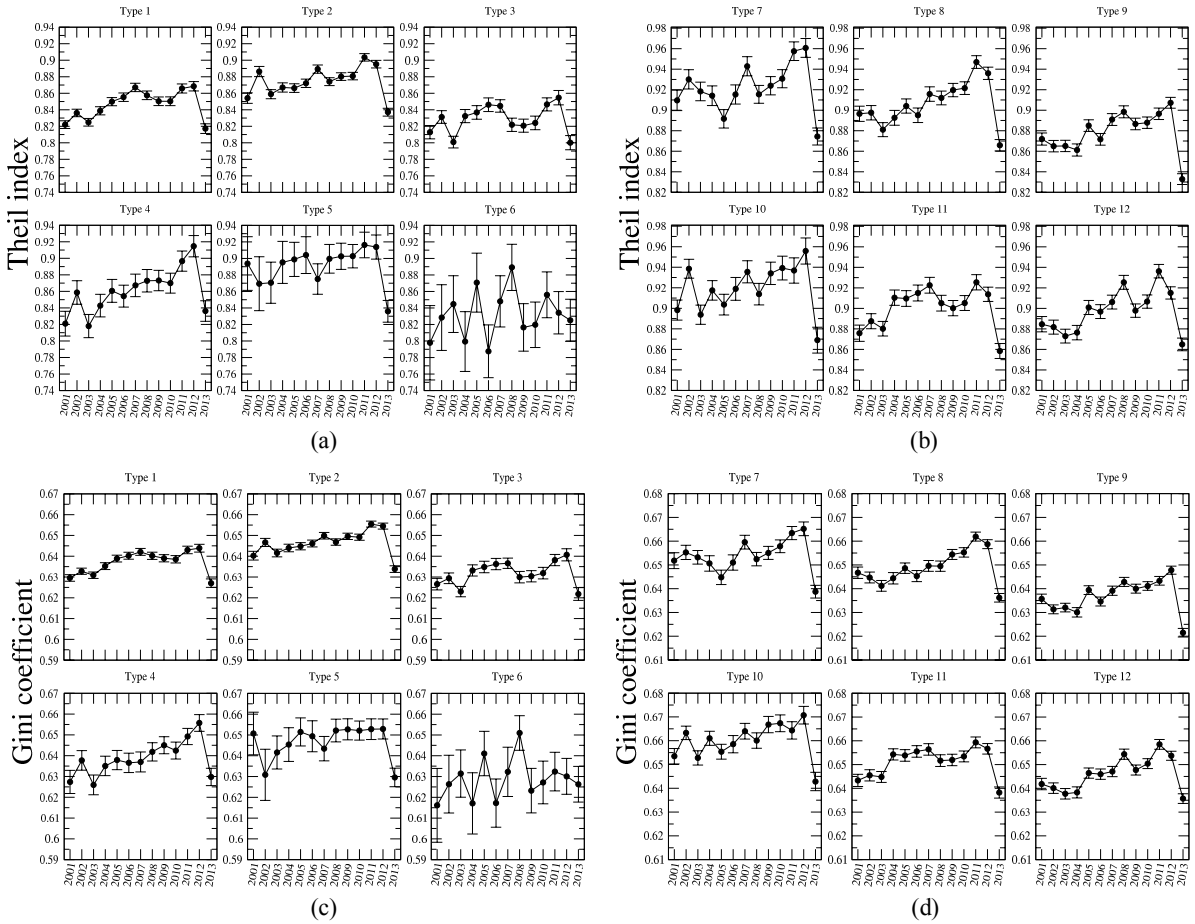


Fig. A.3: Mean values of Theil index (a-b) and Gini coefficient (c-d) calculated for macro-category “House”, for each family type over time. First classification. Error bars indicate the standard error of the mean.

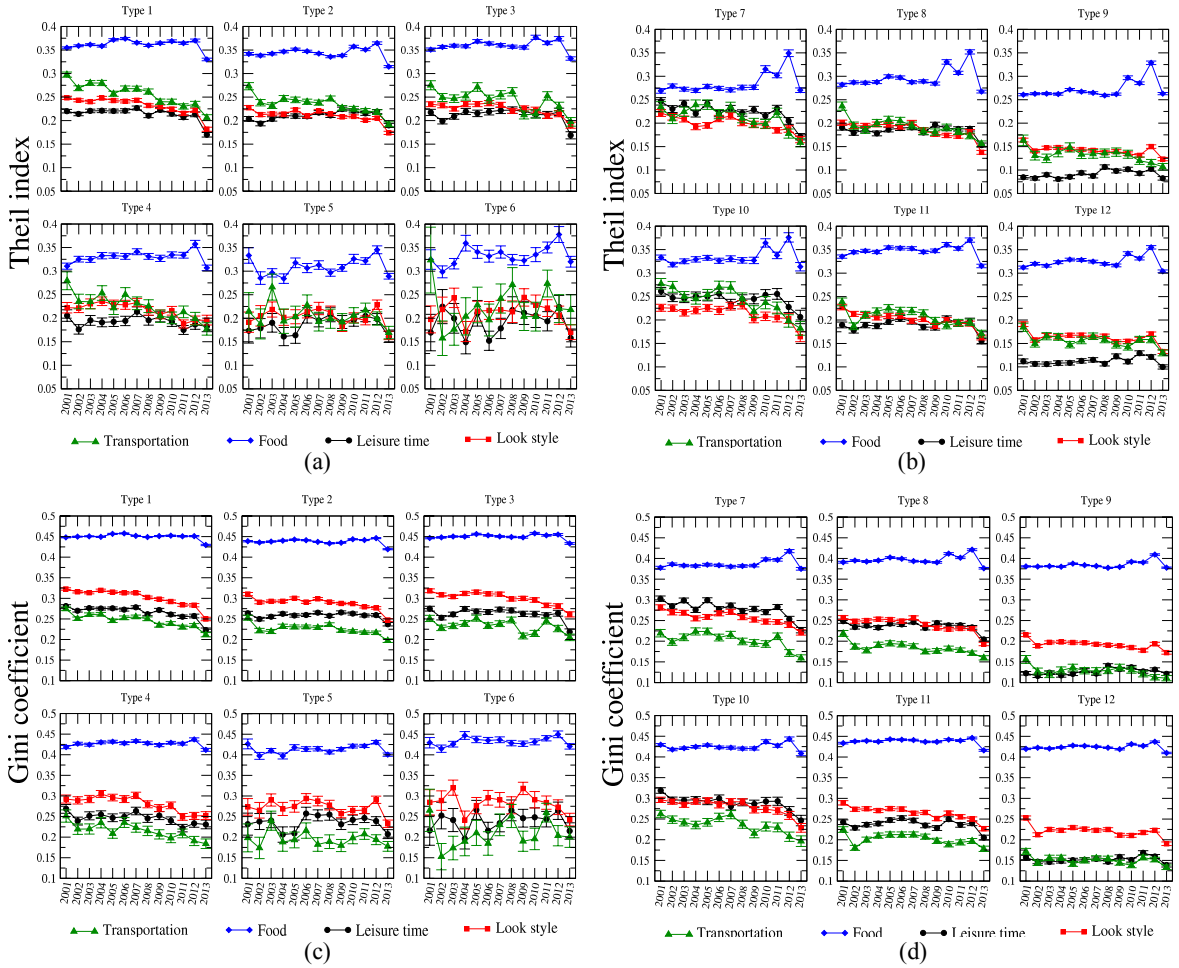


Fig. A.4: Mean values of Theil index (a-b) and Gini coefficient (c-d) calculated for macro-categories "Food", "Leisure time", "Look Style" and "Transportation", for each family type over time. First classification. Error bars indicate the standard error of the mean.

- **Theil index and Gini coefficient for 5 macro-categories of expenditure. Second classification of family types.**

Also for this classification of households–focused on couples with Y- or Z-generation offspring, stratified according to educational level and number of working parents–house reveals the highest mean values of Theil and Gini concentration indices (fig. A.5 and A.6, respectively), which are quite stable for all family types. Concerning the concentration of expenditure on macro-category house, there is no apparent difference between families with Y- and Z-generation children, probably due to the fact that such a macro-category contains ordinary expenditures related to primary needs (as loan, utilities, furniture etc.). Along the same line, the stability of trends detected for expenditure on food products can be interpreted. However, such macro-category shows lower values of indices than the macro-category "House", which includes durable (and expensive) goods. The other macro-categories, namely "Transportation", "Leisure time" and "Look style", show low and decreasing trends, especially for the expenditures related to transport for family types in which only one parent works and the overall educational level is low (Y1L and Z1L).

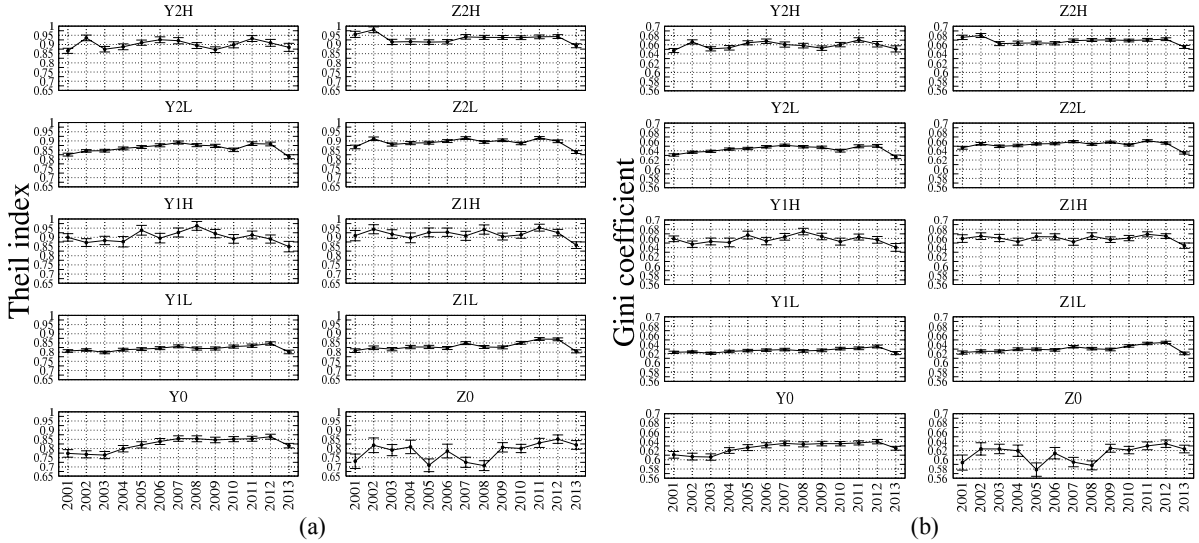


Fig. A.5: Mean values of Theil index (a) and Gini coefficient (b) calculated for macro-category "House", for each family type over time. Second classification. Error bars indicate the standard error of the mean.

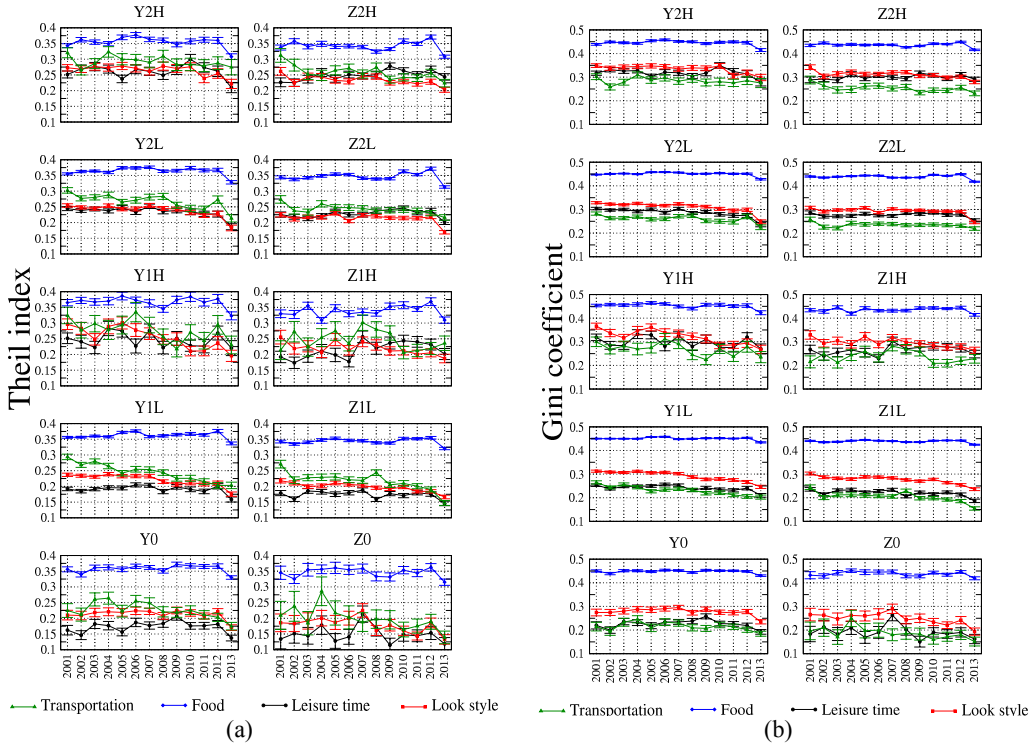
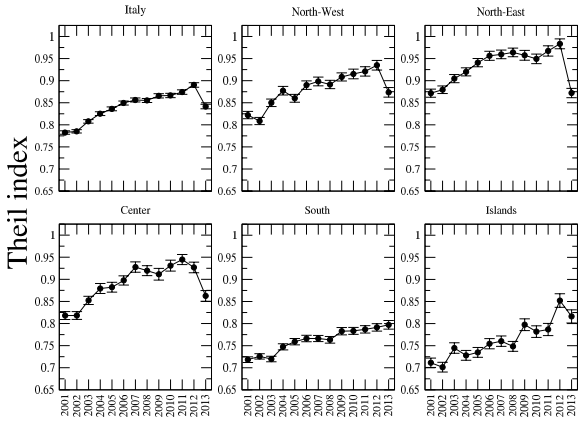


Fig. A.4: Mean values of Theil index (a) and Gini coefficient (c) calculated for macro-categories “Food”, “Leisure time”, “Look Style” and “Transportation”, for each family type over time. Second classification. Error bars indicate the standard error of the mean.

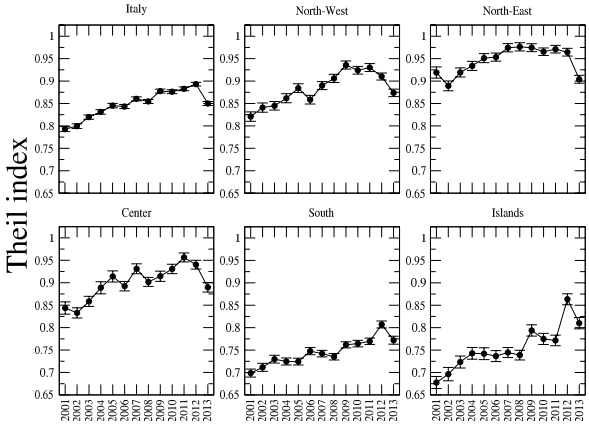
- **Theil index and Gini coefficient in 5 macro-regions. First classification of family types.**

The concentration of expenditures stratified with respect to the five macro-areas shows very different patterns according to macro-area in which the households have been sampled. Households living in the North-East regions reveal the highest values of both Theil index and Gini coefficient (fig. A.5 and A.6, respectively), such values are more pronounced for families without children (family types from 7 to 12). The lower values are observed in Southern regions and the Islands, and trends in the Islands are more unstable, especially for couples (categories 10 and 11) and young singles living alone (category 7). Finally, couples with children (family types from 1 to 3) reveal very similar trends among them according to the macro-area in which they live.

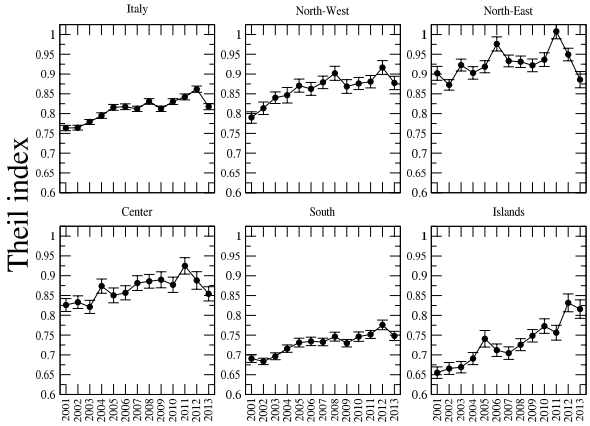
Family type 1: Couple with Y-generation children



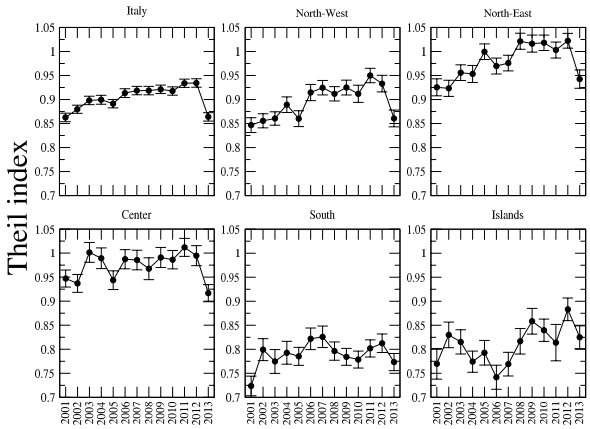
Family type 2: Couple with Z-generation children



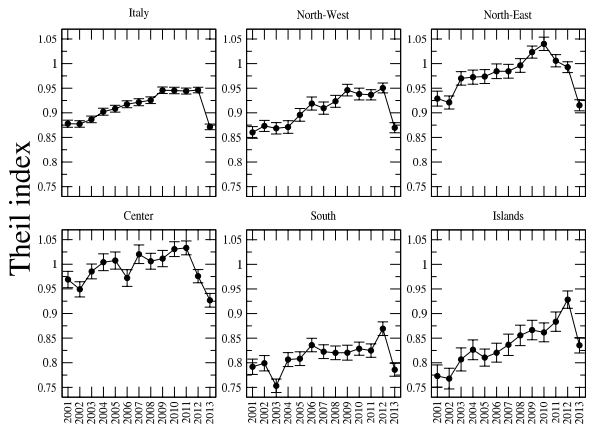
Family type 3: Couple with Y- and Z-generation children



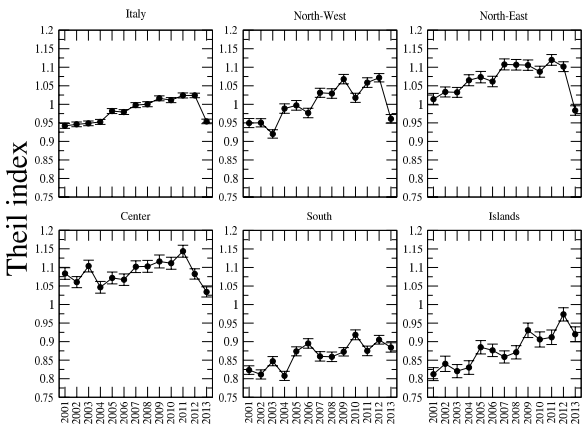
Family type 7: single age 18-39



Family type 8: single age 40-65



Family type 9: single age over 65



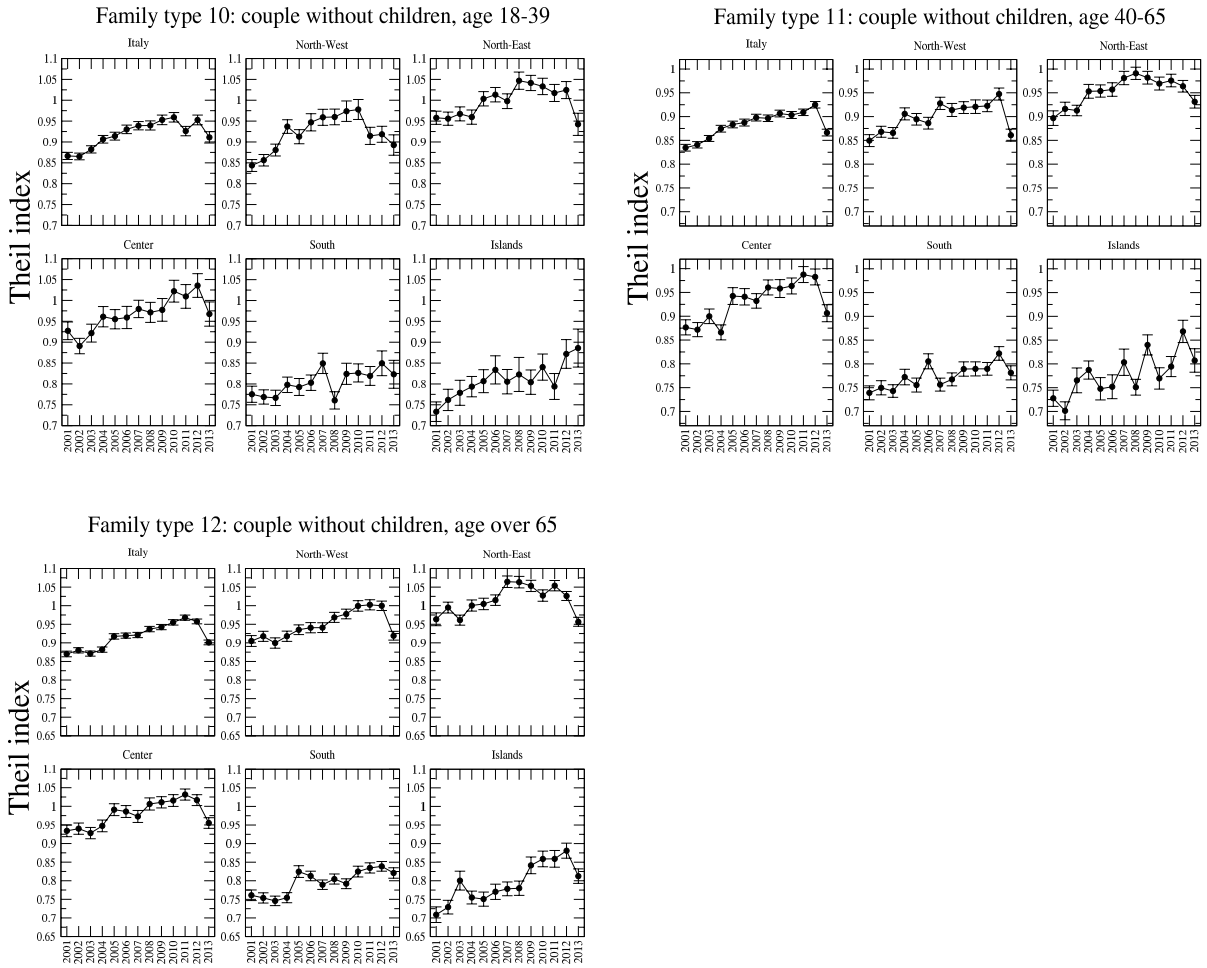
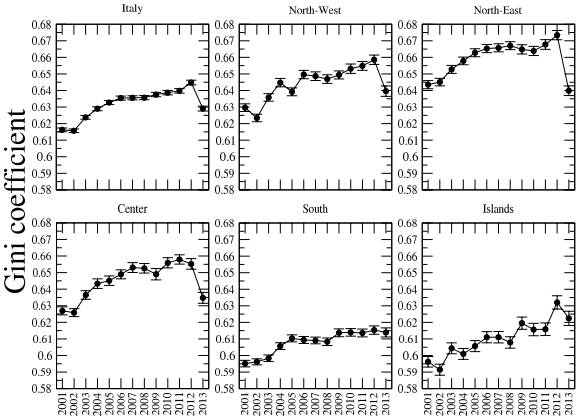
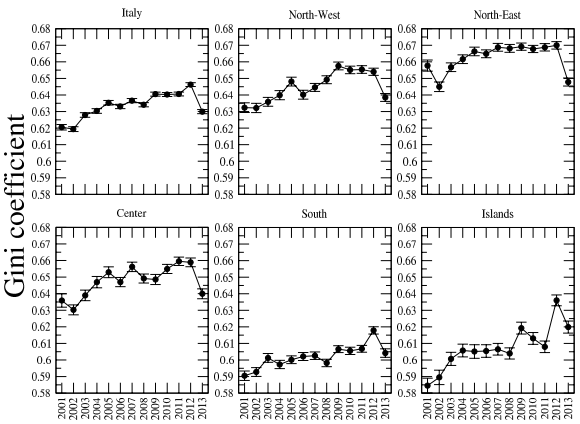


Fig. A.5: Mean values of Theil index calculated across macro-areas, for each family type (excluded categories 4-5-6) over time. First classification. Error bars indicate the standard error of the mean.

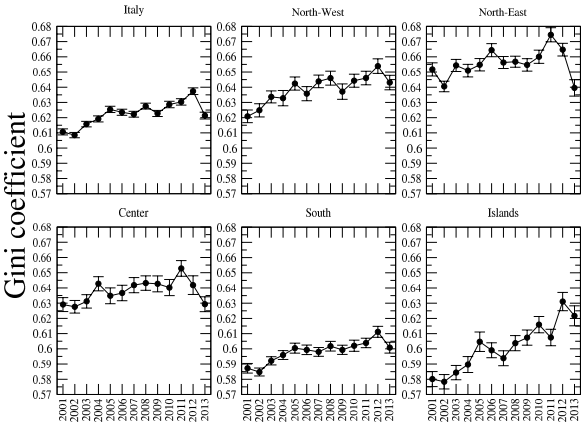
Family type 1: Couple with Y-generation children



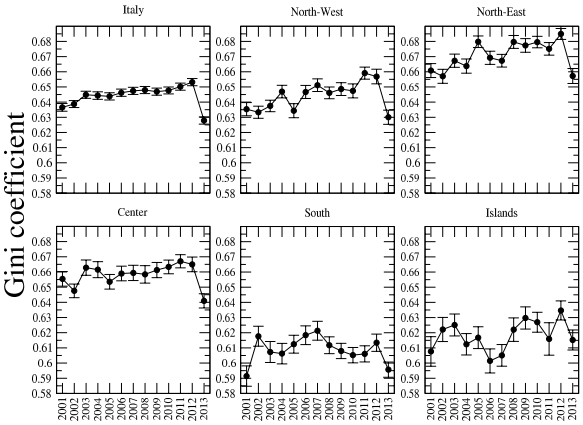
Family type 2: Couple with Z-generation children



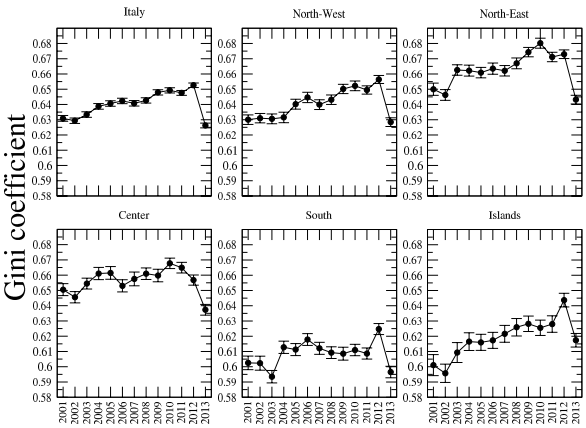
Family type 3: Couple with Y- and Z-generation children



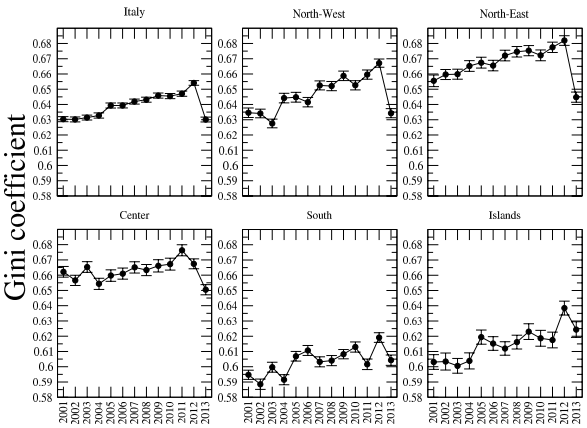
Family type 7: single age 18-39



Family type 8: single age 40-65



Family type 9: single age over 65



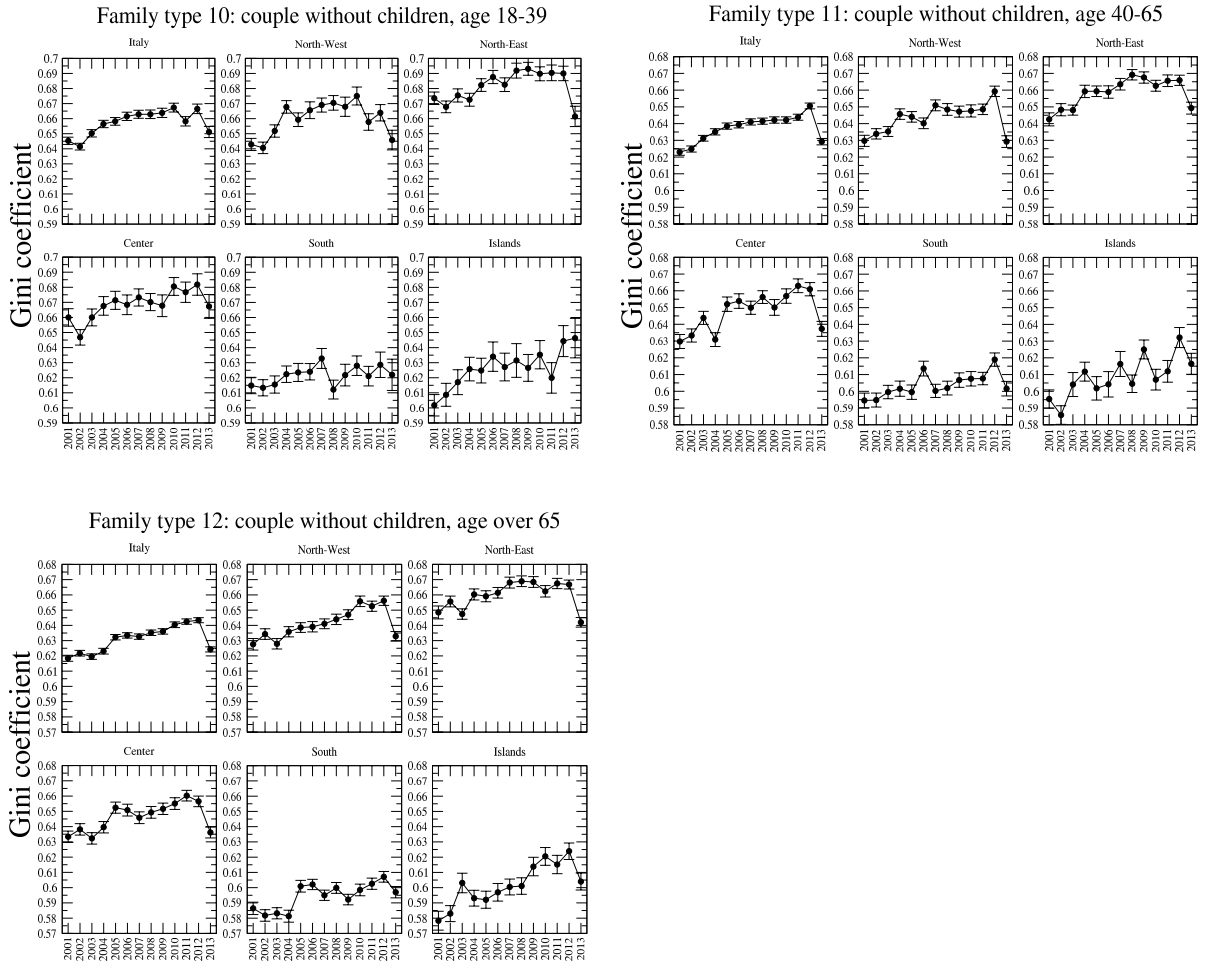


Fig. A.6: Mean values of Gini coefficient calculated across macro-areas, for each family type (excluded categories 4-5-6) over time. First classification. Error bars indicate the standard error of the mean.

- **Macro-array plot of over-expressed expenditures in Bonferroni network. First classification of family types. Data not stratified.**

Micro-array plot summarizes, at once, the over-expressed expenditure categories in the SVNs (Bonferroni correction) for each family type and for each year of the survey. The difference with respect to the micro-array plot presented in chapter 3 (fig. 3.7) relies upon the fact that, in this case, the raw data have been pre-processed by calculating the quota of expense that every household allocates for a specific product, with respect to the *total amount of expense*[1](step 2a). We detect the dichotomy among families with and without children in expenditure patterns already highlighted in fig. 3.7. Nevertheless, some quintiles of expenditures differ, being higher in fig. A.7 than in fig. 3.7 (see, for example, macro-categories "Insurance" and "Leisure"), and some categories of expenditures are over-expressed only in A.7 (see, for example, expenditures on leisure time of family type 8, composed by couples aged 40-65, and expenditure on housing of family type 9, composed by couples over 65).

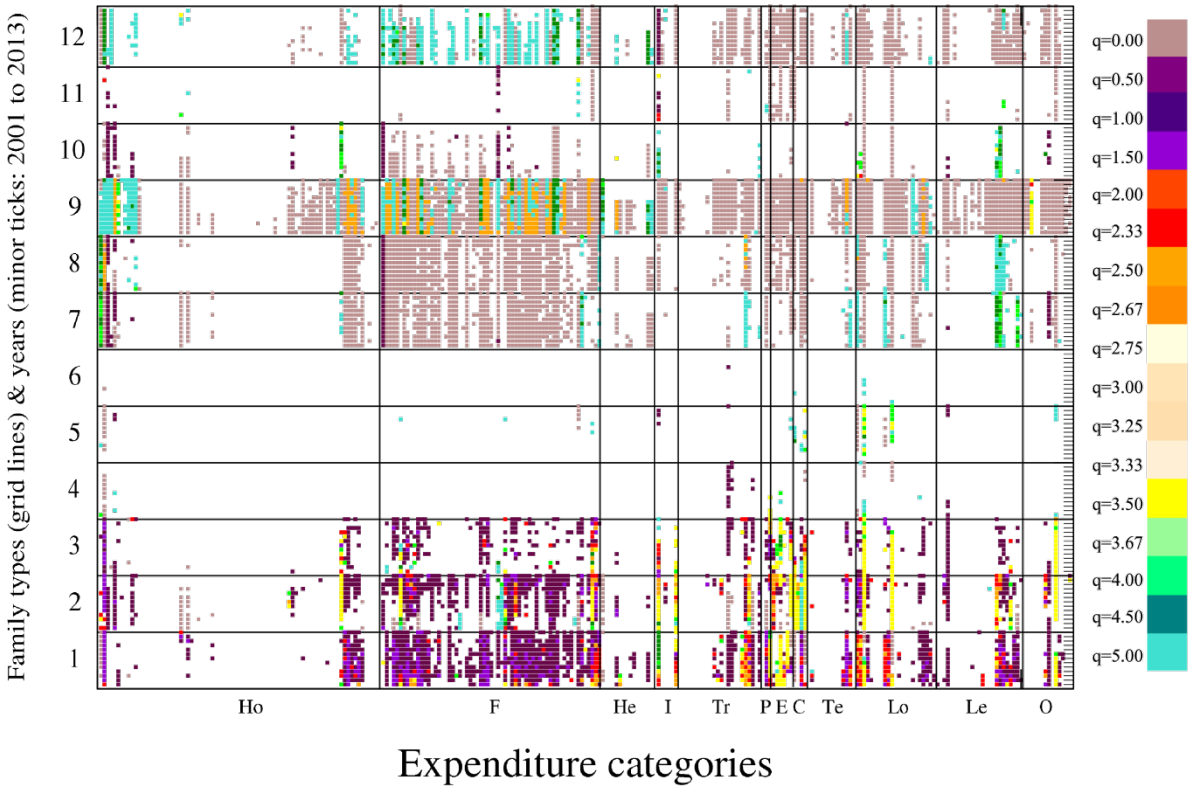


Fig. A.7: Micro-array plot SVNs. First classification of families. Bonferroni correction. Data not stratified within macro-categories.

[1] The resulting quotas have been then independently categorized, according to the quintiles of each expenditure category.

- **Macro-array plot of over-expressed expenditures in FDR network. First classification of family types. Data not stratified.**

Fig. A.8 summarizes the results of SVNs (FDR correction) constructed starting from quotas that have been calculated with respect to the total expenditure of households (as in fig. A.7). Since the p-values corrected with Bonferroni threshold are included in the FDR procedure, the Bonferroni network is properly contained in the FDR network. Fig. A.8 presents then more over-expressed expenditure categories with respect to fig. A.7. Macro-category of food clearly displays the dichotomy among the variegated expenditure patterns of families with children (family types from 1 to 3), and the purchasing behaviour of elderly people of family types 9 and 12 (single and couples over 65), that spend for specific products the greater part of their income (together with the expenditures on housing). Single parents with children (family types from 5 to 6), whose expenses are poorly detected through the Bonferroni correction, reveal purchasing choices oriented to housing (some of them persisting over time), some food products, education and children care (more prominent for households with Y-generation children and families with Z-generation children, respectively), and look style, probably concerning children clothing and footwear. Young and adult single (family types 7 and 8) and young couples (family type 10) reveal expenditure profiles mostly focused on leisure time activities, for which they spend significant amount of their total income (high quintiles).

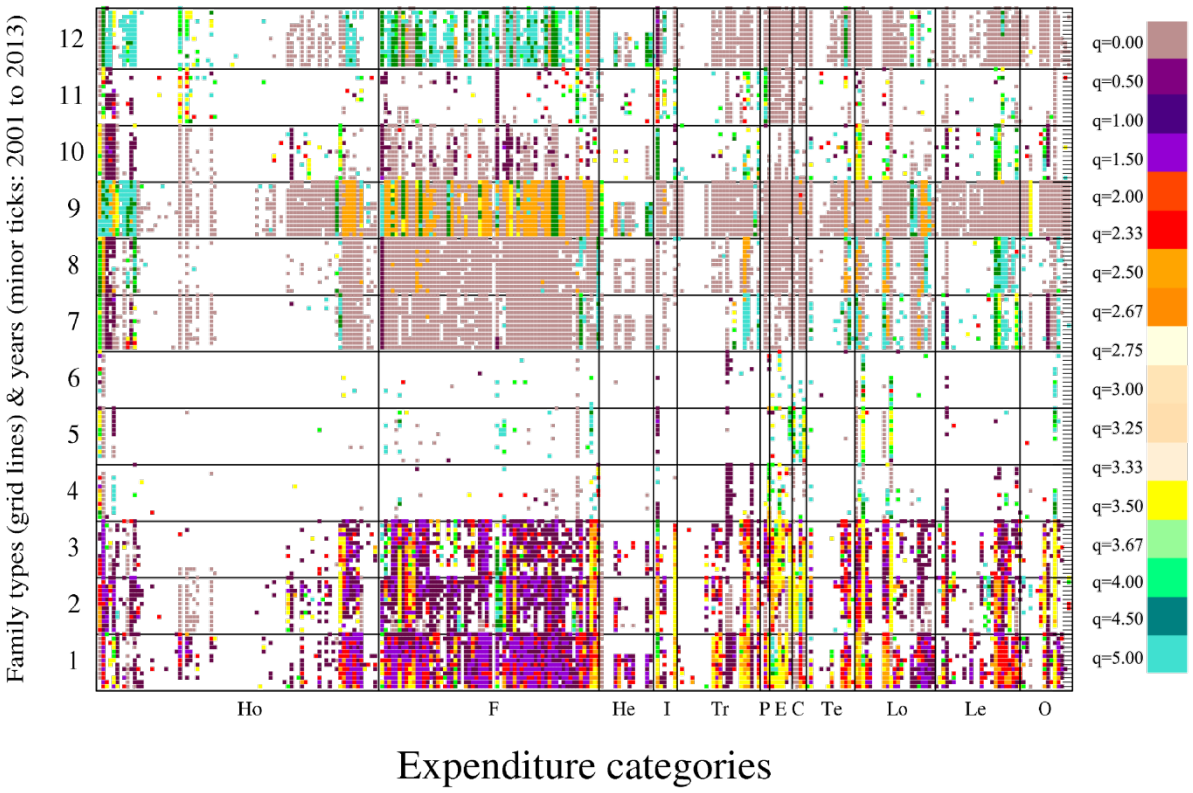


Fig. A.8: Micro-array plot SVNs. First classification of families. FDR correction. Data not stratified within macro-categories.

- **Macro-array plot of over-expressed expenditures in FDR network. First classification of family types. Data stratified.**

Figure A.9 represents the FDR version of SVNs summarized in fig. 3.7 (Chapter 3) that have been constructed applying the Bonferroni correction. For both the versions, raw data have been pre-processed by calculating the quotas of expenditure within each macro-category (step 2b). Households with children (categories 1-2-3) reveal over-expressed expenditures for a wide range of products related to house. Moreover, for these family types, expenses concerning health are over-expressed with high quintiles, and those concerning insurance are persistent over time with high and low quintiles. The FDR networks confirms the dichotomy of expenditure profiles among families with and without children.

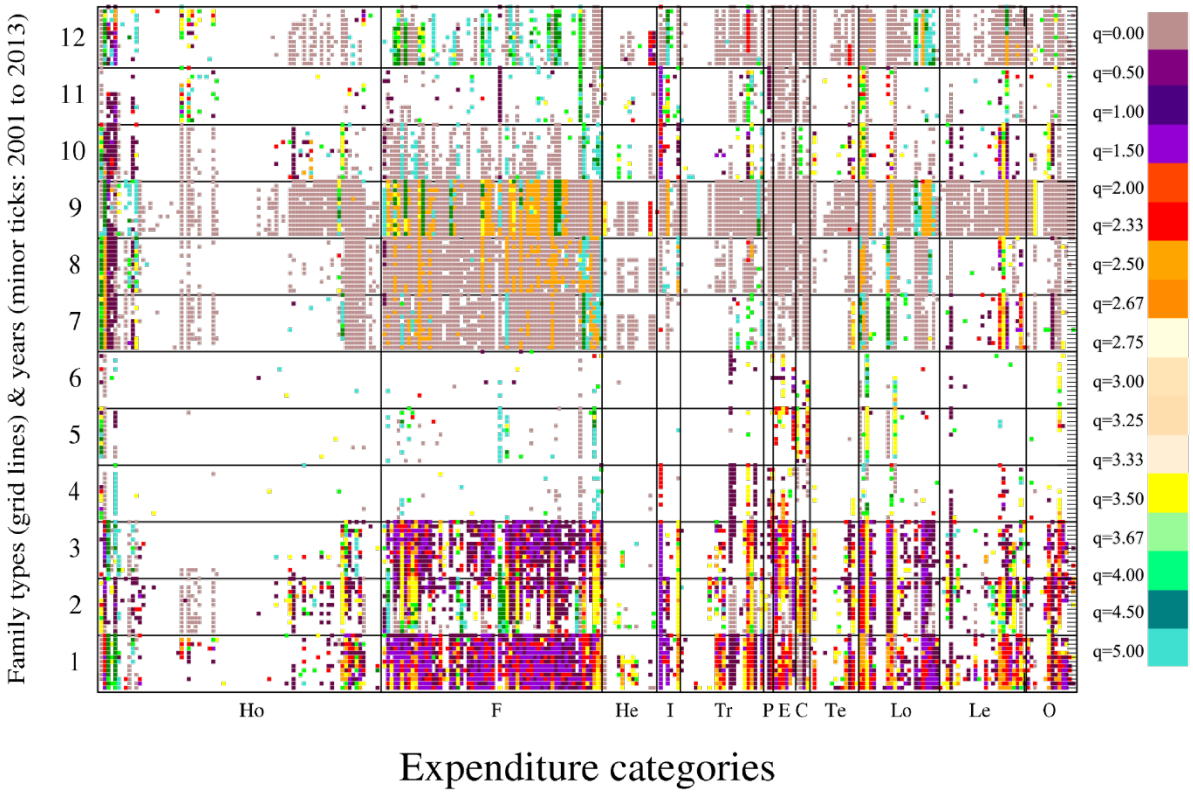


Fig. A.9: Micro-array plot SVNs. First classification of families. FDR correction. Data stratified within macro-categories.

- **Macro-array plot of over-expressed expenditures in FDR network. Second classification of family types. Data not stratified.**

With respect to fig. 3.10 presented in Chapter 3, the micro-array plot in fig. A.10 summarizes the output of SVNs with FDR correction that have been constructed starting from raw data not stratified within the macro-categories (step 2a). In this case, we observe that the expenditures for food products are over-expressed for families with one working parent and low educational level, and for families in which parents do not work (despite the generation of children). The expenditures on food of households Y1L and Z1L are probably influenced by the presence of the housewife, while, concerning Y0 and Z0, such expenses are probably more prominent since they regard the primary needs, that low-income households have to satisfy. In this regard, we observe that, together with food products, the other expenditure categories over-expressed for families in which parents do not work are related to house (probably utilities and loan). Look style category is more prominent for families with Z-generation children compared to families with Y-generation children, especially if both parents work: such an evidence can rely upon the fact that expenditures related to look style of households with Y-generation offspring are more heterogeneous and, then, less characteristic.

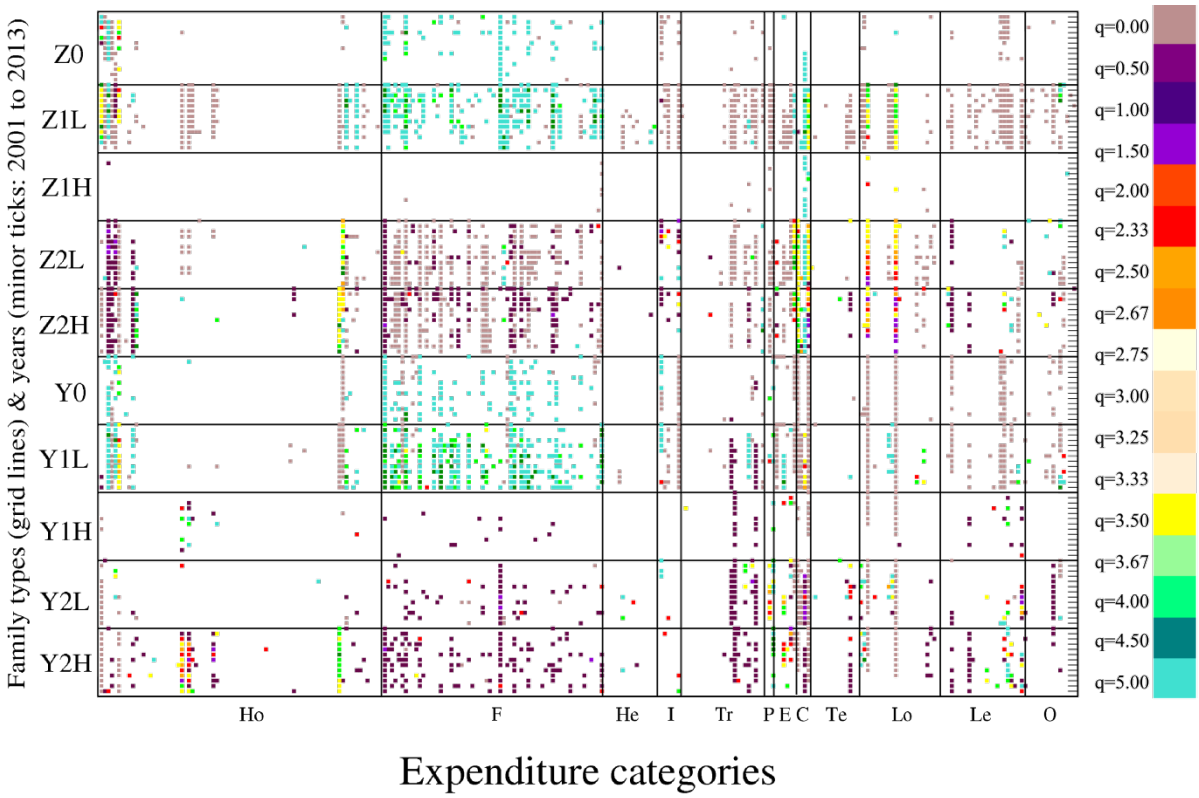


Fig. A.10: Micro-array plot SVNs. Second classification of families. FDR correction. Data not stratified within macro-categories.