Toward an Understanding of “Weak Signals” of Technological Change and Innovation in the Internet Industry

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Identifying the emergence and development of new technologies has become an essential ability for firms competing in dynamic environments. Nonetheless, current technology intelligence practices are unstructured and vaguely defined. Moreover, the existing literature in future technology studies lacks strong, systematic explanations of what technologies are, where technologies come from, and how new technologies emerge and evolve. The present study builds on Structuration Theory, and proposes the structurational model of emerging technologies (SMET). The SMET suggests not only an ongoing view of technologies as social objects, but also a process for thinking through scientifically the complex, multidimensional and emergent dynamic of social and technological change. The SMET proposes that the emergence and development of a new technology can be tracked by examining systematically and collectively the extent of development of its technology-related social structure – its degree of structuration. The degree of structuration of a technology is an ongoing process instantiated in social practices, and can be observed through visible patterns or specific social outcomes of systemic activity organized in three analytical dimensions: structures of meaning, power, and legitimacy. The SMET assumes that the conceptual initiation of a new technology triggers new patterns of social activity or a signal of technological change; thus, the variation in the slope or trajectory of the degree of structuration of a technology may indicate an early signal of technological change. The SMET sets a foundation for identifying early signals of technological change when it is used on a systematic basis.

Empirically, the study conducted an exploratory case study in the Internet industry. The study employed a sequential transformative mixed method procedure, and relied on 77 Internet experts to create retrospectively a systematic and collective interpretation of the Internet industry in the last ten (10) years. The test of hypotheses was based on only seven (7) Internet technologies due to time and instrumental constraints. The results confirm the fundamental relationships among constructs in the model, and support, thus, the SMET. The degree of structuration of a technology is revealed as a process independent of individuals' participation in the enactment of a technology. Technological outcomes are explained by the extent of development of structures of meaning, power, and legitimacy (i.e., the degree of structuration of a technology). Moreover, influential technological outcomes shape individuals' perspectives over time – i.e., the structurational effect. Hence, the study not only provides evidence that supports this novel theoretical framework, but also illustrates methodologically how to identify the emergence and development of new technologies. Likewise, the study discusses the implications of these results for technology management practices (e.g., product and technology development, innovation policies, and technology transfer activities). Lastly, the study recognizes limitations and suggests further research avenues.

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Dedication

For my extraordinary wife, Lulu, and my beloved sons, Julio Mauricio and Diego. No one has given me more love and support than you on this journey. For my admired parents, Julio and Bertha. For my dear brothers, Ricardo and Alejandro.

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Chapter 1. Introduction

Technology has been widely recognized as a major competitive factor in organizations (Mintzberg, 1979; Porter M., 1998; Prahalad & Hamel, 1990; Chesbrough, 2003). Mintzberg (1979) distinguishes the term “technical system” from “technology,” stating clearly that technical systems and operators define the operating core of organizations. Porter (1998) indicates that the effective deployment of technological resources contributes to the achievement of sustainable advantage. Prahalad and Hamel (1990) assert that the abilities to integrate multiple streams of technology and to coordinate production skills are the most powerful ways to prevail in global competition. Chesbrough (2003) contends that technologies are sources to advance technological innovations and organizational profitability. Over the last three decades, a new sub-discipline, management of technology, has emerged to deal with the rise of technology as an important dimension of strategic management (Pilkington & Teichert, 2006; Technovation, 2009; Betz, 2003; Gaynor, 1996; Van Wyk, 1988; Friar & Horwitch, 1985).

In practice, each day new technologies emerge that change individual companies and sometimes entire industries (Baldwin & Clark, 2000; Suarez & Utterback, 1995; Abernathy & Clark, 1985). For one company in a competitive environment, a new technology may represent a remarkable opportunity to lead the market, but for another, it may signal a serious threat of being displaced from competition (Tushman & Anderson, 1986; Christensen, Anthony, & Roth, 2004). Entire industries can be created by a new technology, but they can also disappear as a result of its effects (Day & Schoemaker, 2000; Dierkes, Lutz, & Teele, 2001). For this reason, a firm’s ability to identify early the emergence and development of new technologies has evolved as an essential competency (Day & Schoemaker, 2006; Ashton & Klavans, 1997).

Various methods of analyzing future technologies have been proposed (e.g., forecasting, foresight, technology intelligence, and environmental scanning) (Martino, 2003; Cuhls, 2003; TFAMWG, 2004). However, the conceptual development in future technologies studies remains weak, and the ability to study scientifically the impact of new technologies on business and technological environments is embryonic (TFAMWG, 2004; Miles, Cassingena Harper, Georhgiou, Keena, & Popper, 2008). In practice, existing methods for early identification of new technologies are unsystematic and too broadly defined (Ashton & Stacey, 1995; Reger, 2001). Similarly, current theories of technological evolution are abstract and loosely organized (Devezas, 2005; Bowonder, Muralidharan, & Miyake, 1999; Arthur, 2009). Thus, in the absence of strong systematic explanations of what technologies are, where technologies come from, how technologies evolve and how new technologies emerge, current approaches and theories for future technologies cannot provide a solution to frame the study of identifying early signals of technological change[1].

To address this problem, this study proposes an open framework[2] (Porter M. , 1991; Geels, 2010) and a pragmatic approach[3] (Creswell, 2009) that builds on Structuration Theory (ST) (Giddens, 1984). ST is a process theory that offers a solution to reconcile competitive perspectives about the nature of social reality[4] and illustrates how social organizations and institutions are created, altered and reproduced (Poole, Van de Ven, Dooley, & Holmes, 2000; Barley & Tolbert, 1997). Accordingly, technologies are conceptualized as an ongoing and multidimensional phenomenon (Orlikowski, 2000; 1992). Although technologies may have physical or “material” existence in nature, technologies are subjects of scientific study and development only through the analysis of their social form (i.e., in terms of ST, the social structure lying within individuals’ heads or the social structure instantiated in social practices). Viewing through this theoretical lens, the study proposes the structurational model of emerging technologies (SMET), which aims to capture only

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[1] *Technological change* refers to the process by which a new technology alters the way individuals and organizations fulfill their societal activities, needs, or functions (Geels, 2002).
[2] An *open framework* brings together different theories and perspectives (Porter M., 1991; Geels, 2010).
[3] *Pragmatist research* uses all research resources available to solve the research problem without any particular commitment to one philosophical system or reality (Creswell, 2009).
[4] *Objective* and *subjective* are two long-standing positions about the nature of social reality.

analytically a simpler representation of the complex process of emergence and development of new technologies. Patterns of social activity enacting technologies are proposed as the unit of analysis for studying social and technological change. From this view, new patterns of social activity or a variation in the extent of development of existing social patterns can signal an early indication of social and technological change. Consequently, by examining the extent of development of specific technology-related social processes or patterns, the study explores the explanatory power of the proposed framework and tests several propositions in a case study of the Internet industry.

In sum, since keeping abreast of technology can lead organizations to survive or die, the overall purpose of this study is to develop a robust way to comprehend how new technologies can be identified and tracked in their business and technological environments. The study proposes how to model scientifically the complex and emergent dynamics of social and technological change, and how to think methodologically through the problem of identifying signals of technological evolution. The study is explorative in nature because it investigates a proposed framework for the identification of early signals of technological change when it is used on a systematic basis.

The dissertation is organized as follows. Chapter 2 presents the literature review of approaches and prior contributions relevant to this research. Chapter 3 introduces the theoretical framework and the hypothesized model of emerging technologies. Chapter 4 describes the research design, strategies and methods used to explore our theoretical propositions. Chapter 5 discusses the statistical analysis and presents the empirical results of the study. Chapter 6 examines the high-level outcomes and interprets the results in light of the hypothesized model. As well, limitations are presented in this chapter. Finally, Chapter 8 synthesizes contributions and further research is proposed.

Chapter 2. Literature Review

This chapter organizes the literature review into five sections. The first section clarifies claims of three main streams of future technologies studies. The second section reviews two related terms in the future technologies literature. The third section explores the conceptualization of technologies and technological innovations. The fourth section discusses studies and theories of technological change and evolution. The last section presents some remarks on the literature review.

2.1. The Field of Future Technologies Studies

Attempting to predict the future or future trends is an ancient practice (Prehoda, 1967, p. 11; Cuhls, 2003) (e.g., prophets and Greek oracles). Nevertheless, the systemic analysis of future technologies started mainly after the Second World War when technology clearly emerged as not only a resource to provide dominance in war time, but also a solution to improve social and economic conditions (Cuhls, 2003; Coates, et al., 2001; Jones & Twiss, 1978). This section analyzes three forms of future technologies studies in the extant body of literature: technological forecasting, technology foresight, and technology intelligence (TFAMWG, 2004; Rohrbeck, 2007).

2.1.1. Technology Forecasting (TF)

Generalities of TF Methods

Forecasting methods are commonly classified as one of two methodological approaches, *quantitative* or *qualitative*. Qualitative methods depend on judgments and accumulated knowledge of individuals; quantitative methods rely on numerical historical data for their use and assume a certain rate of technological progress into the future (Coates, et al., 2001; Bengisu & Nekhili, 2006; Makridakis, Wheelwright, & Hyndman, 1998; Wheelwright & Makridakis, 1980). Additionally, forecasting methods are often described as *exploratory* or *normative*. Exploratory forecasting predicts technological achievements based on the application of scientific and technical knowledge, whereas normative forecasting is concerned with the assessment of goals, opportunities, threats, and impacts of technological developments (Coates, et al., 2001; Porter, Roper, Mason, Rossini, & Banks, 1991; Cetron, 1969).

From 1958 – 1975: The Emergence of TF and its Aim to Predict Technical Achievements

The first formal publication of technological forecasting was made by Lenz in 1958 – his master's thesis (Bright, 1972, pp. 2-3), and similar to subsequent publications between 1960 and 1975, the meaning of technological forecasting refers to the prediction of technical dimensions of a particular technology. Table 2-1 presents some definitions. Although the first forecasting methods were intuitive and not prepared for research or planning activities (Lenz, 1969), the first textbooks on TF not only describe forecasting methods but also explain their usefulness for planning and decision making in both the context of government and industry – e.g., Bright (1968); Bright and Shoeman (1973); Wills, Ashton and Taylor (1969); Martino (1972).

Technological Forecasting Definitions
Technological forecasting aims to predict explicitly and quantitatively the invention of a useful machine, its characteristics, and performance (Martino, 1972).
"The description or prediction of a foreseeable invention, specific scientific refinement, or likely scientific discovery that promises to serve some useful function." (Prehoda, 1967, p.12)
Technological forecasting refers to confident predictions of technical achievements in a specific period of time and based on evidence (Cetron, 1969).
"Technology forecasting is defined as a quantified prediction of the timing and of the character of the degree of change of technical parameters and attributes associated with the design, production, and use of devices, materials, and processes, according to a specified system of reasoning." (Bright, 1972, p. 3-1)
A technological forecast aims to estimate the future characteristics of machines, procedures or techniques (Martino, 1972).
Technological forecasting is the process by which a set of inputs (data, insights and assumptions) concerning to specific future technological innovations are translated into a quantified and probabilistic technology estimation in terms of time and performance (Jones & Twiss, 1978).

Table 2-1 Technological forecasting definitions between 1958 and 1975

From 1975 – 1990: Failure and Limitations of TF

Brooks (1971) states that TF has failed to anticipate more complex relations between streams of scientific and technological development because it has assumed that technologies flourish independently of social and political factors. Societal resources and government policies lead also to the development and acquisition of new technologies (Brooks, 1971). According to Cuhls (2003) and Coates, et al. (2001), after the unpredicted oil shock in 1973, forecasting and futures research became a suspicious and neglected approach by planners and politicians. Coates, et al. (2001) argue that as a result of limitations in the systems analysis approach, which is the basis of TF, this field was practically reduced to a set of methods extrapolating technological trends. Hence, very few useful developments took place between 1975 and 1990. However, complementary forms of TF emerged – e.g., foresight, road-mapping, and technology intelligence (Cuhls, 2003; Coates, et al., 2001).

After 1990: A Change in the Scope of Technology Forecasting

After 1990, the scope of TF changed from the simple extrapolation of linear technological developments to predict technological progress (Coates, et al., 2001). The new scope of TF is highly complex because technological progress is based not only on science as self-organized principles in which any change can result in a significant effect (Coates, et al., 2001), but also on socio-economic variables, events beyond the technical functionality of a given technology that may alter its technological development – e.g., a political decision or posture (Bright, 1972). Nowadays, economic, social, and political issues have emerged as key drivers of technological change (Halal, 2008), and systems to which forecasting is applied cannot be understood without their technical, social, political, economic, and ethical contexts (Porter, Roper, Mason, Rossini, & Banks, 1991; TFAMWG, 2004).

The literature reveals evidence of two TF modes. The first TF mode is more focused on the extrapolation of historical data and deals with the complexity of a system under study. For example, Makridakis, Wheelwright, and Hyndman (1998) indicate the existence of highly complex forecasting methods such as neural networks and simultaneous equations econometric systems to deal with the complexity of current systems. These two methods assume the continuation of past patterns into the future. The second TF mode is more focused on the identification of emerging patterns. For example, Saffo (2007, p. 1) asserts that "the primary goal of forecasting is to identify the full range of possibilities, not a limited set of illusory certainties.… The art of forecasting is to identify an S-curve pattern as it begins to emerge, well ahead of the inflection point." Under Saffo's approach, forecasters look for hidden currents in the present. While the former mode focuses on pattern extrapolation, the latter mode focuses on pattern recognition. Both differ in their goals. The former aims to estimate future conditions, and the latter aims to identify or appreciate signals of change in the present. Table 2-2 offers more TF definitions that, compared to Table 2-1, suggest a change in the scope of TF.

Technological Forecasting and Forecasting Definitions
Technological forecasting aims to predict possible future states of technology or its limiting conditions to achieve a set of goals (Porter, Roper, Mason, Rossini, & Banks, 1991).
Technological forecasting refers to techniques to anticipate technological change (Betz, 1998, p. 160).
TF's concern is to determine when an event will happen (Makridakis, Wheelwright, & Hyndman, 1998).
TF is the field in charge of looking to the future of technology. It includes national foresight studies, roadmapping approach, and competitive technological intelligence (Coates, et al., 2001).
Forecasting refers to the prediction of specific future events by using a scientific technique and historical data (Tsoukas, 2004).
"The goal of forecasting is not to predict the future but to tell you what you need to know to take meaningful action in the present." (Saffo, 2007, p. 1)
TF is concerned with the anticipation of technological breakthroughs based on the pace of scientific progress and experts' knowledge (Halal, 2008; 2007).
"The value of technology forecasting lies not in its ability to accurately predict the future but rather in its potential to minimize surprises." (National Academy of Sciences, 2009, p. 1)

Table 2-2 Technological forecasting definitions after 1900

In recent publications, forecasting methods deal with the complexity of the environment and the richness of electronic information. Table 2-3 provides some examples of recent forecasting studies. Although more sophisticated forecasting methods are used, traditional techniques such as the Delphi method, scenario planning, analogies, and growth curves are part of these studies. According to Martino (2003) and Mishra, Deshmukh, and Vrat (2002), methods should be used in combination according to the technology in question and each situation.

Examples of recent studies
Bengisu and Nekhili (2006) propose a method to support national foresight efforts with quantitative information. With the aid of science and technology databases, and using keywords linked to technologies in question, authors produce S-curves and logistic curves that consider 11 years of publications and patents. The study analyzes 20 technologies under the machine and materials category.
Daim, Rueda, Martin, and Gerdsri (2006) integrate the use bibliometrics and patent analysis with scenario planning, growth curves and analogies. Authors use system dynamics to present and model the diffusion of three emerging technology areas: fuel cell, food safety, and optical storage.
Gallego, Luna, & Bueno (2008) use the Delphi method – based on experts' opinions – to foresee the diffusion and adoption of open source software (OSS) for the year 2010. Their findings illustrate the levels of diffusion and adoption of OSS in terms of geographic areas, industries and main applications.
Lo, Wang and Lin (2008) forecast the LCD monitor market. Authors use a hierarchical forecasting (HF) approach and analyze three forecasting techniques for each hierarchical level. Authors conclude that the best forecasting approach result from using the middle level of the LCD monitor product hierarchy.

Table 2-3 Examples of recent forecasting studies

Finally, Table 2-4 presents a summary of the most recent advances in technological forecasting (Martino, 2003). In this summary, at least one method for pattern identification is presented: environmental scanning. Environmental scanning assumes that technological innovations follow a sequence of developmental stages. Similar to Brenner's (1996) argument, technology development can be tracked by identifying technical or business events that indicate the stage of development of technological innovations. Figure 2-1 presents an adapted model from Brenner's (1996) and Martino's (2003) perspectives.

Forecasting techniques
Environmental scanning assumes that technological innovations follow a sequence of steps (e.g., theoretical proposal, scientific findings, laboratory feasibility, operating prototype, and commercial introduction). Hence, this method searches for technical or business signals that may indicate the rate of technological progress in a particular technology domain. Computers, databases, and the Internet facilitate this endeavor. However, experts are needed to classify and understand thousands of accessible documents.
Models assume that the main variables affecting technological development can be modeled by mathematical equations. Nevertheless, variables are often unknown. Moreover, the application of models is limited to conditions in which known factors can be measured.
Scenarios aim to capture the overall picture of a technological environment. Scenarios display interactions among technological trends and events and depict the big picture of a technology domain future.
The Delphi method is an interactive technique that relies on responses from experts. A recent advance is the use of Bayesian weighting to combine Delphi responses.
Extrapolation assumes that the past contains the future. That is, the past of a time series contains the future of that time series. To extrapolate means to project a past time series into a future times series. Growth curves are often used as the extrapolation method (e.g., logistic or Gomptertz curves).
Probabilistic forecasts use computer simulation and provide a range of possible outcomes associated with the occurrence of an event. Mathematical and probabilistic models are the basis of this technique.
Technology measurement proposes to measure the pace of technological progress by observing aggregated technology factors instead of individual devices. This technique allows forecasters to compare technological progress between countries or industries. As well, it helps to identify what technologies drive changes when aggregated technologies are compared.
Chaos-like states assume that a chaotic-like behavior can be observed when two successive growth curves aim to forecast an event. This oscillation between the fitted curves is not a true chaos but a variation.

Table 2-4 Selected recent advances in technological forecasting according to Martino in 2003

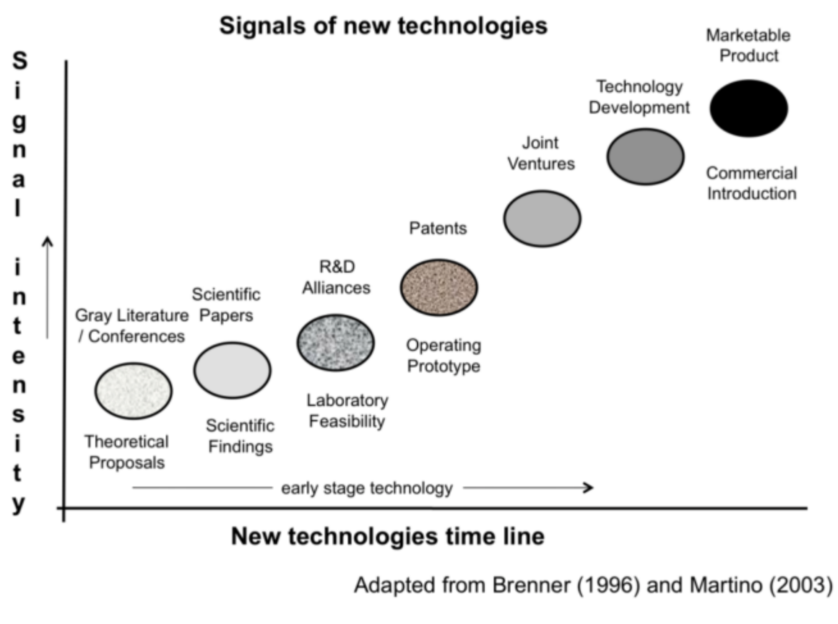

Figure 2-1 Technology development stages

2.1.2. Technology Foresight (TFO)

Generalities of Foresight

The approach of futures studies changed once the future ceased to be explained in terms of the past (Godet, 1991), and foresight was one of those alternative forms of future studies (Coates, et al., 2001). Cuhls (2003) argues that foresight goes further than forecasting because foresight is not concerned with predicting the future. Foresight is conducted to enhance knowledge and understanding about a wide range of current trends but also to prepare for first decisions about a desirable future. Foresight promises the management of uncertainty through a deep understanding of the present extended into possible futures.

The literature of foresight presents many definitions yet limited theoretical development (Amsteus, 2007; Major, Asch, & Cordey-Hayes, 2001). Considering the extant literature, Slaughter may be the most influential author in the field (Miles, Cassingena Harper, Georhgiou, Keena, & Popper, 2008). Slaughter (1995) argues that foresight can be seen as ability, attribute, or process pushing the limits of perception, scanning possible futures, and clarifying emerging situations. Slaughter suggests that foresight is a vision of mind rather than sight. Although Slaughter's definition is conceived at an individual level, his argument is extended to entities as organizations, communities, or governments (Hideg, 2007; Major, Asch, & Cordey-Hayes, 2001). Table 2-5 presents his definition and those of others.

Foresight and Technology Foresight Definitions
Foresight is the ability, attribute, or process to weigh pros and cons, to evaluate possible courses of action and to invest in possible futures (Slaughter, 1995).
"Foresight is about shaping the future through the concerted action of self-sustaining networks of interested groups." (Anderson J., 1997, p. 666)
"Foresight is the process of developing a range of views of possible ways in which the future could develop, and understanding these sufficiently well to be able to decide what decisions can be taken today to create the best possible tomorrow." (Horton, 1999, p. 5)

"Foresight marks the ability to see through the apparent confusion, to spot developments before they become trends, to see patterns before they fully emerge, and to grasp the relevant features of social currents that are likely to shape the direction of future events." (Tsoukas, 2004, p. 137)
"Technology foresight refers to a systemic recognition and observation of new technologies ('weak signals') or existing technologies, the evaluation of their potential and their importance for the competitiveness of the company, and the storing and diffusion of information." (Reger, 2001, p. 535)
Technology foresight is a systematic process identifying not only possible future technologies but also their possible social and environmental impacts. Its purpose is to guide actions for creating a more desirable social and economic future (TFAMWG, 2004).

Table 2-5 Foresight and technology foresight definitions

Two Different Levels of Foresight

The literature on technology foresight in practice can be grouped in two main levels of analysis: *regional* or *national programs studies* – e.g., Georhgiou, Cassingena Harper, Keena, Miles, and Popper (2008); Martin and Johnston (1999); Anderson (1997) – and organizational studies – e.g., Reger (2001); Major, Asch, and Cordey-Hayes (2001). Although national programs have spread rapidly since the 1990s (Martin & Johnston, 1999), Porter and Ashton (2008) suggest that the political background of the United States (anti-centralist) has limited national foresight activities in that country. However, especially in Europe, the practice of foresight was born as participative (Hideg, 2007), signaling the role of governments, business, and key actors to establish knowledgeable networks of individuals focused on identifying areas of strategic research and generic technologies most likely to impact industrial competitiveness, wealth creation, and quality of life (Miles, Cassingena Harper, Georhgiou, Keena, & Popper, 2008). On the other hand, the extant literature of technology foresight in companies has been limited, but it is separately discussed in the following section due to the focus of this study.

Organizational Foresight (OF)

Like Slaughter, Tsoukas (2004) indicates that OF is an ability based on individuals' perception and understanding. It depends on how individuals perceive the past and their ability to identify variations in the present departing from the past. He also extends this ability to the organizational level and says OF is "the ability to read the environment – to observe, to perceive – to spot subtle difference" (Tsoukas, 2004, p. 140). Burt (2006) highlights the idea of *seeing* as the key premise for foresight. He indicates three overlapping circumstances to be able to *see*: 1) a holistic and systemic understanding of the business environment; 2) the recognition of elements of the system, interacting and revealing irregular patterns; and 3) an ongoing discussion, framing and re-framing insights about the deep understanding.

Studying the failure of national foresight programs to enact cultural change, Major, Asch, and Cordey-Hayes (2001) show the connection between the business strategy literature and foresight research. They contend that OF and the core competence of pathfinding[5] refer to the same fundamental concept. Foresight resides in individuals' ability but unfolds through integrated teams at an organizational level. Thus, successful OF emerges as a core competence because it requires the integration of the firm's existing skills and technologies to exploit new opportunities. Moreover, OF evolves in customer value and enables competitive advantage based on organizational practices that are difficult to be imitated.

Reger (2001) studied technology foresight (TFO) in multinational companies, and found four TFO common activities: technology analysis, monitoring, scanning, and prognosis. Because he clarifies that his understanding of TFO is the same as technology intelligence, his contributions are reported mainly in a later section. Although companies have done TFO for 10 to 20 years, TFO is an unstructured and vaguely defined process. This author describes a conceptual model for TFO and highlights that TFO is a continuous process taking place at different organizational levels (corporate level, business units, and specific groups) through formal and informal networks.

………………………………..
[5] Turner and Crawford describe 11 core competencies within organizations (e.g., performance management, reesource application, communication, and pathfinding) (Major, Asch, & Cordey-Hayes, 2001). They say that "Pathfinding is the core competence to identify, crystallise and articulate achievable new directions for the firm." (Major, Asch, & Cordey-Hayes, 2001, p. 101)

Alsan and Oner (2003) develop an integrated and holistic foresight management model, distinguishing not only the levels of management involved (normative, strategic, and operative), but also the organizational activities that are part of it (structures, goals, and behaviours). While the normative foresight level enhances policy formulation to establish behavior, the strategic foresight level helps with strategy formulation and deals with the construction of success. The operative foresight level integrates operational actions to implement both normative and strategic aims.

Cunha, Palma, and de Costa (2006) distinguish four OF modes: strategic planning, scenario thinking, visioning, and planned emergence. They result from a two-by-two analysis: centered on time (future or present) and centered on level of analysis (macro analysis or micro realities). OF is often thought of as a technical and analytic practice restricted to top management, but it is also an ongoing social practice of a collective project emerging from daily interactions. Both practices swing between thinking and acting, between present and future, between the need to know and the fear of knowing. Recognizing the limit of anticipation and analyzing the micro level perspective could help organizations to confront the unexpected.

2.1.3. Technology Intelligence (TI)

Generalities of TI

In the 1990s, Ashton and Stacey (1995) introduced the term *TI.* Like Reger (2001) , they argue that since the 1960s, TI activities have existed in most technology-based companies in order to address their technology decisions. TI emerged as a new form of TF to indicate the place of knowledge and technology to formulate competitive and successful business strategies (Coates, et al., 2001). Ashton and Stacey (1995) indicate that businesses carry out TI activities for three basic purposes: "1) to provide early warning of technical developments; 2) to identify new product process or collaboration opportunities; and 3) to understand technical events or trends and the related competitive environment." Table 2-6 presents TI definitions and suggests that the interpretation of

TI is multifaceted, according to the context in which it is applied. In the literature, TI is variously referred to as an attribute, a process, a set of activities, a task, or an organizational unit. In fact, it has been referred to as information, knowledge, or an entire field of study – e.g., Brenner (1996), Rohrbeck (2007) and Dorgham (2004).

Technical or Technology Intelligence Definitions
TI is the practice of finding, analyzing, and communicating relevant information on technical developments, events, and trends to assist the decision making process (Ashton & Stacey, 1995).
"Technical intelligence is a special class of information, namely information of technical events, trends, activities or issues that has sufficient competitive value to warrant special protection and handling against unintended disclosure or misuse." (Ashton & Stacey, 1995, p. 83)
Technology intelligence focuses on the early identification and understanding of scientific breakthroughs, technological change and trends, and changes on new technological capabilities on competitors, customers, and suppliers (Brenner, 1996).
"Competitive technical intelligence is business-sensitive information on external scientific or technological threats, opportunities, or developments that have the potential to affect a company's competitive situation." (Ashton & Klavans, 1997, p. 11)

Table 2-6 Technical of technology intelligence definitions

Steps in the TI Process

Despite its multifaceted applicability, TI is consistently highlighted as a fundamental process, one not only to reduce the possibility of organizational failure when facing dynamic technological environments, but also to develop the strategy formulation that is essential for new fields of business or strategic innovation (Ashton & Stacey, 1995; Ashton & Klavans, 1997; Reger, 2001; Savioz, 2004). However, empirical evidence suggests that in practice the TI process is unstructured and broadly defined (Reger, 2001). Table 2-7 summarizes the steps involved in the TI process according to Ashton and Stacey (1995), Reger (2001) and Savioz (2004). In essence, the TI process is as follows: 1) identification and understanding of key needs of users, as well as the areas of search including core technologies descriptors; 2) selection of sources, methods, and tools to collect information; 3) collection of data, which consists of searching and assembling relevant information;

4) analysis of information, which includes interpretation and assessment; 5) communication of findings to decision makers; and 6) evaluation of the technology intelligence results.

Steps in the Technology Intelligence Process	
Ashton and Stacey (1995)	(1) Plan intelligence activities; (2) collect source materials; (3) analyze source data; (4) deliver information products; (5) apply intelligence results; and (6) evaluate program performance.
Reger (2001)	(1) Determining information needs and selecting the search area; (2) selecting information source, methods, and instruments; (3) collecting data; (4) filtering, analyzing, and interpreting the information; (5) preparing decision; and (6) evaluating proposals and decision-making; and (7) implementing and carrying out the decision.
Savioz (2004)	(1) Formulation of information need; (2) information collection; (3) information analysis; (4) information dissemination; and (5) information application.

Table 2-7 Steps in the technology intelligence process

Two Basic TI Activities with Different Perspectives

In attempts to clarify the scope and understanding of the TI process, two activities are consistently indicated by the literature: scanning and monitoring. Basically, scanning and monitoring activities refer to searching for relevant information. However, whereas monitoring focuses on observing and analyzing technological trends from a company's existing areas of expertise (commonly known core technologies), scanning focuses on identifying, observing, and analyzing new technological trends outside the company's existing areas of expertise (unknown but *potential somewhere* technologies) (Reger, 2001; Ashton & Stacey, 1995). These two activities are also referred to as perspectives of searching. As well, Reger (2001) and Ashton and Stacey (1995) refer to other activities as technology analysis, prognosis, assessment or evaluation, acquisition or transfer, and internalization.

2.1.4. Remarks on Future Technologies Studies

The conceptual development of the field of future technologies studies has been unsystematic (TFAMWG, 2004; Miles, Cassingena Harper, Georhgiou, Keena, & Popper, 2008). Some authors argue that technology intelligence is a new form of technological forecasting (Coates, et al., 2001); others state that technological forecasting is the first generation of technology foresight or even technology intelligence (Miles, Cassingena Harper, Georhgiou, Keena, & Popper, 2008). Nevertheless, the three aforementioned streams can be explained in terms of different social, political, economic, and institutional needs over time (Coates, et al., 2001; Cuhls, 2003). This study uses the umbrella term of *future technologies studies* (TFAMWG, 2004) but also suggests the following framework to situate each of these three streams (see Figure 2-2).

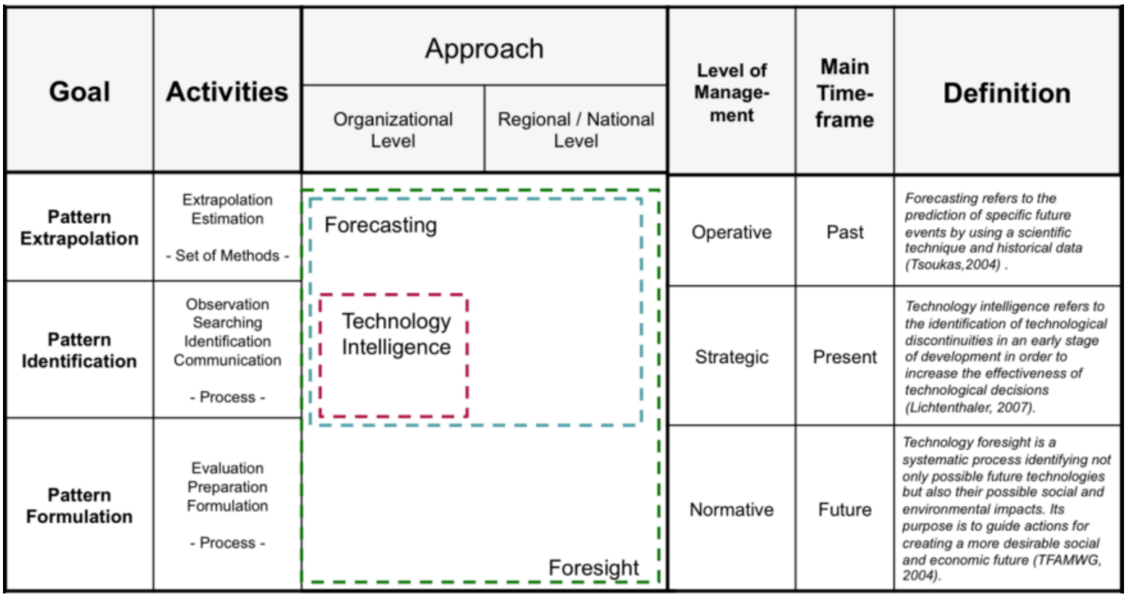

Figure 2-2 Proposed framework to situate future technologies studies

While technological forecasting (TF) is concerned mainly with pattern extrapolation and includes methods of pattern identification (Martino, 2003; Saffo 2007; Bright, 1972), technology intelligence (TI) is totally concerned with pattern identification and foresight (FO) with pattern formulation. The implementation of these methods substantially lies on different levels of management: operative, strategic, and normative. Finally, the three methods differ in their main time frames. TF is essentially based on the past when it extrapolates historical data; TI is essentially focused on observing what happens in the present; FO is essentially envisaging a desired future.

Finally, many terms have been used to distinguish the task of identifying the emergence of new technological trends: technology search (Brenner, 1996); technological monitoring (Bright, 1972; Cleland & Bursic, 1992); competitive technological intelligence and technical intelligence (Ashton & Stacey, 1995; Ashton & Klavans, 1997); technological forecasting (Saffo, 2007; Martino 2003). This study may be better situated in the growing literature of technology intelligence or in the technological forecasting literature focused on pattern identification.

2.2. Environmental Scanning and Weak Signals

The literature review of future technologies studies leads to the examination of two other terms related to this research study: environmental scanning and weak signals. Reviewing the literature on strategic management provides such definitions and further elaborations, and this section discusses the main related points.

2.2.1. The Definition of Environment in the Context of an Organization

Environment is everything that does not comprise the organization (Mintzberg, 1979; Miles R. H., 1980), although this is a broad and not always applicable definition (Shukla, 2006). Particularly, Mintzberg (1979) and Handy (1993) indicate that *environment* typically refers to diverse factors influencing organizational activities, such as the state of the economy, technology and market, geographic and socio-political factors, as well as cultural issues. Porter (1980) states that the firm's environment encompasses social and economic forces, but the key aspects of it are confined to the industry in which the firm competes. Scott (1990) points out that markets, technologies, laws, and institutional elements define the environment of organizations. Differently, Weick (1969, p. 28) says "the environment is a phenomenon tied to processes of attention, and that unless something is attended to it doesn't exist." Weick argues that organizations produce and constitute their own environments, so the environment is created by organizational actors and no one else.

2.2.2. The Practice of Environmental Scanning (ES)

Aguilar (1967) describes environmental scanning (ES) as an organizational practice based on top executive capabilities and intertwined with strategic decisions. He states that environmental scanning refers to the acquisition of information about events, trends and relationships in the outside environment of a company, and aims to identify threats and opportunities in the context of company's business. Aguilar's definition remains today without significant change.

Thomas (1974) and Ansoff (1975) situate environmental analysis as an essential organizational activity by which organizations keep pace with their environments. Fahey and King (1977) study ES activities in organizations and conclude that, contrary to assumptions, organizations carry out informal and unsystematic ES exercises. Similarly, Thomas (1980) finds not only a growing ES activity within organizations but also a trend towards sophisticated and situation-dependent scanning systems. Thompson and Strickland (1992, p. 66) say "environmental scanning involves studying and interpreting social, political, economic, ecological and technological events."

In terms of conceptual development, Daft and Weick (1984) differ from Aguilar (1967) in his four modes of ES (undirected or conditioned view; informal or formal search). Although Daft and Weick also characterize four scanning modes (undirected or conditioned view; enacting or discovering behavior), they are based on two new variables: 1) management's beliefs about the analyzability of the environment (analyzable or unanalyzable); and 2) organizational intrusiveness, the extent to which organizations intrude into their environment to understand it (passive or active). Moreover, Daft and Weick indicate that the interpretation process is affected by how managers deal with multiple interpretations (equivocality reduction) and how organizations process data into collective interpretations (assembly rules). Later, Choo (2001) analyses each scanning mode by examining information needs, information seeking, and information use behaviors. He concludes that ES is not only an information seeking process but also a learning process. Similarly, in their conceptual model of peripheral vision, Day and Shoemaker (2004) situate ES as a central process for organizational learning, intertwined with the business strategy.

No systematic descriptions exist of the ES process. However, Choo (1999) provides the most quoted ES process, an information management model that charts six interrelated sub-processes: identifying information needs, acquiring information, organizing and storing information, developing information products or services, disseminating information, and using information. Choo's model resembles the steps of the technology intelligence processes listed in Table 2-7.

Otherwise, the ES literature grows and explores the link between ES and performance, as well as searches for quick, relatively inexpensive, and flexible scanning methods. Lately, ES research signals the potential use of the Internet, and novel Internet-based techniques are proposed (Liu, Shih, & Liau, 2009; Wei & Lee, 2004). Appendix G describes other similar initiatives (e.g., IBM's WebFountain, TecFlow).

Recently, Tonn (2008) proposes the use of systems models to organize and quantify the results of ES exercises. His methodology captures the essence of the problem under study, and claims not only to organize but also to guide ES exercises. Leads, pieces of information identified in the ES, can be organized and quantified by associating them with the model's components. According to Tonn, at least one or more components should denote technological change and social behavior aspects subject to change.

2.2.3. The Notion of Weak Signals

In the context of strategic management, Ansoff (1975) introduces the term *weak signals* to refer to imprecise early indications of impending impactful events (e.g., in the next five years the new international policy of the USA will reframe the Middle East conflict). As well, Ansoff suggests a model that analyzes such strategic information to gradually guide managerial responses to the environment, but he does not suggest *how* to detect weak signals. Detection of weak signals requires expertise and sensitivity (Ansoff, 1984). The term *weak signals* has been used not only in the context of strategic management but also in the contexts of environmental scanning, technology intelligence, and technological change. For example, Brenner (1996) explains the relationship between technology development stages and technology signals, and refers to the type of signal and its intensity. Reger (2001) uses *weak signals* defining technology foresight in Table 2-5. Mendoca, Pina e Cunha, Kaivo-oja, and Ruff (2004) argue that organizations should use environmental scanning, including weak signal analysis, in order to identify wild cards[6] or black swans[7] that could threaten their future. Ilmola and Kuusi (2006) define *weak signals* as unstructured new information suggesting potential discontinuity and puzzling the organization's *sense-making*.

2.2.4. Remarks on Environmental Scanning and Weak Signals

Although environmental scanning is also referred to as a forecasting technique (Martino, 2003), it casts a wider net in the analysis of environmental information (Choo, 1999). ES is concerned not only with pattern identification of new technologies as technological forecasting methods and technology intelligence processes. Indeed, ES is concerned with signal or pattern identification of any factor potentially influencing organizational activity (see Appendix G for examples of practitioner-oriented techniques such as SRI Consulting Business Intelligence and Fountain Park). Using set theory, Figure 2-3 shows a potential organization of future-related activities including ES and the streams of future technologies studies as presented in Section 2.1.

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[6] Wild cards are sudden events that constitute turning point in the evolution of social systems (Mendoca, Pina e Cunha, Kaivo-oja, & Ruff, 2004, p. 203)

[7] Black swans are unpredictable events with massive impact that afterward they look less random (Taleb, 2007).

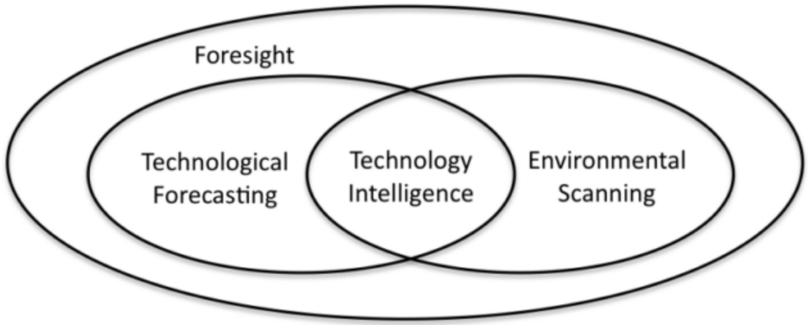

Figure 2-3 Potential organization of future-related activities

2.3. Understanding Technology and Technological Innovations

The term *technology* can suggest different meanings (Mintzberg, 1979). Table 2-8 shows seven definitions of technology. According to Betz (1998), technology is generically the knowledge of the manipulation of nature to satisfy human needs or purposes, where *nature* refers not only to nature in a natural state but also to nature in a technologically manipulated state (i.e., a tool or an artifact such as a lightning rod or a wireless computer router). Taking into account that technology is knowledge (Simon, 1973), technology can be not only embodied in people (i.e., procedures, rules) or means (i.e., books, manuals, processes, methods, models) but also embedded in artifacts or practices (i.e., materials, equipment, utensils, cognitive and physical systems), according to Burgelman, Christensen and Wheelwright (2004).

Technology Definitions
"Technology is not things; it is knowledge – knowledge that is stored in hundreds of millions of books, in hundreds of billions of human heads, and, to an important extent, in the artifacts themselves. Technology is knowledge of how to do things, how to accomplish human goals." (Simon, 1973, p. 1110)
"Technology is the knowledge of the manipulation of nature for human purposes." (Betz, 1998, p. 9)
"Technology can be defined as all knowledge, products, processes, tools, methods, and systems employed in the creation of goods or in providing services. In simple terms, technology is the way we do things. It is the means by which we accomplish objectives." (Khalil, 2000, p. 1)
"Technology refers to the theoretical and practical knowledge, skills and artifacts that can be used to develop products and services as well as their production and delivery systems. Technology can be embodied in people, materials, cognitive and physical processes, plant, equipment, and tools. Key elements of technology may be implicit, existing only in an embedded form (e.g., trade secrets based on knowhow)." (Burgelman, Christensen, & Wheelwright, 2004, p. 2)

"Technology is the process by which an organization transforms labor, capital, materials, and information into products or services." (Burgelman, Christensen, & Wheelwright, 2004, p. 246)
"Technology refers to the manner in which organizational input is transformed into its output." (Shukla, 2006, p. 74)
"A technology is a means to carrying out a purpose." (Arthur, 2007, p. 276)

Table 2-8 Seven definitions of technology

Technologies in embedded form (Burgelman, Christensen, & Wheelwright, 2004) become at the same time not only products or services to satisfy human needs, but also in nature technologically manipulated (Betz, 1998) phenomena that can be newly manipulated and aggregated with other technologies to carry out another, different, human purpose. In other words, technologies, particularly in a product category, can be put together or assembled as component technologies to develop more complex systems aiming to solve other needs or goals (Arthur, 2009). In Murmann and Frenken's (2006) terms, technologies can be seen as nested, hierarchically organized systems, where each component technology itself has purpose or assignment to carry out within the overall system which at the same time has its own purpose.

Betz (1998) distinguishes two types of technologies used by business organizations: core technologies and supportive technologies. The former ones are unique and essential to constitute a given system (product, service, or process), whereas the latter ones are necessary but not unique or essential. Otherwise, several authors use the term *technological innovation* to refer to the invention, the development, and introduction into the marketplace of a new technology (Burgelman, Christensen, & Wheelwright, 2004). In this sense, technological innovations are new technologies in a form of products, processes, or services. The literature describes types of technological innovations to explain technological evolution. Table 2-9 presents types and definitions of technological innovations.

Type of Technological Innovation	Brief Description
Radical and Incremental	The creation of a new functionality versus a change in an existing technological system (i.e. improvement of performance, quality, cost) (Betz, 1998).
Disruptive and Sustaining	The creation of a new market and business model versus the satisfaction of existing demands in established markets (Christensen, Johnson, & Rigby, 2002)
Emerging and Established	Science-based innovations with the potential to create a new industry or transform an existing one versus the continuation of an existing technological regime (Day & Schoemaker, 2000)
Competence-destroying discontinuities Competence-enhancement discontinuities	The creation of a new product class or a new way of making a product versus improvements in price or performance built on existing know-how (Tushman & Anderson, 1986)
Architectural versus Component	The reconfiguration of components and knowledge versus changes in components without changing the configuration (Henderson & Clark, 1990).

Table 2-9 Types and definition of technological innovations

To understand technological evolution implies a need to understand the various technologies such technology employs (Burgelman, Christensen, & Wheelwright, 2004; Murmann & Frenken, 2006). In Arthur's (2007) words, if a technology emerges from a central idea of how to exploit something[8], "to understand a technology means to understand its principle and how this translates into components that share a working architecture" (Arthur, 2007, p. 277). A *principle* refers to the relationship and organization among component or simple technologies and exploitable natural phenomena. Hence, the invention of a new principle or the discovery of a new exploitable phenomenon not only results in an opportunity to observe a radical technological change but also becomes the unique two sources of it (Arthur, 2007). Thus, technological evolution stems from changes in technologies.

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[8] Consistently with Betz's definition, it refers to how to manipulate and exploit nature.

2.4. Studies and Theories of Technological Change and Evolution

According to Misa (1992), theories of change are difficult and theories of change in something that is not well understood are most difficult. The classification of theoretical contributions about technological change is challenging, but six potential categories are described next. First, some frameworks of technological change are focused on analyzing the evolution of technologies as nested and hierarchically organized complex systems. Technologies are seen as designs that at multiple levels evolve through technology cycles of components and subsystems. Core components, peripheral subsystems, operational principles, and dominant designs are essential concepts supporting these propositions. Arthur (2009; 2007), Murmann and Frenken (2006), Henderson and Clark (1990), Tushman and Anderson (1986), Abernathy and Clark (1985), and Van Wyk (1979) are influential authors of this architectural perspective on the evolution of technologies and their industries.

Second, technological change and evolution have been also explained in terms of trajectories of behavioral patterns that emerge from multidimensional trade-offs among cognitive, social, organizational, and economic factors (Dosi, 1982; Foster, 1986). According to Dosi (1982), a technological trajectory (i.e., direction of movement) is established through a complex interaction between some fundamental economic factors (e.g. markets and profits) with institutional resources over a problem solving activity. Foster (1986) proposes the S-curve approach to examine technology diffusion and the pace of technological progress. S-curves in technology diffusion indicate the rate at which the market is making technology adoption decisions. By using S-curves, Farrell (1993) shows that new technologies grow in the absence of competition. However, a new technological trajectory emerges when a new technology has a performance advantage. Farmer (2009) investigates the rate of technological progress in different technology domains and suggests the existence of laws of technological progress. In essence, these studies and theories aggregate behavioral patterns to analyze technologies' behaviour.

Third, a few explanations of the development and change of technology in organizations have explicitly explored cognitive perspectives enhancing prior approaches (Orlikowski & Gash, 1994; Kaplan & Tripsas, 2008; Dierkes, Lutz, & Teele, 2001). The central argument is that when different actors interpret the nature of a given technology, they bring different technological frames[9] and develop a collective interpretation of it (Kaplan & Tripsas, 2008; Dierkes, Lutz, & Teele, 2001). The notion of congruence[10] in technological frames helps to make sense of multidimensional perspectives on technological issues (Orlikowski & Gash, 1994). These studies suggest technological change as a social and cognitive co-evolutionary process similar to what Barley (1986) and Garud and Rappa (1994) found in their studies. Technologies are treated as social objects, and social and institutional structures are treated as ongoing processes. Evidently, cognition plays a central and explicit role in these models.

Fourth, other studies and theories explain technological change as an outcome of social processes and institutional arrangements. Suarez (2004) describes technological battles and suggests few firm- and environmental-level factors that account for technological dominance. While *firm-level* factors include organizational resources and processes such as a firm's installed base and a firm's strategic manoeuvring, *environmental-level* factors refer to institutional context and processes such as regulations and network effects. Bijker, Hughes and Trevor (1987) and Bijker (1995) propose the social construction of technological systems (SCOT). In SCOT, four elements explain technological change as a social process (relevant groups, interpretative flexibility, closure and stabilization). *Relevant groups* solve technical problems and shape gradually the development of technological artifacts. *Interpretative flexibility* refers to the extent of agreement about the meaning and functioning of a technology. *Closure* appears when the interpretative flexibility of technological artifacts diminishes among relevant groups. *Stabilization* refers to the degree of

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9 Technological frames encode experiences with existing technologies.
10 The notion of congruence is defined as the alignment of individuals' technological frames on key elements or categories.

change among relevant groups in the development of the technology itself. According to Olsen and Engen (2007), while technical changes take place within groups and organizations striving for movement in problem solving activities to satisfy market demands (i.e., a technological trajectory perspective), technological developments result as well from a negotiation process among actors with heterogeneous technological frames (i.e., the social construction of technology theory).

Fifth, technological change is also explained by using concepts from the theory of evolution in nature. Bowonder, Muralidharan, and Miyake (1999) summarize five major lessons using the analogies of adaptation, punctuated equilibrium, purposive selection, hierarchical selection and self-organization. *Adaptation* refers to the ability of innovating firms to adapt their organizational processes in response to sudden changes in their business and technological environments. *Punctuated equilibrium* is a theory that denotes two conditions: 1) short periods of rapid bursts of change; and 2) longer periods of relative stability after the punctuational outburst. *Purposive selection* indicates that innovating firms must create technologies that can survive and evolve further; *hierarchical selection* refers to the ability of firms to develop productive configurations and supportive structures for creating new technologies. *Self-organizing* technologies or systems are those able to grow and change autonomously, such as the Internet. In a similar vein, Devezas (2005) discusses the ability to use all these biological, evolution-related concepts to create computational models that capture the complex dynamic of technological evolution. Perhaps his most salient contribution is the definition of the unity of analysis in technological evolution: the *technique* (i.e., the set of rules and procedures that enable the enactment of technological practices).

Lastly, Geels (2002) and Geels and Schot (2007) provide an account for long-term technological transitions with an integrative approach. These authors recognize the use of analytical and heuristic constructs instead of ontological descriptions of reality and illustrate the importance of models to explain complex social phenomena. For them, *technological transitions* refer to a change from one socio-technical[11] configuration to another. *Socio-technical configurations* consist not only of technologies but also elements such as technology-related practices, regulations, industrial networks, infrastructure, and symbolic meaning or culture. Technological transitions imply then a reconfiguration process in which a change or changes in one of the elements of a socio-technical network may gradually trigger new linkages and alignment among other elements. Importantly, socio-technical elements and their linkages are the result of activities produced and reproduced by social groups. Looking at three conceptual socio-technical levels (i.e., technological niches, socio-technical regimes, and socio-technical landscapes), Geels (2002) suggests that three particular phenomena explain socio-technical change: 1) niche-accumulation; 2) technological add-on and hybridization; and 3) riding along with a particular market growth.

2.5. Remarks on the Literature Review

Our literature review shows that future technologies studies have explored the future of technologies as explicit artifacts, outcomes, products. Most future technologies studies treat technologies as entities disconnected from social processes. Clearly, technology intelligence and forecasting methods lack connection with theories of technological change and evolution. If technological progress and new technologies may stem from highly complex relationships not only between streams of scientific and technological development (cognitive factors) but also between individuals and institutional needs (social, economic, and political factors), a theoretical framework that can bring together cognitive, social, and organizational theories is needed. Acknowledging that without all previous relevant contributions, a new proposition would not be possible. Chapter 3 proposes an open framework that builds on the Structuration Theory by (Giddens, 1984).

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[11] In Geels work, at basic level, the socio-technical term refers to the bundle of patterns of individuals' behavior interacting with explicit or physical artifacts.

Chapter 3. Theoretical Framework and Propositions

"The whole of science is nothing more than a refinement of everyday thinking" Albert Einstein

How do we identify early the emergence and development of new technologies, threatening or enhancing, the competence of a firm within an industry? To answer this research question, firms and companies require answers to more fundamental questions: What is technology? Where does technology come from? How does technology evolve? What is the relationship between technology and society? How is technology visible in society? What are signals of technological change? How do we study the emergence and development of technological trends? This chapter provides an open framework for answering this set of questions and suggests a model of emerging technologies that is used in Chapter 4 to determine how to identify methodologically the emergence and development of new technologies.

This study assumes that technologies are *not* animated entities with autonomous laws of an independent development (Brooks, 1971, p. 3). In line with several authors, the study argues that the understanding of technologies should be not separated from societal concerns, activities and change (Orlikowski & Gash, 1994; Latour & Woolgar, 1986; Bijker, Hughes, & Trevor, 1987). Technologies are created by intentional activities aiming to accomplish human goals (Simon, 1973). Thus, technologies are not only a central driver of societal change (Aunger, 2010) but also an endogenous feature of it. Technologies emerge from social and technological systems of humans, and when technologies come to life some signals of their presence may be observed in their immediate environments. Our integrative framework builds on internally consistent theories and brings together different and fundamental aspects related to the emergence and development of technologies. The following sections detail how this study combines complementary theoretical contributions and proposes some testable theoretical propositions.

3.1. With Respect to Well-established Ontological Stances

This study builds on the Structuration Theory (ST) by Giddens (1984), which provides an unconventional account of the constitution of society. ST reconceptualizes the long-standing division associated with the nature of social reality: objective[12] or subjective[13]. Remarkably, ST does not state any ontological position of the social world (i.e., objective or subjective). Instead, ST focuses on explaining regularities in the production and transformation of social life from a practical perspective without engaging in any debate about its nature. Although Giddens acknowledges the existence of a *material* world entirely independent of humans beings – a realm of nature – similar to Searle (1998, pp. 111-134), he illustrates thoroughly the parallel importance of a social realm and posits that society is created and recreated by human beings in every social encounter, highlighting that society is not the product of any single person but the result of a skilled performance and sustained patterns of human interaction (Cohen I. J., 1989, p. 22). The difference between nature and society is that nature is not produced by man, whereas society is unequivocally the result of human action (Giddens, 2007).

3.2. The Social Realm: An Ongoing Process According to Structuration Theory

In explaining the social realm, ST postulates that individuals create and recreate their social systems by patterning behaviours across time and space; simultaneously, individuals' actions are shaped by structural properties[14] of social systems to which these individuals belong. This ongoing reciprocal interaction between individuals and their social systems enables the most fundamental concept of the ST: *the duality of structure*. The *structure* is, thus, a virtual order distinction that refers to the set of embedded procedures (rules) and institutionalized forms of activity (resources) enacted by

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[12] Objective refers to a world comprised of objects and systems of objects.

[13] Subjective refers to a world comprised of perspectives.

[14] Structural properties refer to those institutionalized forms of social practices such as language values, customs and technologies in their conceptual and practical form.

individuals in social practices[15]. These rules and resources are organized recursively. Giddens (1984, p. 25) says "agents and structure are not two independently given sets of phenomena, a dualism, but represent a duality." Individuals and structure are thoroughly interdependent and do not exist separately, although they are treated distinctly (Akgün, Byrne, & Keskin, 2007). Hence, social systems do not comprise "structures" as these are traditionally understood – external entities alien to individuals. Structure is not external or independent of individuals but exists only instantiated in social practices and memory traces guiding the conduct of individuals. Giddens refers to the structural properties of a social system as the *structure* of it. In essence, Giddens postulates a reciprocal constitution of individual and social systems. The structure is both an outcome and a medium (Stones, 2005).

According to Giddens (1984, p. 31; 1979 p. 81), only analytically, structures of social systems can be analyzed by three dimensions: structures of signification, legitimation, and domination.

- *Signification structures* refers to the set of rules and resources not only enabling shared meanings but also informing and defining interaction (e.g., doctoral committee members and PhD students share to some extent a meaning with respect to a doctoral defense and define their interaction in this specific domain of action).
- *Legitimation structures* refers to the set of rules and resources sanctioning the normative aspects of social conduct and practices, including the communication of meaning (e.g., researchers share to some extent a set of rules governing what empirical research is and what it is not, how it should be performed and how it should not, why this practice is important or why it is not).
- *Domination structures* refers to the set of rules and resources facilitating interactions to reaffirm or modify social practices (e.g., computer science professors possess specific knowledge in computer science that emerge when they interact to discuss a course in that field).

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15 Social practices are patterns of social activity (e.g., to thank after receiving a service or to submit a research proposal as a requirement of applying for funds).

Resources refer to institutionalized forms of transformative capacity[16]. Giddens (1979, p. 92) says that "Resources are the means whereby transformative capacity is employed as power in the routine course of social interaction; but they are at the same time structural elements of social systems as systems, reconstituted through their utilization in social interaction." Two types of resources are distinguished:

- Authoritative resources refers to forms of transformative capacity facilitating interactions with actors.
- Allocative resources refers to forms of transformative capacity generating command over objects, goods or material phenomena.

In addition to the recursive interplay between individuals and their social systems, the recognition that individuals are knowledgeable and reflexive is a second fundamental premise of ST (Orlikowski, 1992). Individuals not only possess the rules implicated in the production and reproduction of social life, but also are able to intervene and change the course of events. Cohen (1989, p. 18) indicates that individuals can alter whatever degree of "systemness" exists in their social systems, although they are always bounded by their contextual situation, by what they know, by what they can do, by what they cannot articulate, and by how they are motivated, as well as by unintended consequences of their actions (Giddens, 1984). In ST terms, material and social – institutional – constraints vary considerably across time and space, but individuals experience always a degree of freedom to act differently. Neither total freedom nor total determination in human action seem to exist (Cohen I. J., 1989, p. 25; Elder-Vass, 2010, p. 87). For Giddens, individuals' capability to reaffirm or modify social practices refers to individuals' "power" or "transformative capacity." Giddens (1979, p. 91) says:

> "power must be treated in the context of the duality of structure ... power is not a type of act; rather power is instantiated in action, as a regular routine phenomenon. It is mistaken moreover to treat power itself as a resource as many theorists of power do. Resources are the media through which power is exercised, and structures of domination reproduced."

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16 Transformative capacity refers to the capability to make a difference and alter the course of events.

To be knowledgeable and reflexive refers also to the social awareness of individuals, understanding practically rather than theoretically the social circumstances of their actions and the rules they follow in the ongoing flow of social life (Akgün, Byrne, & Keskin, 2007). In his interpretation of human agents, Giddens (1984) states that individuals are purposive agents and presents three sets of underlying processes and three layers of cognition/motivation in action.

Three underlying processes in human action (p. 5-14):

- Reflexive monitoring of action refers to a chronic feature of individuals to be aware of and monitor what they and others do and contextual circumstances of their social and physical environments.
- Rationalization of action refers to individuals' capability as competent actors to maintain a continuing theoretical understanding of what they do, what others do and their contextual circumstances, such that if asked by others, they can supply a rationale for their actions.
- Motivation of action refers to unconscious forms of cognition and impulsion, the wants that prompt action. Motives appear in consciousness in a distorted form or are entirely repressed from it.

Three layers of cognition/motivation in human action (p-5-14):

- Discursive consciousness refers to what individuals can say – verbal expression – about their actions, the actions of others, and their social circumstances (i.e., social awareness in discursive form – explicit or discursively accessible knowledge).
- Practical consciousness refers to what actors can do or understand about their actions, the actions of others, and their social circumstances, but they cannot articulate discursively (i.e., social awareness in practical form – tacit or practically accessible knowledge).
- Unconscious motives refers to what actors do not know about their actions, the action of others, and their social conditions (i.e., lack of awareness that is simply and obviously "something" not accessible).

3.3. The Role of Language in the Structurational Perspective

ST assumes the fundamental role of language as an institutionalized form of social activity (a resource) that is produced, sustained and changed by individuals in interaction (Giddens, 1984). Giddens (1984, p. 20) refers to Searle in explaining the development of rules and resources in language. Searle (1998) suggests that the creation of language (i.e., each symbolic device in it) is the result of a long period of individuals' acceptance of a collective assignment of status function and constitutive rules. In other words, each symbolic device of language not only implies constitutive rules of meaning and functioning, but also constitutes an institutionalized form of social activity produced and sustained by individuals in interaction. Thus, when individuals interact, they rely on such rules and resources to communicate and coordinate social activities. Therefore, language seems to be more than a tool enabling the development of collective meaning of social and natural phenomena, and its basic symbolizing feature assumes the fundamental role for the creation of other human inventions such as conceptual, organizational and technological systems (Searle, 1998). Empirical evidence suggests that social groups develop different rules and resources in language and other aspects of human life according to cultural attributes, environmental conditions and genetic variations (Everett, 2010; Henrich, Heine, & Norenzayan, 2010).

3.4. Rethinking Technology: A Structurational Model of Technology

With structuration theory, technologies are not only "material" but also social objects (Barley, 1986; Olsen & Engen, 2007). Technologies and social systems are not conceptualized separately. Technologies and social systems evolve in parallel (Bijker, Hughes, & Trevor, 1987; Aunger, 2010). Giddens does not directly develop the concept of technology in ST. However, Orlikowski (2000; 1992) extends the structurational perspective of technology and illustrates how to understand technology in the ongoing process of human action. In Figure 3-1, this study proposes an integrative description that makes explicit the multidimensional view of technology and helps to explain fundamental aspects in two influential contributions from Orlikowski (2000; 1992).

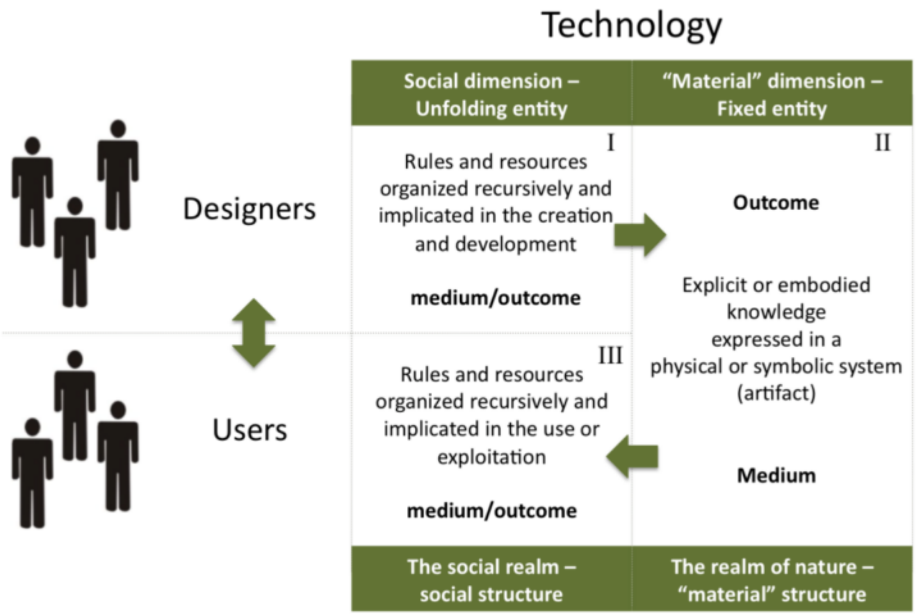

Figure 3-1 An integrative description to make sense of technology

Similar to Weick's view (1990), Figure 3-1 indicates that while technology can refer to explicit or embodied knowledge instantiated in a "material" artifact (physical[17] or symbolic[18]) constructed by actors (II) (Orlikowski, 1992), technology refers also to social structures (knowledge), means and outcome, only instantiated in the social practices of individuals (I and III) (Orlikowski, 2000). Thus, technology can exist simultaneously and analytically in these two dimensions or realms: one "material" and the other social (Weick, 1990; 1979). In this study, this proposition builds on Giddens (1984, p. 20) and Searle (1998) who propose that individuals develop gradually and accept to some extent collectively the creation of a symbolic device – a technology name – to identify and name new practices and objects enacted by them. In other words, individuals use language in the

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[17] Physical refers to a tangible or concrete presence, such as machines, hardware, devices or gadgets.
[18] Symbolic refers to an abstract but systematic form of knowledge available in an explicit form, such as books, manuals, procedures, algorithms and software (Simon, 1962).

assignment of function and reference to social activities and entities. Hence, not surprisingly, the same symbolic device or name is commonly used to refer to the set of rules and resources (the body of knowledge) to manipulate nature and the physical or symbolic artifact aiming to fulfill a societal function but resulting from applying the set of rules and resources in the mind of their creators. Technology is both an unfolding conceptual social entity about the manipulation of nature and, simultaneously, a fixed "material" object manipulating nature and perhaps evolving in future versions. In both cases, language is needed to refer to technology and commonly uses the same or similar labels (e.g., GPS is a label used to refer to a commercial device or artifact but also to the set of rules and resources constituting the global positioning system technology).

Under this lens, it is important to say that in its "material" form, technology is only technology once it is recognized in such a way in social interaction. Otherwise, such "material" form becomes any extra or unnoticed feature of the environment with no meaningful role potentially in social practice (Orlikowski, 1992).

In regard to the previous discussion, Giddens (1984, p. 33) says some resources might seem to have a "real existence," suggesting that structure may be also external or independent of individuals' knowledge (e.g., raw materials, land, etc.); however, the "materiality" of such phenomena does not affect the fact that they become resources in the manner in which ST applies the term. Hence, in disagreement with DeSanctis and Poole (1994), social structures are not located in technologies; instead, they are enacted by individuals, users or designers, in their social life (Orlikowski, 2000).

Figure 3-2 shows the structurational model proposed originally by Orlikowski (1992) but the following statements also incorporate fundamental clarifications according to Orlikowski (2000) and our suggested integrative description.

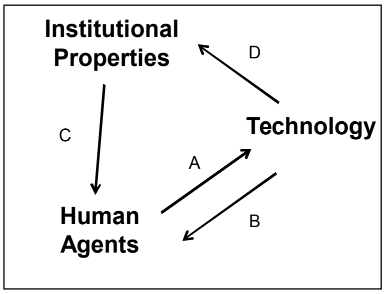

Figure 3-2 Structurational model of technology from Orlikowski in 1992

A. Technology is the product of human action (Quadrant I and II in Figure 3-1), resulting from creative human interaction either when it is designed, developed, adapted or changed. Technology refers to both (I) ongoing knowledge social structures constructed through human interactions and (II) physical or explicit artifacts constructed by individuals in interaction.
B. Technology is the medium of human action (Quadrant III and II in Figure 3-1), facilitating and constraining how humans carry out their activities and interactions. Technology refers to both (III) ongoing knowledge social structures enacted by individuals in social practices and (II) physical or explicit artifacts put into practice by individuals in their social life. Technology can condition human practices but cannot determine them because humans always can choose to act differently.
C. Institutional properties – e.g., organizational policies, professional regulations, state-of-the-art materials, dominant designs, and available resources (time, money and skills) – influence how humans interact with technology.
D. Institutional consequences emerge as a result of human interaction with technology, either reinforcing certain institutional properties or transforming them.

This new concept of technology highlights the analytical decoupling of "material" artifacts from the social structure that enables their instantiation (Orlikowski, 2000; 1992). This separation not only points out the social dimension of technology as an outcome of human interaction, but also brings to mind the discussion about the interpretation of technology resulting from social actors experiencing a time-space discontinuity[19] in the production and reproduction of technology-related social practices (Giddens, 1984). According to Barley (1986), the interpretation of technology is heterogeneous when “material” artifacts are enacted. Orlikowski (2000; 1992) says “technology is interpretively flexible,” technology can be enacted differently by individuals. Moreover, the interpretative flexibility of technology is a function of the explicit attributes of the “material” objects, the characteristics of individuals in relation with them and the socio-historical context implicated in their development and use (Bijker, Hughes, & Trevor, 1987; Orlikowski, 2000). For example, the design and use of a technology occur typically and analytically at different times and spaces (Orlikowski, 2000; 1992). In Figure 3-1, while technology is socially and physically constructed by designers, technology is socially enacted and physically put into practice by users. The recognition of the interpretative flexibility of technology is a fundamental aspect to better understand the social processes of creation and development of technology as well as its use and exploitation.

With the above discussion, rather than rigorous models of limited complexity that may define technology, this study calls for an open framework for the understanding of technology and its evolution (Geels, 2010). Open frameworks help researchers not only to think better through a given problem but also to capture more complexity from multi-dimensional and complex topics (Porter M. , 1991; Geels, 2010). Hence, like Matthewman (2011), Khalil (2000) and Burgelman, Christensen and Wheelwright (2004), this study does not rely on a definition of technology within only one perspective but instead embraces each definition of technology in Section 2.3 as complementary contributions in order to build a better theory (Poole & Van De Ven, 1989; Geels, 2010).

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19 Time-space discontinuity refers to the time difference in which technologies are produced and reproduced. Individuals are not always socially and physically producing and reproducing a technology. They create or make use of it in different times and spaces (e.g., when they are ready for or need it). Individuals produce and reproduce technologies according to their contextual situation.

3.5. The Creation of New Technologies and the Process of Technological Change in Society

The structurational model of technology suggests that our social and technological world is created and powered by individuals' patterns of activity. In dealing with their environments (Aunger, 2010; Simon, 1973), knowledgeable and reflexive individuals produce and reproduce technologies recursively. They envision technological solutions and opportunities to address their problems and needs, fulfilling societal functions. Individuals not only know how to use natural features of the environment but also know how to manipulate and produce changes on the existing nature of the environment, creating social and explicit artifacts. In this way, technologies are not only exploitable but also reusable, and they enable the creation of more complex technologies. Technology is an ongoing phenomenon in which mostly new technologies build on existing technologies as components (Arthur, 2009; Aunger, 2010). In Murmann and Frenken's (2006) terms, technologies become nested and hierarchically organized complex conceptual and explicit systems that evolved through technology cycles of components and subsystems at multiple levels.

This study further assumes that the basis of the complex dynamic of our world stems from thousands of purposive individuals designing, developing, adapting and changing technologies and social practices at various levels and domains of interaction (Kash & Rycroft, 2002). While technologies may be intended initially to solve a particular problem in the mind of their creators, technologies evolve frequently in unintended projects. Technologies do not result in products of or for any single person. Like any other resource in ST, technologies are created and recreated on an ongoing basis by individuals. Moreover, technologies are continuously interpreted, enacted, adapted and changed. Their conceptual form evolves and their explicit form does as well. From this perspective, the myth of the sole inventor (Lemley, 2012) or the literature of multiple independent inventions (Merton, 1973, p. 45; Voss, 1984) becomes highly compelling because similar resources and problems lead individuals to produce similar technological solutions. Only analytically technological change refers to the process by which a new technology alters the way individuals and organizations fulfill their societal activities, needs or functions (Geels, 2002). Technology refers to both social structures – individuals' knowledge – and explicit artifacts constructed by human interaction in contextual circumstances for purposive reasons. If technologies and technological trends are then highly complex ongoing processes in which individuals in their social organizations create, adopt, replace and alter technologies, what is a weak signal of technological change?

3.6. Weak Signals of Technological Change

In an ever-changing social and technological world, a weak signal of technological change may take many forms because human activities change at very different levels and domains. Consequently, this study proposes that a weak signal of technological change refers to an early indication of new patterns of activity triggered by the conceptual initiation of a new technology. A weak signal of technological change is not a speculative or discursive description of a potential new technology but rather a real behavioral pattern producing conceptually and explicitly the development of a new technology. Thus, the first sign of change is the creative action or the set of creative actions aiming toward the development a new technology (e.g., technology initiatives and developments by university scientists, industrial researchers, entrepreneurs in high-tech startups). In essence, weak signals are not the result of an imaginary future but of patterns of activity powered by purposive and knowledgeable actors seeding, leading and shaping the emergence of a new technological trend. Hence, events and patterns enacting the technology itself are the unit of analysis – the act of making or using explicit or embodied knowledge. Moreover, the engagement, routines and practices of actors along with the outcomes are essential features characterizing the emergence of a new social and technological trend.

3.7. Modeling the Structurational Process as an Object of Scientific Study

In Section 2.4, the multi-level perspective on technological transitions (MLPTT) by (Geels, 2002; Geels & Schot, 2007) describes theoretically mechanisms[20] associated with the process of reconfiguration and substitution of technology. However, the MLPTT does not seek to understand and manage the process of creation and development of technological change in practical terms. Like most institutional theories of change[21] (Poole, 2004; Barley & Tolbert, 1997), the MLPTT focuses on macro-level societal processes and long-term technological transformations in specific institutionalized forms of social activity. The MLPTT studies scientific factors that produce change but does not explain how change in day-to-day practice is brought about – a theory of changing. The MLPTT does not point out how social entities or institutional forms are created, altered and reproduced, so it lacks a process theory of institutionalization. For this reason, the MLPTT does not help to identify the emergence and development of new technologies and trends, but it inspired and guided our integrative theoretical framework[22].

On the other hand, ST illustrates analytically and conceptually the concrete processes of social life including how social organizations and institutions are created, altered and reproduced. ST explains generally a process narrative about how social forms unfold and produce social outcomes. However, ST does not explain how specific outcomes of systemic activity can occur or suggest a method of theory construction (Cohen I. J., 1989, p. 1). In this respect, Barley and Tolbert (1997) develop an argument to fuse ST and institutionalization theory because ST remains an abstract process theory that is difficult to apply in empirical studies. ST addresses how social life is

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20 Mechanisms refer to the explanation of how change takes place when pre-defined parts of a system interact.

21 Institutional theories of change focus on identifying the most important social entities and processes as variables in organizational fields and seek to explain change in terms of relationships among such variables (Poole, 2004; Barley & Tolbert, 1997).

22 The MLPTT reaffirms three basic arguments in line with our perspective: 1) the fundamental role of human agency; 2) the concept of alignment among heterogeneous sets of entities; and 3) the multi-level perspective integrating findings from different literatures. Moreover, the MLPTT uses the concept of structuration of activities in social practices (Geels & Schot, 2007).

produced and how change occurs but ST does not suggest what the change and the causes of change are in a given situation. ST is a general process theory of social change and, inherently, requires a complementary approach for scientific study of its explanatory power. Giddens (1984) indicates that ST can guide researchers to understand the process of social change, but it does not provide a methodological framework to identify factors that can be managed or manipulated. Once the object of study is defined, a researcher has to determine the logical implications of this theory in studying a subject matter, in order to suggest a methodological approach.

Poole, Van de Ven, Dooley and Holmes (2000), Langley (1999), Poole and Van de Ven (2004), Van de Ven and Poole (2005) advance the conceptual development of process approaches for conducting research and provide strategies to research methods that can support the study of process theories explaining change and innovation in organizational studies. These authors identify three main approaches in the study of change and innovation: variance method, process method, and modeling. While the variance method focuses on the test of hypotheses related to mechanisms and factors of change, the process method focuses on identifying the sequence of events, activities and their linkages producing change. Models refer to formal representations of theories and realities, and models offer an opportunity to bridge the gap between variance and process methods. Although the best method for a particular study depends on the type of research questions and the researchers' assumptions about the nature of the social world, the best approach is to find a way to combine variance and process approaches in a single analysis, enabling a deeper understanding of the dynamic of change that a single approach cannot provide (Poole, Van de Ven, Dooley, & Holmes, 2000; Poole, 2004; Van de Ven & Poole, 2005). Models are, therefore, not only a widely accepted approach in social science (Geels, 2002; Osterwalder & Pigneur, 2010; Senge, 1999) but also a powerful and essential practice in science (Thagard, 2009; Johnson-Laird, 1983; Frankfort-Nachimias & Nachimias, 1996) and particularly a well-suited approach for our study (Poole, 2004; Poole, Van de Ven, Dooley, & Holmes, 2000).

The structurational perspective of this study assumes the definition of process as a developmental sequence of events[23]. Consequently, based on insights and recommendations regarding how process theories can be mapped into models (Poole, Van de Ven, Dooley, & Holmes, 2000, p. 22; Poole, 2004, p. 14), the study proposes a hypothesized model of emerging technologies in Section 3.8, bringing together variance and process approaches. The structurational model of emerging technologies captures characteristics of processes – the extent of its development – as variables or constructs. While several variables refer to specific social attributes in a given time (e.g., technological outcome, level of impact, level of engagement and level of awareness), one variable is an operational measure characterizing specific patterns of social activity – our unit of analysis – in different levels and domains, illustrating theoretically how technological change occurs over time (e.g., degree of structuration). This latter variable does not refer to actions of individuals or organizations but encapsulates the presence and scale of specific social patterns in a given technological context. The model does not only exemplify the process of technological change but also enables one to test theoretical propositions – hypotheses – with traditional variable and analytical methodologies used in the variance approach. The model resembles an artifact simplifying in a single analysis the scientific study of technological change produced by emerging technologies (Hevner, Martch, Park, & Ram, 2004; March & Smith Gerald, 1995). As a process theory, this model assumes necessary but not sufficient causality. To provide evidence that the theoretical framework captures how change occurs, the structurational model of emerging technologies is an attempt to generalize first in terms of a process theory (i.e., ST) instead of generalizing in terms of variables (Poole, Van de Ven, Dooley, & Holmes, 2000). In essence, the study proposes how to model scientifically the complex and emergent dynamic of social and

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[23] Poole et. al (2000, p. 16) distinguish three strategies to research "process" in organizational studies: "(a) as a logic that explains a causal relationship between independent and dependent variables, (b) as a category of concepts or variables that refer to actions of individuals or organizations, and (c) as a sequence of events that describe how things change over time".

technological change and to think methodologically through the problem of identifying signals of technological change.

3.8. The Hypothesized Structurational Model of Emerging Technologies

The structurational model of emerging technologies (SMET) assumes that technologies are both ever-changing explicit artifacts constructed by individuals in interaction and continuous, social, contextual and abstract forms of knowledge instantiated in individuals' memory traces and social practices. Hence, as Giddens says, only analytically can such social forms be studied.

In Figure 3-3, the SMET proposes that once designers or creators put forward conceptually the development of a new technology, new technologies can develop different results in an ongoing, gradual process of institutionalization.

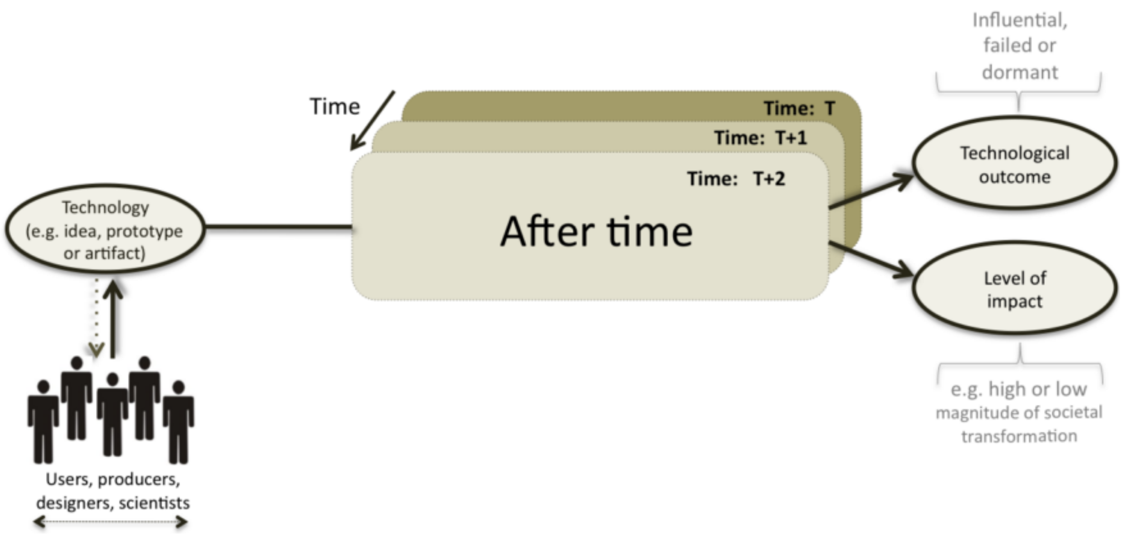

Figure 3-3 Technologies developing different results after a period of time

Figure 3-3 presents two widely accepted attributes referring to how a technology turns out after a period of time: technological outcome (Kaplan & Tripsas, 2008; Shilling, 2002; Khalil, 2000) and level of impact (Betz, 1998; Schilling, 2008; Whaley & Burrows, 1987). From our view, technological outcome and level of impact are ongoing, never fixed attributes depending on the evolution of the technology within its social and technological systems.

Technological Outcome

For practical and empirical research purposes, the SMET assumes that in time technological outcomes can be classified in one of three categories that best describe the technology status: influential, failed or dormant. First, influential technologies are those technologies that have transformed how individuals or organizations fulfill their activities, needs and functions. Second, failed technologies are technologies that were not adopted by their potential users and, thus, the technologies did not change how individuals or organizations operate in their technical, business and social environments. Lastly, dormant technologies are technologies that exist commercially but they are not popular or they are not growing. In essence, technological outcome refers to an attribute that describes the type of development that a given technology presents after a period of time: influential, failed, or dormant.

Level of Impact

Although Solow (1957; 1956) indicates that the aggregate impact of technological change can be quantitatively observed by looking at the residual of economic growth in GDP that does not result from growth in labor and capital inputs, the impact of individual technologies is not commonly studied and exists in very limited descriptive accounts (Friedewald & Raabe, 2011; Randeree, 2009).

In the technology assessment (TA) literature, impact assessment[24] focuses on contextual technological implications and consequences. In this study "impact" focuses on quantifying the overall degree of change or transformation resulting from the application of technology. Level of impact is concerned with the extent of change a technology produces on transforming patterns of social activity in society, but it is not concerned with the type of consequences of change. Thus, in the SMET, level of impact is a variable that aims to quantifying the total effect of a technology on society in a given time. "Impact" as a magnitude of change is well supported by other researchers. For example, Streatfiled and Marakless (2009), Ashkanasy (2009) and Kiernan (2012) indicate that the essential element of impact is a major identifiable change in individual or organizational practices. In sum, level of impact refers to the extent to which a technology has changed how individuals and organizations fulfill their activities, needs and functions.

Therefore, the question is, what makes a technology become influential, failed or dormant? Or, what allows one technology achieve higher levels of impact than others? The structurational view of technological change suggests that technologies experience over time a degree of structuration, which explains their technological outcome and impact.

<u>Degree of Structuration</u>

The SMET assumes that since their conceptual initiation, new technologies trigger new patterns of human activity at different levels and domains in their social and technological systems. Knowledgeable and creative individuals may engage or not as producers – "enactors" – of a new and ongoing recursively implicated technological development. Thus, over time new technologies can develop recursively organized rules and resources – institutionalized social forms – or social

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[24] Impact assessment refers to evidence based qualitative, quantitative and future oriented analyses of the effects of a technology on society (Tran & Daim, 2008; Coates J. F., 2001). Technology assessment aims to provide information on problems, alternatives and consequences of the application of technology and thus advise policy makers (Banta, 2009; Eijndhoven, 1997). Certainly, positive or negative aspects of the effects are the main subject of these discussions.

structure that not only constitute technologies themselves and guide their enactment by social actors, but also refer to social outcomes and visible patterns of human activity in their social system (Stones, 1991, p. 675). Although this theoretical framework focuses on the development of social structure as outcomes[25], it recognizes that changes in social outcomes come from variations in social means[26] – the duality of the structure. The emphasis on social outcomes comes from the objective of identifying changes in the performance of social practices at the system level – the enactment of a technology in a given social system. Our emphasis on social outcomes as visible patterns (Stones, 1991) is consistent with that of Snowden (2002, p. 107), Aaltonen (2007, pp. 79-81) and Kuosa (2011) who indicate that in the analysis of complex phenomena, behavioural patterns are the basis of individuals' sense making and more tangible than knowledge, understanding and beliefs by itself.

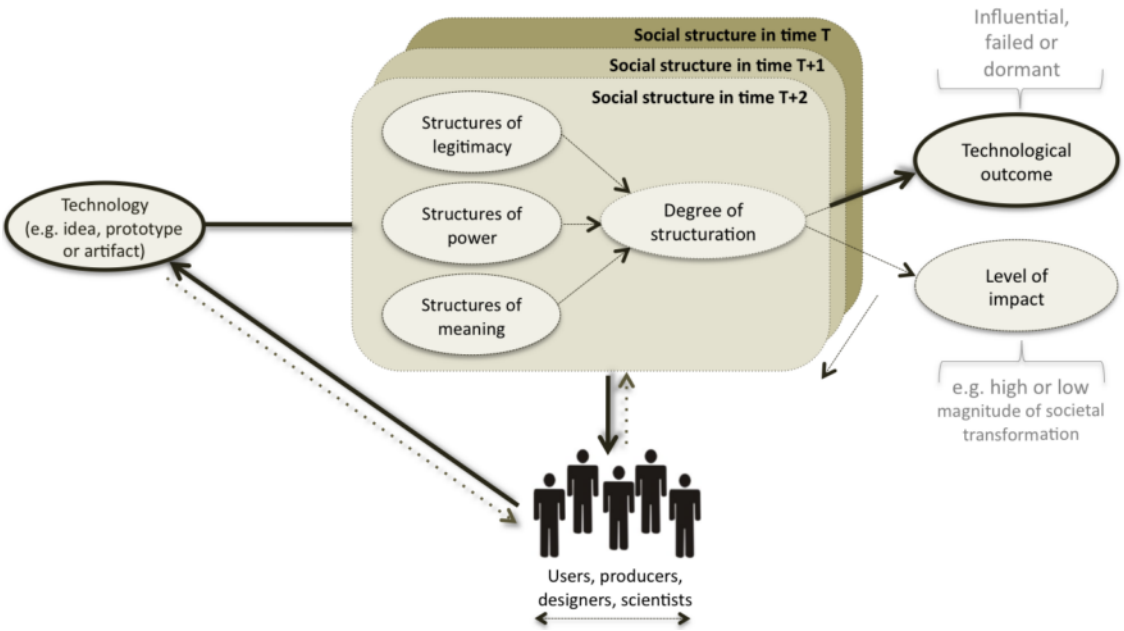

Figure 3-4 Technologies developing different degree of structuration – social structure

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[25] According to (Giddens, 1984, p. 288; Cohen I. J., 1989, p. 89; Stones, 1991), the social structure can be empirically analyzed in two ways: as an outcome (institutional analysis) or as a means (strategic conduct analysis).

[26] Social means refers to rules and resources instantiated in individuals' heads.

Figure 3-4 introduces the construct of *degree of structuration*, which captures for a given technology the development of its social structure over a period of time. The study hypothesizes that only those technologies experiencing and developing social structure can reach an influential status and consequently higher levels of impact. Certainly, while new technologies can accumulate social structure, existing ones can also restructure or dissolve it.

The degree of structuration (DS) is the central construct in the SMET and refers to the extent of development of social structure enabling and resulting from the enactment of a technology. DS refers to the degree to which social outcomes[27] indicate the existence of rules and resources enabling and resulting from the enactment of a technology. Importantly, DS entails the extent of development of social structure in its three analytical dimensions: structures of meaning, structures of power, and structures of legitimacy (Giddens, 1979, p. 81; 1984, p. 31). Hence, the SMET proposes that new technologies experience over time a DS that can be estimated by examining the extent of development of their analytical structures of meaning, power, and legitimacy.

Structures of meaning (SM, see Table 3-1) refers to the degree of development of social outcomes indicating the existence of rules and resources that not only inform and define individuals' interaction but also enable shared meaning among them. In other words, SM looks at the extent to which some institutionalized forms of activity enable shared meaning and define the enactment of a technology in question. Table 3-1 provides three examples of social outcomes suggesting structures of meaning that, not surprisingly, are consistent with findings and arguments in the literature of technological change and scientific development. These theories and findings suggest such underlying patterns in the development and use of a new technology. It is interesting to

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[27] Social outcomes refers to events, activities, organizations, institutions, technologies, practices, trends that result from ongoing patterns of human activity.

reframe these studies referring to the developmental process of rules and resources that inform and define individuals' interaction and enable shared meaning among them.

Structures of meaning	Social outcomes	Findings and arguments suggesting specific patterns or milestones in the enactment of a new technology
Social outcomes indicating the existence of rules and resources that not only inform and define individuals' interaction but also enable shared meaning among them	A collective interpretation of the technology	Latour and Woolgar (1986), Barley (1986) and Orlikowski and Gash (1994) suggest the fundamental development of a collective interpretation of the essential attributes characterizing a new technology in its context.
	An explicit and exploitable artifact	Munir (2003), Suarez (2004) and Arthur (2007) point out the prerequisite of an explicit and exploitable artifact – technological system – that provides factual solutions to speculative claims about a new technology.
	A collective vision of purpose and usefulness	Kaplan and Tripsas (2008), Weick (1990) and Bijker (1995) argue the development of a collective vision of purpose and usefulness achieving interpretative stability about where and how to make use of a new technology.

Table 3-1 Examples of structures of meaning

Structures of power (SP, see Table 3-2) refers to the degree of development of social outcomes indicating the existence of rules and resources that not only enable individuals' interaction but also enable them to reaffirm or alter the degree of "systemness" in their social systems. In other words, SP examines the extent to which some institutionalized forms of activity transform earlier social practices showing evidence of the transformative capacity of individuals. Table 3-2 presents three examples of social outcomes suggesting structures of power. These three outcomes entail a social transformation. Although arguments and frameworks in the existing literature do not emphasize strongly the role of and effect on social actors, often they make explicit these assumption in their explanations. That is, these authors assume that individuals are creators and users of technologies, and technologies are means of transformation (e.g., solving problems, anticipating needs, creating wealth, and improving wellbeing).

Structures of power	Social outcomes	Findings and arguments suggesting specific patterns or milestones in the enactment of a new technology
Social outcomes indicating the existence of rules and resources that not only enable individuals' interaction but also enable them to reaffirm or alter the degree of "systemness" existing in their social systems	Solution of problems and needs	Simon (1973), Betz (1998), Arthur (2007) and Aunger (2010) point out the fundamental role of technologies as means that enable the solution of problems and needs for individuals and society.
	The creation of new technologies	Clark (1985), Baldwin and Clark (2000), Murmann and Frenken (2006), and Arthur (2009) describe the powerful effect of technologies as systemic entities hierarchically organized and assembled from previous technologies creating or destroying entire industries in an aimless project.
	The creation of new businesses	Dosi (1982), Prahalad and Hamel (1990), Mitchell (1985; 1990), and Suarez and Utterback (1995) suggest the central role of technologies as a driving force in business and social organizations aiming to create wealth and improve wellbeing.

Table 3-2 Examples of structures of power

Structures of legitimacy (SL, see Table 3-3) refers to the degree of development of social outcomes indicating the existence of rules and resources that sanction the normative aspects of social practices including meaning. SL pays attention to the extent to which some rules and institutionalized forms of activity support and approve the production or reproduction of particular social practices. Table 3-3 shows three examples of social outcomes suggesting structures of legitimacy. In Geels and Schot (2007) terms, most of these rules and resource are deep structural conditions enabling and guiding action in context. Although some of these institutionalized forms may have taken a "material" form (e.g., laws, policies, institutional agreements, and industrial standards), the consequence of the enactment of these rules and resources is what matters in the ongoing social constitution. As said in Section 3.4, the potential "material" form of such rules and resources is an additional aspect of the structurational process proposed here.

Structures of legitimacy	Social outcomes	Findings and arguments suggesting specific patterns or milestones in the enactment of a new technology
Social outcomes indicating the existence of rules and resources that sanction the normative aspects of social practices including meaning.	New social norms or routines evaluating social practices	Latour and Woolgar (1986), Garud and Rappa (1994), Kaplan and Tripsas (2008) and Schilling (2008) point out the social and cognitive processes that unfold as part of the development of a new technology and sanction new routines and social practices.
	Institutional agreements or alliances	Suarez (2004), Geels (2002) and Geels and Schot (2007), and Leblebici, Salancik, Copay and King (1991) indicates the role of organizational resources and institutional arrangements supporting the development of technological trajectories.
	Alignment with regulatory frameworks	Nelson and Winter (1982), Geels (2002), Antonelli and Quatraro (2010), Weber and Rohracher (2012) highlight the significant influence of regulatory frameworks and public policy in the direction of technological change.

Table 3-3 Examples of structures of legitimacy

Table 3-1, Table 3-2 and Table 3-3 suggest some examples of social outcomes that can indicate the development of structures of meaning, power and legitimacy, respectively. This list is not exhaustive and the study does not claim for it.

The SMET and DS result from deductive reasoning based on the structurational perspective explained briefly in previous sections. However, it is equally important to state that theories[28] and findings in the literature of technological change and scientific development inspire and support our theoretical proposition. Moreover, while several theories and findings provide a top-down perspective – an institutional view – to identify fairly what social outcomes to look at in this knowledge domain (e.g., Geels (2000); Suarez (2004); Arthur (2007)), few other theories and findings draw on a bottom-up approach that is internally consistent with the structurational

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[28] For example, by following Giddens, Geels (2002) and Geels and Schot (2007) conceptualize technological transitions as realignments between social configurations at three different levels (i.e., technological niches, socio-technical regimes, and socio-technical landscape) and they make clear that each level entails a social structure produced and reproduced by the actions of social actors, indicating that social practices vary in their degree and kind of structuration across the three levels. More precisely, they say that while technological niches present weak structuration, socio-technical regimes experience strong structuration. In the case of socio-technical landscapes, they refer to deep structural conditions making some actions more natural than others.

approach (e.g., Latour and Woolgar (1986); Barley (1986); Garud and Rappa (1984)). Because any theory seeks to understand and manage practically the process of creation and development of technological change, our study proposes to explore the explanatory power of this integrative framework. Moreover, it is believed that this framework has the potential to reconcile the existing literature, currently fragmented for the most part and based mostly on linear explanations with few exceptions.

The SMET categorizes analytically, then, three key intertwined social processes and structures that may not be sufficient but necessary to explain the emergence and development of influential new technologies. In particular, the study postulates that only those technologies that experience and develop social structure in their three analytical dimensions will reach an influential status and consequently higher levels of impact than failed or dormant technologies. Hence, the following first set of hypotheses is offered:

H1: Influential technologies develop a higher degree of structuration than failed or dormant technologies.

H2: Influential technologies increase their degree of structuration over time while failed or dormant technologies do not.

H3: The perceived level of impact of a technology is positively associated with its degree of structuration.

The structurational perspective (examined in H1-3) not only assumes that technologies develop a degree of structuration over time but also suggests that individuals producing and reproducing that social structure are shaped by the result of their own actions and the role they play in the production of the social structure. The recognition of this structurational premise enables a second set of hypotheses (H4-8), geared largely to the interpretation and broader understanding of structuration, which are explained after we present the hypothesized SMET in Figure 3-5.

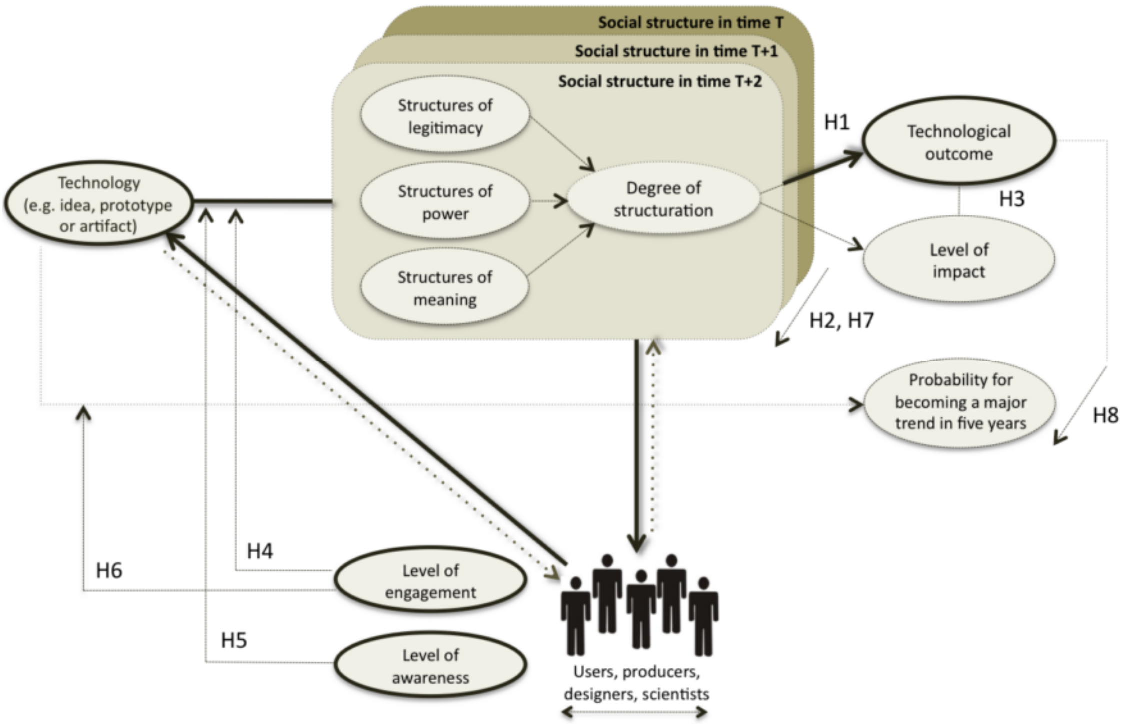

Figure 3-5 Hypothesized structurational model of emerging technologies (SMET)

Level of engagement

In Section 3.5, the structurational perspective indicates that social and technological systems in which individuals and organizations operate are produced and reproduced by a vast number of purposive individuals dealing with their environments. Although the resulting social and technological structure is not the product of one individual but the consequence of interactions of a collectivity, the SMET suggests that those individuals highly engaged as creators and producers of a specific technology domain not only possess the rules and resources for the production of that social system but also are able to better identify resulting social outcomes characterizing the system.

Level of engagement refers to the degree of participation that an individual experiences in the enactment of a technology and its trend. Level of engagement considers the extent to which an individual has been involved with the use, study and development (technical or business) of rules and resources enabling or related to a specific social and technological system.

The SMET postulates that those individuals with high level of engagement in the enactment of a technology and its trend not only possess the rules and resources implicated in the technology enactment but also are able to say more and perceive better the resulting social outcomes and activities shaping the social and technological system. Thus, it is hypothesized:

H4: Individuals highly engaged with the enactment of a technology perceive more highly its degree of structuration.

Level of awareness

In Section 3.2, the structurational perspective indicates that to be knowledgeable and reflexive refers also to the social awareness of individuals. Level of awareness refers to the extent of being conscious of events and their surrounding circumstances. Level of awareness examines the degree to which an individual knows and understands his or her actions, the actions of others, and the social and technological conditions implicated in the enactment of a technological environment.

The SMET supposes that those individuals with high level of awareness about technologies and trends not only monitor what they and others do and the contextual circumstances of their social and physical environments, but are also able to perceive and rationalize better the resulting social outcomes and activities that enact their system. Thus, it is hypothesized:

H5: Individuals with higher level of awareness with a technology perceive more highly its degree of structuration.

Probability of becoming a major trend in five years

The SMET proposes to estimate for each technology a construct of its probability of becoming a major trend in five years. Probability of becoming a major trend in five years refers to an individual's inference, based on experience and reasoning, with respect to the success[29] of a

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[29] Success is defined as technology adoption by at least 50% of the population in a given environment.

technological trend in five years. Similar to our rationale for level of engagement, the SMET postulates that those individuals with high level of engagement in the enactment of a technology and its trend not only possess the rules and resources implicated in the technology enactment but also are expecting and working toward the success of their technological propositions. Thus, it is hypothesized:

H6: Individuals highly engaged with the enactment of a technology perceive a higher probability of it becoming a major trend in five years.

The structurational process and collectivity

The SMET assumes that the structurational process of a technology can be observed not only through the means of assessing the development of its social structure as outcomes[30] but also through the development of consensus with respect to its social outcomes, independently of individuals' levels of engagement with such technology. Thus, the SMET proposes that influential technologies develop consensus with respect to their social outcomes among individuals while failed or dormant technologies do not. Since the structurational process operates particularly in influential technologies but not in failed or dormant ones, it is hypothesized:

H7: Over time, influential technologies decrease variance in their degree of structuration while failed or dormant technologies do not.

H8: Over time, influential technologies decrease variance in their probability of becoming a major trend in five years while failed or dormant technologies do not.

Finally, the structurational perspective assumes that individuals are always bounded by their contextual circumstances, knowledge, skills, unconscious motivations and unacknowledged conditions of action (Giddens, 1984, p. 281). The SMET recognizes this phenomenon as a threat

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[30] Social outcome refers to events, activities, organizations, institutions, technologies, practices, trends that result from ongoing patterns of human activity.

and potential source of distortion (bias) for our scientific study. Consequently, in Section 4.6 the SMET proposes methodologically the use of effective and practical procedures for controlling and reducing the effect of this pervasive and inherent feature in human reasoning (Davies, 1987; Arkes, Guilmette, Faust, & Hart, 1988; Roese & Vohs, 2012; Koriat, Lichtenstein, & Fishhoff, 1980; Hertwig, Fanselow, & Hoffrage, 2003; Hoffrage, Hertwig, & Gigerenzer, 2000). Nonetheless, the SMET aims to explore also participants' perception with respect to their own personal hindsight bias[31] and the extent of hindsight bias that other participants in the study may experience. To this end, while not a formal hypothesis, we seek to initiate some preliminary probing of how hindsight bias may operate in this type of retrospective study. Consequently, it is anticipated that the self-reported personal hindsight bias of participants is lower than the perceived hindsight bias of other participants.

3.9. Methodological Notes: Building the SMET and Rethinking Expertise

In Sections 3.2 and 3.5, the structurational perspective suggests that the social and technological systems in which individuals and organizations operate are produced by a vast number of individuals and organizations aiming to manipulate and transform their environments. Individuals participate differently in such multi-level and multi-dimensional complexity[32]. Not surprisingly, in Simon's terms (1979; 1955), individuals experience bounded rationality, limited knowledge and ability. Or as stated by Giddens (1984, p. 281), individuals are always bounded by their contextual circumstances, knowledge, skills, motivations and unacknowledged conditions. Thus, no one

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[31] Hindsight bias refers to the human tendency to overestimate judgments of past events (e.g., likelihood of predicting an outcome) based on the outcome knowledge of what happened rather than on evidence and knowledge of the original conditions (Mackay & Mckiernan, 2004; Christensen-Szalanski & Willham, 1991; Guilbault, Bryant, Brockway, & Posavac, 2004).

[32] While some individuals may produce enabling technologies, others may apply resulting technologies for solving problems in different social and technological domains. Social and technological systems are the result of a highly complex process of transformation in which enablers, creators, users, adaptors and changers produce an extensive set of social outcomes recursively organized.

knows everything to understand and depict "truth" statements of her or his particular social and technological reality.

Hence, the SMET proposes to approximate (Simon, 1979) the social and technological system by eliciting experts' knowledge[33] from the technology domain in question. Knowledgeable and reflexive individuals possess the rules and resources implicated in the production and reproduction of their systems. This approach may resemble Popper's (1968) proposition suggesting that the consensus of experts in a field can lead reasonably to objective knowledge independent from individuals, although in our case there is no claim to achieve the truth "out there." The study is consistent with the ST that does not assert any ontological position. In Chapter 4, this study suggests nothing more than an application of suitable scientific methods to explore methodologically and practically solutions for representing an ongoing social and technological system. Thus, the SMET proposes analytically to model the social structure of the social and technological system by eliciting a collective interpretation from knowledgeable individuals. Note that the SMET does not propose to consider the opinion of knowledgeable individuals about the technology itself but instead focuses on making use of their social awareness in perceiving patterns – social outcomes – in a situated context (Glaser & Chi, 1988, p. xvii). These knowledgeable individuals act as sensors in a monitoring system. Particularly, the SMET is interested in identifying patterns of activity resulting from the interaction between new technologies and their technological environment. Certainly, although the SMET suggests that increasing the variety and number of individuals with realm and substantive experience (Rask, 2008) leads to a better representation, the study recognizes that time and instrumental constraints are always part of the equation. Not surprisingly, this structurational perspective may resemble a social constructivist approach (Geels, 2010) in which

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[33] The concept of expert is refined below according to the structurational proposition.

an approximation of reality can be studied only holistically[34] (Guba & Lincoln, 1982), inquiring into subjective interpretations from knowledgeable individuals in the field in question.

The SMET suggests a reconceptualization of expertise. The existing literature of expertise demonstrates the superior performance of experts in their specific domains of knowledge and indicates what aspects distinguish experts from people in general. Expertise literature focuses mostly on answering these questions: What constitutes an expert[35] (Glaser & Chi, 1988) and how is expertise and superior performance acquired and explained[36] (Ericsson, 2005)? However, as a rule the literature of expertise is concerned with the observation of individuals' performance in standardized situations[37]. The study of expertise in natural context or real-life situations – in practice – is very limited and difficult (Ericsson & Smith, 1991). Nonetheless, several findings and arguments are consistent with our structurational proposition. For example, Ericsson, Krampe, and Tesch-Römer (1993) assert that the crucial factor leading individuals to the acquisition of a superior performance is their engagement in training and deliberate practice – a special set of effortful activities aiming to improve specific aspects of their performance. In structurational terms, those knowledgeable and reflexive individuals highly engaged in the production and reproduction of their social and technological systems are more able to say, do, and understand the rules and resources that constitute their enacted systems. Rossano (2003) suggests that consciousness and social awareness are indicators of expertise.

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34 "Holistically" implies a systemic perspective in which plausible explanations can be drawn in their natural context from identifying elements of the system (e.g., events, activities or factors), their purposes and the interacting relationship among them (Guba & Lincoln, 1982). They emphasize that the dissociation of the wholes is to alter them radically.

35 For example, experts excel and perceive large meaningful patterns in their domains; experts are faster and perform more error free; experts demonstrate superior short- and long-term memory and develop deeper representations of their problems; experts spend a great deal of time analyzing problems and have strong self-monitoring skills.

36 For example, the chunking theory suggested by Chase and Simon in 1973; the template theory indicated by Gobet and Simon in 1996; the skilled memory theory put forward by Chase and Ericsson in 1982; and the deliberate practice theory proposed by Ericsson, Krampe and Tesch-Römer in 1993 (Rikers & Paas, 2005).

37 Standardized situations refer to representative activities capturing the relevant aspects of superior performance under controlled conditions (Ericsson & Smith, 1991, p. 8). For example, laboratory tasks or test.

Similarly, consistent with Collins and Evans (2007), the SMET suggests that expertise is more than attribution by members of a social group in a knowledge domain. Substantive and real expertise in natural context is not only a matter of expert's relations with others. Expertise status is a dynamic attribute emerging from continual interactions and immersion within a group of experts, as well as performance and contributions within such a practical technology domain. In structurational terms, the social structure of a social and technological system exists only in individuals who are producing and reproducing it on an ongoing basis. Social outcomes and contributions are fundamental results distinguishing experts from people in general (Knox, O'Doherty, Vurdubakis, & Westrup, 2007). Those experts spending time away from their expert's group or system can lose expertise – the rules and resources making up the domain in question in an ongoing world. Therefore, the structurational lens suggests, in essence, that expertise status is more a temporal attribute describing the extent of engagement that individuals experience in the enactment of specific aspects of their social and technological systems. For this reason, the selection of individuals with high level of engagement – experts – in the technology domain of question is a crucial point in our proposition to build the SMET.

Chapter 4. Research Design, Strategies and Methods

This study applied a pragmatic[38] worldview such that the basic principle guiding the researcher's actions was to examine the original research question: How to identify early signals of technological change? The study used several theories and perspectives to integrate a novel social constructivist systematic framework that examines the emergence and development of new technologies. Based on this theoretical lens, the study devised an original strategy of inquiry to explore the explanatory power of the proposed framework and test several propositions. Although the theoretical framework of the study may suggest a nature of the social world comprised of interpretations – a social constructivist view – the study did not rely on participants' insights to account for the process of technological evolution. As well, the research design[39] was not focused on investigating a variance theory[40] to explain the emergence and development of technological trends. Instead, the study was focused on proposing and testing a set of minimum required social processes involved in the emergence and development of technological trends – it explored and tested, then, the integrative theoretical framework summarized by the model in Section 3.8.

This study conducted an exploratory case study employing a sequential transformative mixed method procedure. This type of procedure refers to a research strategy in which the researcher uses a theoretical lens that guides the entire empirical study and combines sequentially qualitative and quantitative methods to explore and advance a particular research problem (Creswell, 2009). The case study strategy offered the opportunity to analyze in depth a contemporary situation bounded by time and activities (Creswell, 2009, p. 13). Besides, the case study strategy allowed the use of

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38 Pragmatist research uses all research resources available to solve the research problem without any particular commitment to one philosophical system or reality (Creswell, 2009).

39 "A research design is the logic that links the data to be collected (and the conclusions to be drawn) to the initial questions of study"(Yin, 2003, p. 19).

40 "A variance theory explains change in terms of relationships among independent and dependent variables, while a process theory explains how a sequence of events leads to some outcome" (Poole, 2004).

multiple research methods[41] to examine in practice a complex social phenomenon (Yin, 2003, p. 2). The exploratory attribute of the case study refers to the overall goal of the study, exploring the concept of weak signals of technological change and exploring the explanatory power of the proposed theoretical lens (Yin, 2003, p. 3; Creswell, 2009, p. 98).

In sum, guided mainly by the Structuration Theory, the proposed framework informed the research design of the study and shaped not only what to look at but also what to ask about in the data collection phases. Accordingly, qualitative methods were employed to address specific challenges of the research process, and quantitative methods enabled the examination of the study propositions.

4.1. An Exploratory Case Study of Technologies in the Internet Industry

Because the case study investigated empirically the theoretical propositions linked to our hypothesized model described in Section 3.8, the study had an inevitable focus on a retrospective analysis. In particular, the case study focused on testing the extent of development of specific social patterns enabling or constraining – explaining – the emergence and growth of technologies and technological trends in the Internet industry in the last ten years.

The Internet industry was selected as the case study because the Internet has been by far the most important technological breakthrough in recent decades and has changed the world in fundamental ways (President's-Advisors, 2010; Bargh & McKenna, 2004; Forman & van Zeebroeck, 2012; Lysenko & Desouza, 2012). Several studies have shown clear evidence that Internet technologies have had a significant effect on economic growth (Choi & Myung, 2009; Stryszowski, 2012). OECD[42] classifies "Internet" as a principal sector along with health, education and agriculture. Manyika and Roxburgh (2011) estimate that 21 percent of GDP growth in mature economies over

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41 Research strategies can overlap and coexist in a research design (Yin, 2003, pp. 3-5)

42 OECD is the acronym for Organization for Economic Co-operation and Development.

the past five years has been the result of Internet technologies. Furthermore, OECD reports[43] describe the impact of Internet technologies on improving consumer welfare, employment, business environments, firm performance, environmental challenges, education and research, healthcare and government activities. Hence, the Internet industry provided an exciting field with potential stakeholders interested not only in participating but also in our findings.

The research design preferred face-to-face interviews with Internet experts instead of a review of archival documentation. Four main reasons supported this decision: 1) transformative designed interviews did not require the researcher to have in advance extensive expertise in the technology domain under investigation; 2) transformative designed interviews avoided the challenge of complexity of the data existing in secondary source analysis; 3) transformative designed interviews offered the opportunity of producing a standard procedure for improving current technology intelligence practices; and 4) interviews presented the opportunity to interact with persons directly involved in enacting the technology domain in question.

The case study examined Internet technologies and trends in the last ten (10) years. A ten-year time frame represented a reasonable balance in the trade-off between participants' memories and the evidence of social and technological change in the industry. Although the Internet industry is widely considered a fast-changing environment, obvious and unambiguous new social and technological practices take time (e.g., more than five (5) years in some cases). On the other hand, it was believed that a ten-year time frame was an appropriate time period to recall generally contextual conditions that Internet experts had experienced in their recent professional lives. For these two reasons, a ten-year time frame was a reasonable and practical time period for our research.

The case study also examined the future of Internet technologies for three reasons: 1) there was research interest in exploring the future of Internet technologies with a group of Internet experts;

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43 OECD's Internet-related reports are in a special section called "The Internet Economy".

2) there was a desire to produce a practical outcome of benefit for our research participants (e.g., a foresight exercise); and 3) it offered an opportunity to analyze foresight data through our theoretical lens.

For convenience, the region of the study focused on Southern Ontario, although it included some international participation that fulfilled the same selection criteria. Two groups of Internet experts were interviewed in the study: 1) Internet business experts[44] (IBEs) focused on the commercialization or exploitation of Internet technologies; and 2) Internet technology experts[45] (ITEs) focused on the study and technological development of Internet technologies. The criteria and standard procedures for selecting experts are reported in Appendix C Section C.1. Our theoretical framework suggested particular attention to the selection of experts. Expert status was considered as a dynamic attribute emerging from continuous interaction and contribution within a group of experts in a technology domain. Hence, the purposive but systematic selection of experts in Appendix C Section C.1 focused on experts' involvement in their field instead of a set of experts' qualifications (credentials). Based on Collins and Evans (2007) and our framework, this approach was expected to improve the reliability of studies relying on expertise. See Appendix C Section C.5 for a complete description of our research participants – Internet experts.

The case study employed the sequential transformative method procedure illustrated in Figure 4-1.

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[44] For example: chief executive officers, chief technology officers, project managers, product developers and entrepreneurs.

[45] For example: researchers, professors and scientists studying and developing Internet technologies.

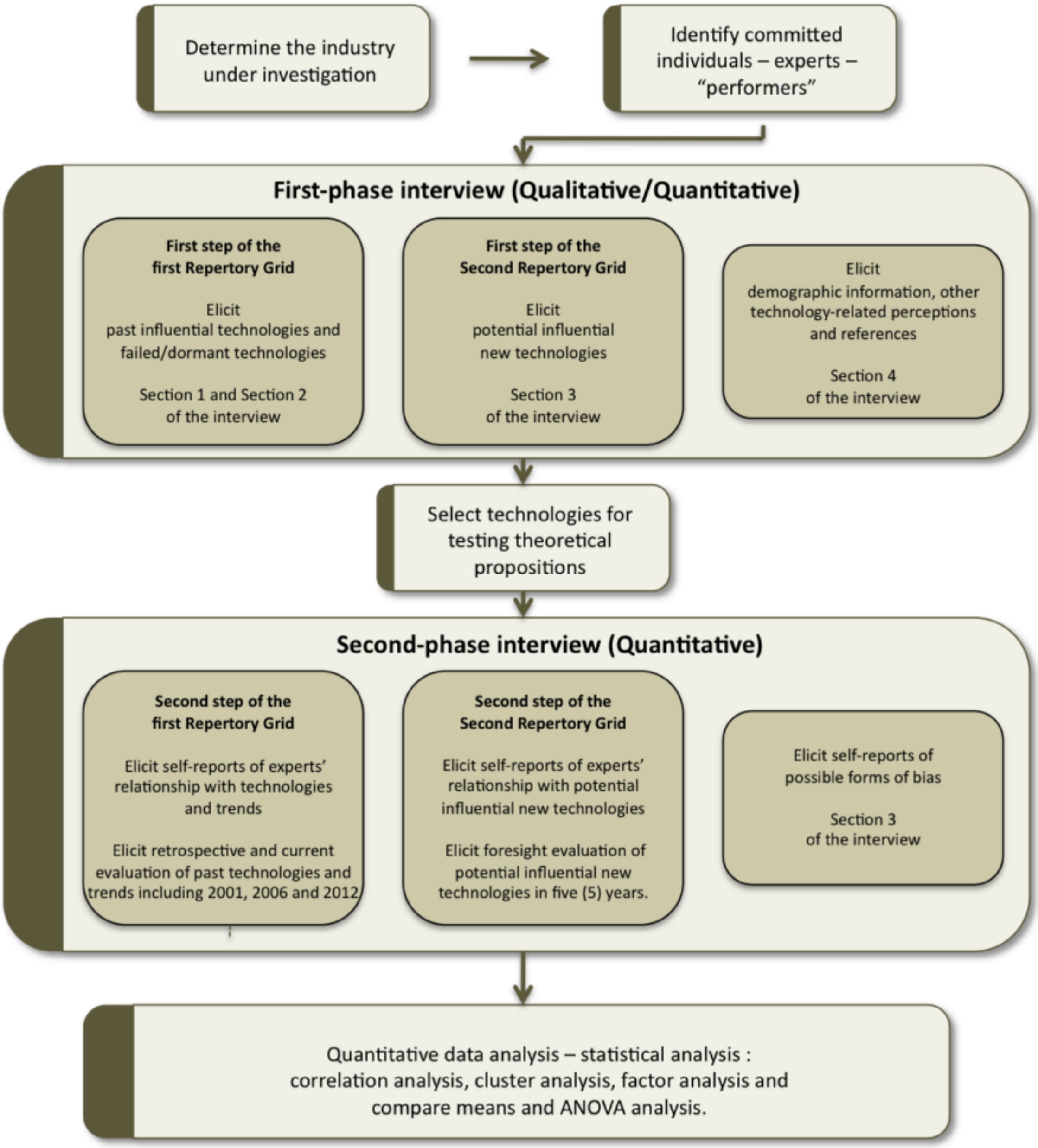

Figure 4-1 Sequential transformative method procedure

This procedure was inspired by the Repertory Grid Technique (RGT) from Kelly (1955) and consisted of two-phase, face-to-face, computer-assisted interviews conducted with each expert. The first-phase interview was a qualitative and quantitative study (using a structured questionnaire) that includes the first step of an Adapated Repertory Grid (ARG). The second phase was a quantitative study (using a structured questionnaire) that comprises the second step of an ARG.

4.2. An Adapted Repertory Grid (ARG)

The RGT[46] enables researchers to build a cognitive model of how research participants differentiate between specific elements, social events, or entities. The three main components of a full repertory grid are elements, constructs and links (Tan & Hunter, 2002). Figure 4-2 displays a repertory grid example.

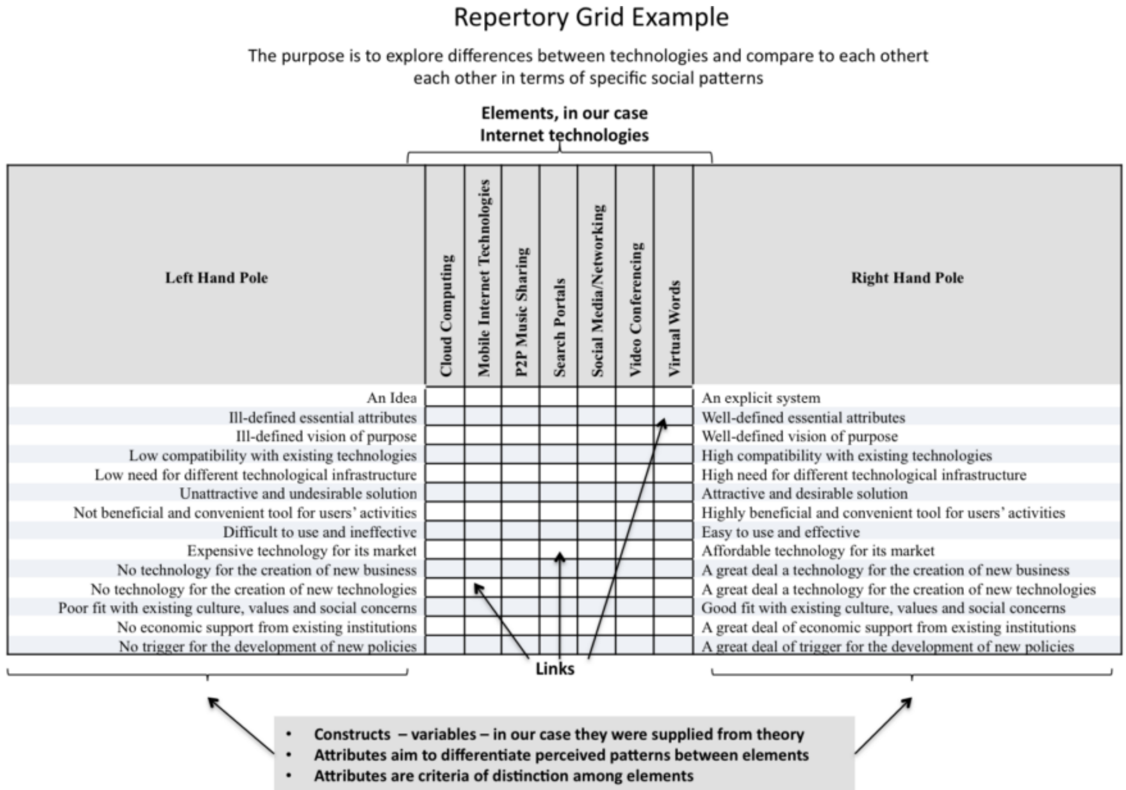

Figure 4-2 Repertory grid example

Elements refer to a representative set of specific subjects of attention (e.g., individuals, technologies, events, or activities) from the same predefined category. Elements play the main role

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46 The RGT models a subset of the personal construct system of an individual (Kelly, 1955). The technique aims to better understand how individuals make sense and respond to situations they encounter in their social world (Dillon & McKnight, 1990). The RGT focuses on eliciting individuals' ideologies with respect to specific domain of experiences (Wilson & Hall, 1998). The RGT provides an abstract characterization of how individuals classify things and events (Wacker, 1981).

in the situation under investigation[47]. Constructs refer to a set of interpretations that distinguish elements and relate them to a particular situation. Constructs are bipolar. That is, constructs have opposite sides (e.g., high sensitivity to humidity – low sensitivity to humidity; high color quality – poor color quality). Links refer to how interviewees interpret and rate each element with respect to each construct.

The RGT is an adaptable procedure that allows for a wide variety of designs and uses. (Alexander & Van Loggerenberg, 2005; Easterby-Smith, 1980). In our study, elements were technologies, and the first-phase interview focused on characterizing past and future Internet technologies. While elements were elicited in the first interview, constructs were supplied in the second interview and they were variables from our structurational model of emerging technologies (SMET). The RGT was not used to elicit personal construct systems from participants with respect to how they understand and explain the emergence and development of Internet technologies. Constructs were provided in order to evaluate and differentiate among selected technologies and trends. Hence, this Adapted Repertory Grid (ARG) was used as a semantic differential instrument (Judd, Smith, & Kidder, 1991, p. 167; Easterby-Smith, 1980; Fransella & Bannister, 1977, p. 3) by which Internet experts assessed and differentiated among technologies and trends in terms of a set of proposed constructs. The purpose of the ARG was to explore differences among technologies and compare them to each other in the extent of development of specific social patterns – constructs (Stewart & Stewart, 1981, p. 67; Fransella & Bannister, 1977). That is, constructs aim to capture the extent of development of specific social patterns for each technology. Thus, Internet experts were asked to characterize technologies and trends in a situated context of action and time in the Internet industry. In essence, our SMET was embedded in the ARG.

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[47] The literature of RGT suggests that elements are usually concrete and precise entities whose nature, definition and names can be agreed by experts (Shaw & Gaines, 1989).

The ARG supported two tasks. First, it enabled a methodological modeling of how experts understand and structure particular experiences related to technologies and trends in the Internet industry. Second, it enabled the gathering of gather experts' knowledge and testing to determine if our theoretical framework provided explanatory power for the emergence and development of a selected group of Internet technologies. Additionally, the RGT offered not only a structured procedure for eliciting data from research participants but also multiple and powerful ways to perform statistical analysis of the collected data (Tan & Gallupe, 2006; Tan & Hunter, 2002). Hence, the ARG resulted in a suitable and powerful analytical tool. The ARG enabled the researcher to achieve three main objectives: 1) model methodologically the examination of specific social patterns – recurring situations and processes – involved in explaining the emergence and development of technological trends; 2) propose a systematic "collective" interpretation of the Internet industry based on a participatory process; and 3) examine experts' understanding of specific social patterns[48] in a situated context of action and time in order to test propositions related to the emergence and development of technologies and trends. In this way, as mentioned in the introduction, the researchers fulfilled his commitment to explore and solve in practice the original research question: How to identify early signals of technological change? The study not only proposed a method to capture the complexity of technologies and trends in an industry and track them, but also probed a conceptual artifact addressing the original concern.

4.3. First-Phase Interview: A Structured Questionnaire Eliciting Technologies

The first-phase interview comprised qualitative research sections that aimed to learn about and characterize the Internet industry in terms of its past, present and future technologies and trends.

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[48] According to Snowden (2002, p. 107) and Kuosa (2011, p. 460), individuals also make decisions based on the understanding of past or perceived future patterns. These authors suggest that patterns refer to a visible evidence of behavioual outcomes in relation to individuals' environments.

As well, the first-phase interview included quantitative sections focused on quantifying specific attributes about technologies. The qualitative research sections were not aimed at theory development as typically qualitative research, but they were intended to understand and develop a collective interpretation of the Internet industry based on our theoretical lens and experts' perceptions. According to our lens, the constituent actors of the Internet industry – committed Internet contributors – were individuals able to verbalize and clearly identify technologies and trends making up the technological landscape in question. Hence, the first-phase interview aimed to achieve four purposes: 1) identify influential technologies enabled by the Internet in the last ten years; 2) identify failed or dormant technologies enabled by the Internet in the last ten years; 3) identify potential influential new technologies enabled by the Internet in the next five and ten years; and 4) obtain self-reports from participants indicating demographics, level of involvement in the industry, and some other technology-related perceptions. Figure 4-3 shows the content areas addressed in the first-phase interview. First-phase interviews lasted approximately 50 minutes, and they were conducted between October 27, 2011 to January 30, 2012.

A total 82 Internet experts were interviewed in the first phase. All interviews were computer-assisted and used the prescribed protocol as reported in Appendix A. This protocol was tested and refined iteratively with the voluntary involvement of other researchers (8) and technology-oriented individuals (8) responding to a request from the researcher. The protocol consisted of a structured questionnaire divided into four sections. Each section corresponded to one of the aforementioned purposes.

Of the 82 interviews in this first phase, a total of 13 interviews were conducted through Skype[49] or WebEx[50]. The option of videoconference interviews was given when participants were located

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[49] Skype is a Web-based service providing video communication – videoconferencing – over the Internet as well as other video and data sharing capabilities.

[50] WebEx is a Web-based service enabling face-to-face meetings online, real-time data sharing and other video sharing capabilities.

outside Southern Ontario (e.g., U.S., Australia and France) or when for convenience, participant and researcher agreed upon such arrangement. The option of videoconference as a research medium was tested and refined previously from the first experience in the study. Videoconference interviews and face-to-face interviews followed the same research protocol – the same animated PowerPoint slide deck pacing the rhythm – prompting and guiding the questioning process. Similar to Hanna (2012) and Hwang and Vrongistinos (2012), videoconference interviews with video and data sharing capabilities resulted in a fine research medium that provided high-quality participation. The remaining interviews (69) were conducted face-to-face, mostly in participants' offices across Southern Ontario (e.g., Ottawa, Kingston, Toronto and Waterloo Region) with a few interviews conducted at other agreed-upon locations.

The doctoral researcher conducting this study received support from a research assistant team of five persons who were blind to the research hypotheses. The research assistants supported mainly some recruitment activities and assumed the role of principal interviewers once they completed a training program. With the exception of one, face-to-face interviews were conducted by two persons, a principal interviewer and an assistant interviewer. The assistant interviewer in face-to-face interviews was required to handle three activities that required attention and time during the interview process: 1) to set up a laptop computer (with a 17" monitor) running the visual aid and pacing the research protocol; 2) to set up and verify the operation of a digital audio recorder; and 3) to take hand-written notes as a backup to the interview. It was believed that two interviewers dealt better with the original concerns of time and attention. Most videoconference interviews were conducted only by one interviewer since one person can handle the required activities under such modality. Accordingly, a total of 12 videoconference interviews were conducted by the doctoral researcher fully and one more was conducted with assistance. Table 4-1 shows the total number and modality of interviews in the first phase and the number of interviewers involved in each.

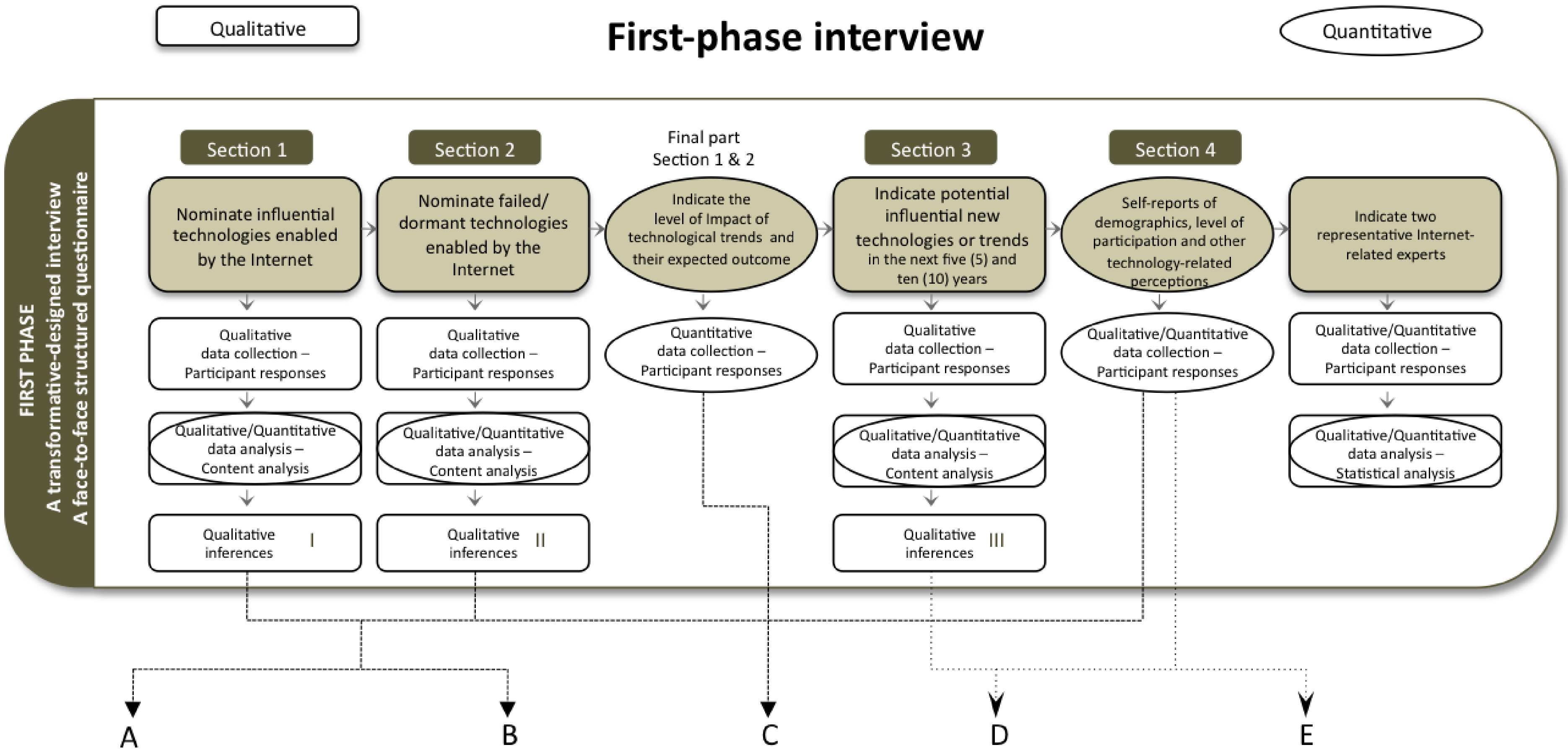

Figure 4-3 Content areas addressed in the first-phase interview

Importantly, of the 82 interviews in this first phase, the doctoral researcher conducted 81 either in the role of principal interviewer or in the role of assistant interviewer and supervisor. He was absent for only one interview because of a time conflict with another interview.

Modality	Number of interviews	Two interviewers	One interviewer	Doctoral researcher presence
Face-to-face	69	69	-	68
Videoconference	13	1	12	13
Total	82	70	12	81

Table 4-1 Total number of interviews in the first phase

A total of 80 interviews were audio recorded digitally; only two were not, due to a lack of participants' consent. In these two cases, both interviewers took research notes independently and the corresponding computer inputs of these interviews were typed based on both hand-written records.

As stated, Figure 4-3 presents a brief description of the content of each section in this first-phase interview and Table 4-2 indicates the slide numbers of the sections according to the protocol in Appendix A.

Sections	Slide Number
Purpose and initial	Slides 1 to 2
Section 1	Slides 3 to 5
Section 2	Slides 6 and 7
Final part Section 1 and 2	Slides 8 to 10
Section 3	Slides 12 and 13
Section 4	Slides 14 to 27

Table 4-2 Sections and slides numbers of the first-phase interview

Section 1 and 2 – qualitative sections – consisted of three open-ended questions carefully designed according to our theoretical framework. While Section 1 asked for past influential technologies, Section 2 asked for failed or dormant technologies. Instructions emphasized particularly the situated context for each question and the set of theoretical assumptions guiding the process. In other words, instructions created a situation – a framework – and participants provided the expected subject-matter "knowledge." While the first question in each section asked for technology names – an introductory question according to Kvale's typology (Bryman, Teevan, & Bell, 2009, p. 163), the second and third questions asked about purpose and examples of use for each technology – specifying questions in Kvale's terms. That is, the second and third questions inquired into particular aspects and details about each nominated technology. Answers about purpose and examples for each technology not only enabled the researcher to deal with experts' differences in terms of terminologies and meaning for same technology names, but also were essential to carrying out the aggregation of answers in order to create a collective interpretation. In Appendix C, Sections C.2 and C.3 provide a detailed description of the aggregation process based on an inductive systematic coding approach.

In the final part of Sections 1 and 2, a quantitative section is reported. Three 9-point Likert scale[51] questions prompted participants to provide self-reports of two factors: the perceived level of impact of each technology and trend, and the expected level of impact of each technology and trend in its initial emergence. Specifically, the measurement of the perceived level of impact of each technology and trend in this first-phase interview aimed for a strategy to control and study the effect of common method bias[52]. Section 4.6 delves into how this research design addressed this potential bias within the context of designing a rigorous and practical research study.

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51 Likert scale refers to a psychometric response scale widely used to indicate participant's agreement with respect to a statement. The 9-point Likert scale was preferred over a 5 or 7-point scale based on the idea of increasing variability – as a desirable quality of measurement – in the level of detail from participants self-reports (DeVellis, 2003, p. 75). The 9-point Likert scale may be also regarded as a better approximation to a "continuous variable," thus enabling the use of parametric statistics.

52 Common method bias refers to the extent to which the relationship among measures is altered systematically due to the use of a single method of measurement (Spector & Brannick, 2009; Meade, Watson, & Kroustalis, 2007; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

Section 3 was entirely a qualitative research section. It aimed to identify potential influential new technologies in the Internet industry in the next five and ten years. This section consisted of open-ended questions similar to the ones in Section 1 and 2. However, there were two significant differences: 1) there was no third question inquiring about examples of use since they do not exist; and 2) the first question was refined by including not only the names of potential new technologies but also the names of potential new kinds of activities enabled by the Internet. The rationale for including the names of new technologies or names of new activities depended on assumptions from our theoretical lens where new technologies do not yet have an institutionalized name but experts might foresee potential new activities based on existing current trends and projects. Thus, the first question was deliberately adjusted to elicit names for those potential new technologies or activities enabled by the Internet in the near future. As in Sections 1 and 2, the second question asked for the intended purposes behind those technologies or activities in order to better deal with the aggregation process later. Likewise, Appendix C Section C.4 provides a detailed description of the aggregation process based on an inductive systematic coding approach.

Section 4 comprised 33 questions collecting three types of data: demographics, perceived level of participation in the industry, and other technology-related perceptions. This section included several types of questions that vary in their level and type of measurement (see Table 4-3). There were three types of questions: 22 closed-ended, nine partially open, and two open-ended. Note that different measurements were used in this section, such as nominal, ratio, 9-point Likert scale, and differential semantic scale. In addition to demographics, the section explored some technology-related concepts with participants and evaluated some required measurement methods to use in the second-phase interview. Finally, there were two open-ended questions, and one of them asked for referrals to other Internet experts (Q33). Section C.5 presents descriptive statistics based on several of these questions.

Type of questions	Close-ended questions				Partially open questions	Open-ended questions
	Nominal measures	Ratio measures	9-point Likert scale measures	Semantic differential scale measures	Nominal measures	
	4	3	13	2	9	2
These questions start in slide 14 of the protocol (Appendix A) – Q means question	Q1, Q16, Q22, Q24	Q3, Q7, Q15	Q12, Q13, Q14, Q17, Q20, Q21, Q25, Q26, Q27, Q28, Q29, Q30, Q31	Q23, Q32	Q2, Q5, Q6, Q8, Q9, Q10, Q11, Q18, Q19	Q4, Q33

Table 4-3 Type of questions specifying their level and type of measurement

4.4. Selecting Technologies for Testing Theoretical Propositions

To test the internal validity[53] of our theoretical propositions, the researcher selected seven past Internet technologies from the results of the first phase of the study. These results are reported in Appendix C and include a detailed description of the aggregation process used to characterize the Internet industry in terms of its past, present, and future technologies. The researcher selected four past influential Internet technologies and three past failed or dormant Internet technologies. The most frequent past influential technologies were selected and the most frequent generic failed or dormant technologies were selected. Generic technologies were preferred over specific technologies based on the assumption that more participants would recognize the technology in question. Likewise, "Virtual Worlds" technology was preferred as failed or dormant technology over "Email" technology because "Virtual Worlds" does not appear in the list of past influential technologies but "Email" does. Hence, the selected group of past Internet technologies examined in the second phase was the following: "Social Media/Networking," "Mobile Internet

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53 According to Yin (2003, pp. 36, 109), in case studies, internal validity can be extended to the extent that the study strives for high-quality analysis of evidence to address the initial propositions. Typically, high internal validity implies that the study demonstrate that any interpretations related to an event or outcome – a dependent variable – resulted from the causal effect of other variable ruling out other rival explanations.

Technologies," "Cloud Computing," "Video Conferencing," "Music Sharing Technologies," "Search Portals," and "Virtual Worlds." Only seven technologies were included in order to maintain a reasonable second-phase interview time of one hour and 20 minutes in the evaluation process. Section 4.5 describes briefly the multiplying time effect of adding technologies to the second-phase protocol.

As stated, the case study aimed also to explore the future of Internet technologies. Hence, seven potential influential new technologies were selected in order to explore their evolutionary potential with respect to our theoretical framework. Appendix C Section C.4 indicates the resulting list of potential influential new technologies in the next five and ten years. The researcher selected three technologies from the five-year time frame and four technologies from the ten-year time frame. The selection was not arbitrary and the rationale was the following: 1) one Internet technology that had been used in the same grid of past Internet technologies (i.e., Cloud Computing – the most frequent potential influential new technology); 2) one rare input from each time frame (i.e., Gamification and Brain Computer Interface); 3) one generic enabling technology for each of the most potential influential technology domains with end-user technologies[54] (i.e., Geo-Location Identification, Wireless Body Area Networks, Virtual Personal Assistant and Natural Human Interfaces). Importantly, the idea of exploring the structurational model of emerging technologies (SMET) with potential influential new technologies aimed to produce a limited foresight exercise that might be considered for further research work.

Table 4-4 lists the seven selected Internet technologies considered for each section in the second-phase interview.

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[54] It was assumed that end-user technologies affect directly how individuals in organizations fulfill their activities, needs or functions.

Past Internet technologies	Potential influential new Internet technologies
Social Media/Networking (I)	Cloud Computing (5Y)
Mobile Internet Technologies (I)	Gamification (5Y)
Cloud Computing (I)	Geo-Location Identification (5Y)
Video Conferencing (I)	Brain Computer Interface (10Y)
Music Sharing (F/d)	Wireless Body Area Networks (10Y)
Search Portals (F/d)	Virtual Personal Assistant (10Y and 5Y)
Virtual Worlds (F/d)	Natural Human Interfaces (10Y)

(I-influential, F/d-failed/dormant, 5Y-Five-year time frame and 10Y-Ten-year time frame)

Table 4-4 List of selected past and potential new Internet technologies

4.5. Second-Phase Interview: A Structured Questionnaire Evaluating Technologies and Trends

The overall goal of the second phase of the study was to evaluate and differentiate among selected technologies and trends in order to test the theoretical propositions in Section 3.8. Hence, the second-phase interview was a quantitative research section focused on eliciting numeric judgments from our Internet experts. Each participant filled out two grids. One grid was used to evaluate the set of seven selected past Internet technologies, and the other was used to evaluate the set of seven selected potential influential new Internet technologies. While the first grid allowed the examination of our theoretical propositions, the second grid enabled us to examine the evolutionary potential of selected technologies. Importantly, although the interviews strived to elicit responses for both grids, priority was always given to complete at least the first grid. The first grid was essential because testing our theoretical propositions depended on these data. Consequently, this second-phase interview was divided into three sections: 1) a retrospective evaluation of seven selected past Internet technologies; 2) a foresight evaluation of seven selected potential new technologies; and 3) self-report questions about potential forms of bias. Figure 4-4 shows the content areas addressed in this second-phase interview. Second-phase interviews lasted approximately 80 minutes, and they were conducted between April 3, 2012 to July 26, 2012.

A total of 77 Internet experts were interviewed in the second phase of the 82 participants in the first phase. That is, the study had five "dropouts" who were unavailable to take part in this second phase. As in the first phase, all second-phase interviews were computer-assisted and used the prescribed protocol reported in Appendix B. In the second-phase, the research protocol was not implemented through a collection of PowerPoint slides; instead, a tailored software application was used to collect numeric judgments from experts and store the judgments directly in a database. In this way, experts' responses were immediately typed into the computer during the interview. Appendix E shows examples of screen captures from the software application. Like the first-phase protocol, the second-phase protocol was tested and refined iteratively with the involvement of other researchers and technology-oriented individuals who responded to a request from the researcher. Due to the grid approach, special attention was given to the number of technologies and questions. Each technology required time for the set of questions in the grid questionnaire to be answered, so adding a question multiplied the answer time according to the total number of technologies in the grid. Hence, the number of technologies and questions was very time sensitive. For this reason, the researcher used only seven technologies for each grid, and the scale for the degree of structuration was based only on a limited set of questions related to the complex process of developing social structure referred to in our theoretical framework.

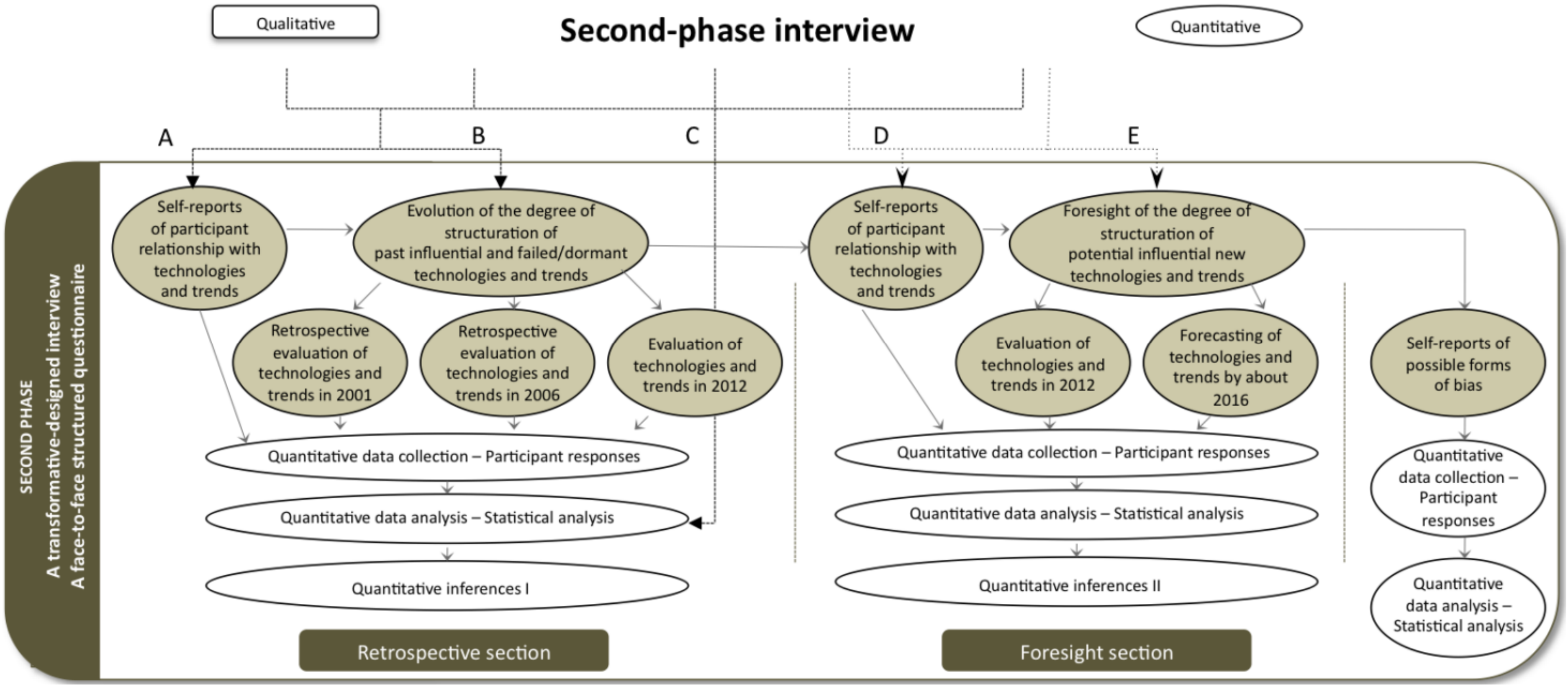

Figure 4-4 Content areas addressed in both first and second interviews

Of the 77 interviews in this second phase, ten were videoconference interviews, while 67 were face-to-face interviews. The option of videoconference interviews was given based on participant location or participant convenience. As in the first phase, videoconference and face-to-face interviews in the second phase followed the same research protocol and used the same computer application to capture responses. The video sharing capability of videoconferencing enabled this suitable option, and it is believed that the study maintained a high-quality of participation. Similarly, with the exception of two interviews due to time conflicts among the research team members, face-to-face interviews were conducted by two persons, a principal interviewer and an assistant interviewer. An assistant interviewer in face-to-face interviews was required due to the same three required activities that challenged the attention and time of the interview process. As in the first-phase interview, most videoconference interviews were conducted by one interviewer, the doctoral researcher. One person could handle the required activities under such modality. In this second-phase, the doctoral researcher conducted all 77 interviews either in the role of principal interviewer or in the role of assistant interviewer and supervisor. Table 4-5 shows the total number and modality of interviews in this second phase, as well as the number of interviewers involved.

Modality	Number of interviews	Two interviewers	One interviewer	Doctoral researcher presence
Face-to-face	67	65	2	67
Videoconference	10	1	9	10
Total	77	66	11	77

Table 4-5 Total number of interviews in the second phase

A total of 73 interviews were audio recorded digitally; only four were not recorded due to a lack of participants' consent. In these four cases, both interviewers took research notes independently and participants' responses were typed immediately into the computer during the interview.

As stated, the first section of the second-phase interview was the retrospective section, which comprised four parts. The first part characterized the relationship that participants had with each of the selected past Internet technologies at the time of the interview. The other three parts of the retrospective section corresponded respectively to the retrospective evaluation of the selected past Internet technologies in three different time frames. Internet experts were asked to evaluate and differentiate between the selected technologies and trends in three different years within our ten-year time frame: 2001, 2006, and 2012. Based on recommendations from the literature on hindsight bias, the evaluation of each time frame was introduced by a special set of instructions seeking to locate participants in the situated context of action and time under investigation (see Sections 3, 6 and 9 within the second-phase interview protocol in Appendix B).

The study did not focus on experts' opinions about technologies themselves but investigated experts' knowledge and views about specific outcomes and patterns of activity related to the set of selected technologies and trends in each of the selected three years (i.e., 2001, 2006, and 2012). It was assumed that when experts were asked about the level of impact in each year, they based their answers on a retrospective judgment of evidence and outcomes. As well, when experts were asked about the probability that each technology would become a major trend in five years, it was expected that they shared their retrospective judgments with respect to such perception. Similarly, in the final set of questions for each year and technology, experts were asked to look at the extent of development of six specific social patterns[55] of activity at different levels of abstraction and domains of applications. Thus, experts provided numeric judgments with respect to the extent of development of such technology-related social patterns enabling our construct of the degree of structuration of such technology in that situated context of action.[56]

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[55] Social patterns refers to recurring situations and processes in the situated context of action and time.

[56] The unit of analysis was social patterns resulting from the interaction between the technology and a situated context of action in time – a domain of human activity in time.

Table 4-6 lists the constructs that were measured in the first part of this retrospective section. While the first construct measured the relationship that participants had with each of the selected Internet technologies at the current time, the rest measured participants' perceptions with respect to the selected Internet technologies.

Constructs	Items
Level of engagement	Q2.1, Q2.2, Q2.3, Q2.4
Technological impact on further Internet developments	Q2.5
Technology physicality	Q2.6
Type of advancement (incremental or radical)	Q2.7

Table 4-6 Constructs and their related items with respect to technology-participant relationship

Table 4-7 presents the list of constructs that were measured in the other three parts of this retrospective section. These constructs measured the effect and perceptions of each selected technology in a situated context of action in time.

Constructs	Items
Level of impact in 2001	Q4.1
Level of impact in 2006	Q7.1
Level of impact on 2012	Q10.1
Level of awareness in 2001	Q4.2
Level of awareness in 2006	Q7.2
Level of awareness in 2012	Q10.2
Probability of becoming a major trend in 5 years in 2001	Q4.3
Probability of becoming a major trend in 5 years in 2006	Q7.3
Probability of becoming a major trend in 5 years in 2012	Q10.3
Degree of structuration in 2001	Q5.1, Q5.2, Q5.3, Q5.4, Q5.5, Q5.6
Degree of structuration in 2006	Q8.1, Q8.2, Q8.3, Q8.4, Q8.5, Q8.6
Degree of structuration in 2012	Q11.1, Q11.2, Q11.3, Q11.4, Q11.5, Q11.6

Table 4-7 Constructs and their related items with respect to each past Internet technology

Importantly, participants were never told which type of technology they were evaluating. Thus, participants did not know if past Internet technologies had been mentioned as influential or had been mentioned as failed or dormant technologies. Moreover, although all participants in the second phase evaluated the same list of seven selected past Internet technologies, all participants performed the evaluation based on a list presented to them in random order.

As for the foresight section, it consisted of three parts. Like the retrospective section, the first part characterized the relationship that participants had with each of the selected potential influential new Internet technologies at the time of the interview. The other two parts corresponded respectively to a foresight evaluation of the selected Internet technologies in two time frames. Participants were asked to evaluate the selected technologies and trends in 2012 and by about 2016. As stated, the study did not ask for the experts' opinions about the technologies themselves but asked for their views about the current and potential development of specific patterns of activity related to the set of potential influential new technologies and trends. It was assumed that the experts provided their best judgments and best estimates, respectively.

Table 4-8 lists the constructs measured in the first part of the foresight section. While the first construct measured the relationship that participants had with each of the selected potential influential new Internet technologies at the time of the interview, the rest measured participants' perceptions with respect to the selected potential influential new Internet technologies.

Constructs	Items
Level of engagement	Q13.1, Q13.2, Q13.3
Technological impact on further Internet developments	Q13.4
Technology physicality	Q13.5
Type of advancement (incremental or radical)	Q13.6
Extent of inflated expectations	Q13.7

Table 4-8 Constructs and their related items with respect to technology-participant relationship

Table 4-9 presents the list of constructs measured in the other two parts of the foresight section. These constructs measured perceptions of and estimates for each selected potential influential new technology in a respective year.

Constructs	Items
Level of impact in 2012	Q15.1
Level of impact in 2016	Q18.1
Level of awareness in 2012	Q15.2
Probability of becoming a major trend in 5 years	Q15.3
Estimate in years to become a major trend	Q15.4
Level of confidence with respect to the estimate	Q15.5
Degree of structuration in 2012	Q16.1, Q16.2, Q16.3, Q16.4, Q16.5, Q16.6
Degree of structuration in 2016	Q19.1, Q19.2, Q19.3, Q19.4, Q19.5, Q19.6

Table 4-9 Constructs and their related items with respect to each potential influential new Internet technology

Lastly, Section 3 aimed to measure participants' perceptions about the presence of certain forms of bias in the study, bias that might affect the assessment of past and future events (i.e., hindsight and foresight bias). Although the study's purpose was not to examine the magnitude of bias effects, we did aim to explore participants' perceptions about the possible operation of these forms of bias during our interviews. Accordingly, our theoretical framework suggests that individuals are always bound by their contextual circumstances. Thus, the study not only implemented some procedural remedies to reduce forms of bias, but also included a preliminary probe that might lead us to articulate further research questions. Table 4-10 shows the list of constructs measured in this section.

Constructs	Items
Participants hindsight bias	Q20.1
Participants foresight bias	Q20.2
Personal hindsight bias	Q20.3
Personal foresight bias	Q20.4

Table 4-10 Constructs and their related items with respect to participants' perception about some forms of bias in the study

Finally, Table 4-11 shows the number of participants completing each of the time frame evaluations. While retrospective evaluation considered the selected past Internet technologies, foresight evaluation examined the selected potential influential new technologies. The decline in numbers in the foresight section was the result of honoring the time made by our research participants and limiting the interview time to 80 minutes. As stated earlier, priority was always given to the completion of the retrospective section (i.e., the first grid).

Retrospective evaluation			Foresight evaluation	
2001	2006	2012	2012	2016
77	77	77	76	68

Table 4-11 Number of participants completing the different time frame evaluations

4.6. The Quality of the Research Design: Reliability and Validity

This research study aimed to answer a complex problem, and the complex nature of the problem resulted in a novel and challenging research design. Nonetheless, it is believed that the complex research design did not prevent the researcher from being reflective and effective at implementing widely accepted conceptual and instrumental strategies to establish and maintain the quality of this research. Within the context of designing a practical research study, the researcher intended to establish methodological rigour at every phase of the research process. This section aims to highlight important research decisions that were essential to the pursuit of trustworthy results.

The two most widely accepted criteria used to determine the quality of a research studies are reliability and validity. Although some qualitative researchers and interpretative approaches may not accept the use of those terms without significant adjustment, this case study – influenced by a quantitative stance – decided that the use of these terms was appropriate (Bryman, Teevan, & Bell, 2009, p. 38; Neuman & Robson, 2009, p. 116). Reliability refers to the extent to which other researchers can conduct a similar study, following the same research methods, and arrive at similar findings. Yin (2003, p. 37) writes that “the emphasis is on doing the same case over again, not on ‘replicating’ the results of one case by doing another case study.” On the other hand, validity refers to the extent to which the research method measures what was intended to be measured.

In terms of reliability, the case study relied widely on standardized procedures throughout the different phases of the research process. For example: 1) the purposive but systematic procedure for selecting participant experts (see Section C.1.); 2) the two structured interviews with their respective computer-assisted protocols for the data collection process; 3) the clear set of written instructions for the aggregation process of data from the first-phase interview (see Sections C.2, C.3 and C.4); and 4) the use of widely accepted statistical analysis to examine the reliability and internal validity of our theoretical propositions (see Chapter 5). Additionally, this research design chapter has tried to communicate the most important research decisions in order to enable not only the assessment of the study but also the reproduction of this potential model for a systematic technology intelligence process in the same or other technology domain.

Yin (2003) distinguishes three kinds of validity: construct validity, internal validity, and external validity. Construct validity refers to the extent to which the operational set of measures reflects successfully the theoretical set of constructs that model the phenomenon of interest (Yin, 2003; Frankfort-Nachimias & Nachimias, 1996, p. 168). To meet the test of construct validity, the researcher has made efforts in this document – especially in Chapters 3, 4 and 6 – to explain and show the logical relationship among variables, their theoretical counterparts, and the objectives of this research (Babbie, 1998, p. 134).

Briefly explained in Section 4.4, internal validity refers to the extent to which the research design permits us to demonstrate the causal relationships between independent and dependent variables without having an alternative explanation for the phenomenon in question (Yin, 2003; Judd, Smith, & Kidder, 1991). According to Yin (2003, pp. 36, 109), in cases studies, internal validity can be extended to the case of making correct and airtight inferences where all evidence is convergent to support a given conclusion without rival explanations. Despite the fact of the exploratory stance of this case study, Chapter 5 probes statistically the assumed explanatory relationships in our theoretical propositions. In particular, empirical evidence suggests that technological outcomes or the level of impact of technologies can be explained by the extent of development of specific social technology-related patterns, although they may not be sufficient. Chapter 6 discusses potential inferences and conclusions suggesting that our research design anticipated questions to deal with the overall goal of internal validity in a research study.

External validity refers to the extent to which a study's results are generalizable from the specific setting of the study to a broader range of settings of interest related to the hypothesis (Yin, 2003; Neuman & Robson, 2009). This may be the main reason to adopt the exploratory stance in describing our case study. Due to the complexity of the problem and the lack of conceptual development in the field to deal with the research problem, the study did not focus on statistical generalization[57]. Instead, the study focused on analytical generalization, striving to develop and probe a theoretical framework that might be applicable to other similar technology domain settings. On the side of a practical design, the case study probed the theoretical framework by examining only seven selected technologies. For this reason, the study was exploratory and probed the explanatory power of the theoretical framework. However, as with experiments, in case studies theories do not emerge from observing statistical patterns among variables but from identifying the regularities and structural properties explaining similar setting in different case studies. In this vein, Yin (2003, p. 33) states that "The use of a theory, in doing case studies, is not only an immense aid in defining the appropriate research design and data collection but also becomes the main vehicle for generalizing the results of the case study." Nonetheless, as suggested in Chapter 7, more work must be done towards the generalization of this study's findings.

This last part of the section describes how the research design implemented several recommendations from the research literature that aim to deal better with threats to the validity of the study. The theoretical framework of the study recognizes that human actors are always bounded by the unconscious motivations and unacknowledged conditions of action (Giddens, 1984, p. 281). Hence, one of the most important tasks in the research design is to identify and control for sources

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[57] Survey researchers argue that if a sample is selected correctly, its results are generalizable to explain similar setting in other populations (Yin, 2003, p. 37).

of distortion in human reasoning (i.e., bias) and systematic measurement errors (i.e., the systematic unintended portion of a measure). Next, without being exhaustive, the study discusses recommendations that were implemented to control for some sources of distortion and potential errors.

Selection bias or sampling bias refers to the extent to which the sample is not representative of the population of interest (Delgado-Rodríguez & Llorca, 2004; Krishna, Maithreyi, & Surapaneni, 2010; Neuman & Robson, 2009, p. 207).

Recommendations in the literature
• Define the study population along with a clear objective for data collection (Judd, Smith, & Kidder, 1991, p. 136; Hartman, Forsen, Wallace, & Neely, 2002, p. 27). • Define objective bases for making sample judgments, inclusion and exclusion criteria for selecting participants (Hartman, Forsen, Wallace, & Neely, 2002, pp. 28-29).

Implemented remedies and actions
• Participants were targeted based on the objective of the study and data collection requirements – i.e., the study uses a purposive sampling (Neuman & Robson, 2009, p. 137). • The study relied on a standardized procedure – i.e., written criteria for inclusion and exclusion – in the identification and invitation of Internet experts (see procedure in Section C.1). • The researcher made an effort to interview as many Internet experts as possible in order to improve the validity of the study and reduce certain forms of bias. The initial goal was 60 interviews and the study ended with 77 in the second phase (28% more). According to the literature, a larger sample size helps to control for sampling error.

Common method bias refers to the extent to which the relationship among measures is altered systematically due to the use of a single method[58] of measurement (Spector & Brannick, 2009; Meade, Watson, & Kroustalis, 2007; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

Discussion and recommendations in the literature
Authors differ on the existence of a significant effect in correlations caused by the use of a single method of assessment[59] (e.g., Spector (2006), Crampton and Wagner III (1994) and Podsakoff, MacKenzie, Lee, and Podsakoff (2003)). Nonetheless, within the context of designing a practical and rigorous research study, these common recommendations were identified: • When possible, use different source for IV[60] and DV[61] (Spector & Brannick, 2009, p. 353; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003, p. 887). • Eliminate item ambiguity and complexity (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003, p. 886). • Control for response patterns that refer to participant tendency to rate objects without distinctions or answer in the same way (Neuman & Robson, 2009, p. 128).

Implemented remedies and actions
• The study used a different source of measurement for one of the IV: technological outcome. The first phase of the study identified two types of technological outcomes that were evaluated in the second phase. Participants were not told which type of technological outcome they were evaluating. For the rest of IV that were measured in the second phase along with DV, the study applied methods of psychological and visual separation. • The researcher used statistical remedies to assess the validity of conclusions related to the assessment of variables using the same method of measurement (see Chapter 5). • Interview protocols were tested and refined iteratively in pursuit of clear, simple, and concise questions, always keeping participants' perspectives in mind and avoiding ambiguity and jargon (Neuman & Robson, 2009, p. 165). • Face-to-face interviews were preferred over surveys in order not only to increase participants' commitment but also to better deal with the quality of responses.

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[58] The term *method* in the literature of common method bias is ambiguous because it can refer to items, scale types, respond formats, wording of questions, research instruments, research means, and so forth.

[59] Secptor and Brannick (2009, p. 360) say "There is not a constant inflation of correlations among all variables attributable to the use of a single method. However, the lack of common method variance does not mean that measurement biases are not at play, and do not themselves affect the magnitude of observed correlations."

[60] IV – independent variable

[61] DV – dependent variable

Hindsight bias refers to the human tendency to overestimate judgments of past events (e.g., likelihood of predicting an outcome) based on the outcome knowledge of what happened rather than on evidence and knowledge of the original conditions (Mackay & Mckiernan, 2004; Christensen-Szalanski & Willham, 1991; Guilbault, Bryant, Brockway, & Posavac, 2004).

Discussion and recommendations in the literature
The phenomenon of hindsight seems to affect pervasively individuals around the world (Pohl Rüdiger, Bender, & Lachmann, 2002; Bernstein, Erdfelder, Meltzoff, Peria, & Loftus, 2011). The literature on hindsight bias provides effective recommendations for controlling and reducing the effects of this pervasive and inherent phenomenon in human reasoning (Davies, 1987; Arkes, Guilmette, Faust, & Hart, 1988; Roese & Vohs, 2012; Koriat, Lichtenstein, & Fishhoff, 1980; Hertwig, Fanselow, & Hoffrage, 2003; Hoffrage, Hertwig, & Gigerenzer, 2000). • Select participants with experience and expertise (familiarity) on the subject matter because doing so moderates hindsight bias (Christensen-Szalanski & Willham, 1991; Hertwig, Fanselow, & Hoffrage, 2003; Roese & Vohs, 2012). • Restore the foresight perspective of participants by creating conditions in which participants can recall their original thoughts and feelings (Davies, 1987). • Ask participants for reasons, evidence, and references about their judgments (Arkes, Guilmette, Faust, & Hart, 1988). • Enable participants to consider alternative explanations and outcomes (Roese & Vohs, 2012; Koriat, Lichtenstein, & Fishhoff, 1980). • Enable participants to reconstruct a probabilistic mental model (Hertwig, Fanselow, & Hoffrage, 2003).

Implemented remedies and actions
Consistent with our theoretical framework and new insights in the literature of expertise, the study selected participants with experience and expertise (familiarity) in the Internet industry. In the first-phase interviews, questions about past Internet technologies located participants in a situated context of action and time through instructions. Especially, in the second-phase interviews, this research design did not ignore the potential threat of hindsight bias in participants' retrospective evaluations: • Instructions were carefully designed to locate participants in the retrospective context according to the evaluation of the time frame in question, 2001 and 2006 – a special set of instructions is reported in Sections 3 and 6 of the interview protocol in Appendix B. • Interviewers made special effort to provide participants with conditions to relocate their cognitions and thoughts. • Interviewers asked periodically questions about the rationale for the participants' judgments. This practice was not written in the protocol but was part of interviewers' mandate. For example, why did a participant answer 5 in "x" technology and 3 in "y" technology? Importantly, participants had always a coherent rationale with which to respond. • Although our adapted Repertory Grid enabled natural conditions to evaluate alternative explanations and outcomes, interviewers placed emphasis on the task of rating technologies in terms of differences among them with respect to our constructs – seeking their semantic differential. Additionally, the researcher not only implemented procedural remedies to strengthen the validity of the study before the impending hindsight bias possibility, but also opted for exploring further the relationship between the participants' perceptions about hindsight bias and some results of the study. The second-phase interview protocol had a special section inquiring into this participants' perspective. Finally, the theoretical framework of the study suggested that a systematic participatory process deals better with individual bias. Thus, it is believed that our 28% larger sample size helped to control for hindsight bias as well.

Chapter 5. Analyses and Results

As discussed in Chapter 4, whereas the first phase of the study permitted the identification of influential and failed or dormant technologies in the Internet industry, the second phase of the study aimed to test theoretical propositions encapsulating the process of emergence and development of new technologies. The results and details from the first phase of the study are included in Appendix C, showing descriptive statistics and methodological procedures that were fundamental for the realization of the second phase. The objective of this chapter is to present the high-level outcomes from the second phase of the study. Specifically, this chapter focuses on major empirical results related to our set of hypotheses and is organized as follows. First, Sections 5.1 and 5.2 present preliminary research measures estimating and assessing the reliability and validity of our results. Later, Section 5.3 provides an overview of the data structure used in our analyses. Next, Section 5.4 explains reasons, analyses, and research decisions related to having two types of Internet experts in the study. Subsequently, from Section 5.5 to Section 5.11 several analyses are presented in order to test the hypothesized model. All analyses were performed using SPSS.

5.1. Internal Consistency of Constructs

Degree of structuration and level of engagement were constructs based on multiple-items measures. Table 5-1 presents the alpha coefficients[62] of these two constructs that exceed the value of 0.70, which is the acceptable standard for academic research (Nunnally & Bernstein, 1994, p. 265). Thus, degree of structuration and level of engagement indicate an acceptable internal consistency in their items. For more details about the internal consistency of these two constructs, please refer to Appendix D Section D.1.

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[62] An *alpha coefficient* estimates the internal consistency of a measure based on the average correlation among items of the same measure. Thus, it indicates the ability of a set of items to estimate similar scores.

Constructs	Cronbach's alpha
Degree of structuration	0.872
Level of engagement	0.820

Table 5-1 Reliability of multiple-item constructs

For our hypotheses testing purposes and for these two latent variables (i.e., degree of structuration and level of engagement), a single indicator was created based on the average of all their composite items. This approach has been commonly used and helps to correct for random measurement error (Carlson & Perrewé, 1999, p. 525).

Given the pragmatic perspective of the study[63], its exploratory purpose, the nature of the constructs, and the time-sensitive interview method[64] (Fuchs & Diamantopoulos, 2009; Bergkvist & Rossiter, 2007; Rossiter, 2002), three constructs used single-item representative[65] measures as stated in Chapter 3 and Chapter 4: level of impact, level of awareness, and probability of becoming a major trend in five years. It is believed that the operationalization of these three constructs was straightforward and well-defined, aiming to measure one and only one concept. Moreover, their operationalization was virtually identical to what they intend to measure (Sackett & Larson, 1990). In Rossiter's terms (2002), these constructs were reasonably simple and defined in terms of concrete singular objects (i.e., technologies) and concrete attributes (i.e., impact as an overall magnitude of change, probability of becoming a major trend, and overall awareness with respect to a technology situation). Likewise, according to Rossiter (2002), the rater entity was clearly identified in the study (i.e., individuals highly engaged with the commercialization or development of Internet technologies – in other words, Internet experts).

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63 The pragmatic perspective refers to not only the avoidance of debating about the nature of reality but also the stance of creating a model that represents a collective subjective reality.

64 The interview was time sensitive because the aim was to elicit 424 responses in approximately 80-minute interviews. Due to our repertory grid approach, the time to answer each question was a function of the number of technologies and the three time frames.

65 The term *representative* is used because this study does not lay claim to unique measures of reality.

Although single-item measures have been suggested as easy, efficient, and suitable alternatives under the above explained circumstances (Scarpello & Campbell, 1983; Nagy, 2002; Robins, Hendin, & Trzesniewski, 2001; Lucas & Donnellan, 2012; Elo, Leppänen, & Jahkola, 2003; Milton, Clemes, & Bull, 2013; Bergkvist & Rossiter, 2007), Sackett and Larson (1990, p. 468) say that "The critical issue here is the lack of information about the adequacy of measurement." Thus, although it is very difficult to estimate the exact reliability of a single-item measure (Wanous & Hudy, 2001), Wanous and Reichers (1996), Wanous, Reichers, and Hudy (1997) and Wanous and Hudy (2001) suggest two methods for estimating minimum single-item reliabilities. Table 5-2 displays reliability estimates for our three single-item constructs.

Constructs	Minimum reliability estimates		
	Using the correction for attenuation formula[66]	Using factor analysis[67]	Average[68]
Level of impact	0.639[69]	0.854	0.746
Level of awareness	0.526[70]	0.737	0.632
Probability of becoming a major trend in five years	0.626[71]	0.825	0.725

Table 5-2 Estimates of minimum reliability of single-item constructs

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[66] According to Wanous and Reichers (1996), the reliability for a single item can be estimated based on the formula of "correction for attenuation" (Nunnally & Bernstein, 1994, p. 257), which indicates that the *true* correlation between two perfectly reliable variables x and y is equal to the correlation between x and y divided by the square root of the product of each variable reliability.

[67] Factor analysis can be used also as a method for estimating single-item reliability. Wanous and Hudy (2001) indicate that the reliable variance of an item can be represented by the sum of its communality and its specificity. Thus, the communality of a single-item can be considered as a conservative estimate of its reliability. For more details, please refer to Wanous and Hudy's paper.

[68] Wanous and Hudy (2001) and Wanous, Reichers, and Hudy (1997) use the average of minimum reliability estimates as a reasonable reference to produce overall judgments of reliability estimates. They indicate that the minimum reliability estimates are based on conservative assumptions.

[69] This estimate was calculated under a demanding assumption: a construct correlation of 0.95 between this single-item measure and the best correlated measure available. This is a conservative estimate.

[70] This estimate was calculated under the assumption of a construct correlation of 0.70 between this single-item measure and the best possible correlated measure available. The 0.70 assumption resulted from reducing the estimated correlation using factor analysis since there were no bases for assuming a correlation between the single-item and the best possible correlated measure available.

[71] This estimate was calculated under a demanding assumption: a construct correlation of 0.95 between this single-item measure and the best correlated measure available. This is a conservative estimate.

This study lies within a different research domain compared to the domain studied by Wanous and Hudy (2001). Nevertheless, if a minimum estimated single-item reliability measure close to 0.70 is reasonable (Wanous, Reichers, & Hudy, 1997), it is believed that our single-item measures are sufficiently reliable for data analysis purposes[72]. The rationale behind this argument is that the averages of minimum reliability estimates are above or close to 0.70 (Wanous, Reichers, & Hudy, 1997). Moreover, the correction for attenuation analysis has been based on conservative assumptions between the single-item measure and the best correlated measure available.

The researcher recognizes that future research efforts need to explore measures based on multiple-items and multiple methods.

5.2. The Assessment of Common Method Bias

As stated in Section 4.6, within the context of designing a practical and rigorous research study, this work implemented several procedural remedies for controlling the effect of potential measurement biases. In that section, the researcher reported the use of additional statistical techniques to assess whether the variance of measurement biases[73] or common method variance shared across measures was not a serious limitation for this work's conclusions. In particular, this assessment may be recommended because the data for dependent and independent variables were collected via a single source through self-report questionnaires.

Two tests were conducted to assess if the relationship among measures was altered systematically due to measurement biases. First, the researcher conducted a Harman's single-factor test[74]

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[72] Although this study used an alpha coefficient standard of 0.70, in a number of studies alpha coefficient values of 0.60 have been used as sufficiently reliable measures for data analysis (Zahra & Covin, 1993, p. 463; Carlson & Perrewé, 1999, p. 522; Alojairi, 2010, p. 94).

[73] Spector and Brannick (2009, p. 360) states that "measurement bias is specific and not universally shared across all traits assessed with a particular method."

[74] *Harman's single-factor* is a widely used technique that requires loading all of the measures in the study into an exploratory factor analysis. The basic assumption is that if a single factor emerges or one general factor accounts for the majority of covariance among the measures, this is an indication of a substantial amount common method variance (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003, p. 889). Harman's

(Podsakoff, MacKenzie, Lee, & Podsakoff, 2003) and did not find a single general factor accounting for the variance in the variables. Appendix D Section D.2 shows the result from the analysis and the presence of four factors indicates that method variance may not be a significant problem in the data (Podsakoff & Organ, 1986). Secondly, to confirm our first results, the researcher conducted also a single-common-method-factor test[75] controlling statistically for the effect of method variances (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003; Williams, Buckley, & Cote, 1989). A hierarchical multiple regression model indicates that the addition of the single common method factor to our latent predictive factor model did improve the model fit but not significantly. Thus, the additional method factor accounts for only 8.3% of the total variance which is a small proportion in comparison to the total measurement variance (64.6%) (Carlson & Kacmar, 2000; Carlson & Perrewé, 1999). These results suggest that common method bias is not a serious problem in the study.

5.3. Overview of the Data Structure

Figure 5-1 provides a general visual description of the collected data at the technology level. Nevertheless, most of the statistical analyses in the study were performed at the aggregated level of all technologies, as well as at the aggregated level of technological outcomes.

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single-factor has been used in several studies (e.g., Cousins, Lawson, Petersen and Handfield (2011) and Carlson and Pamela (1999)).

[75] *Single-common-method* factor is also a widely used technique that allows all items to load on their theoretical constructs, as well as on a latent common method variance factor. The effect of method variance can be estimated by testing the regression model with and without the latent common method variance factor (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003, p. 891). Single-common-method factor has been widely used in studies (e.g., Elangovan and Xie (1999), Podsakoff, Mackenzie, Moorman, and Fetter (1990) and Carlson and Kacmar (2000)).

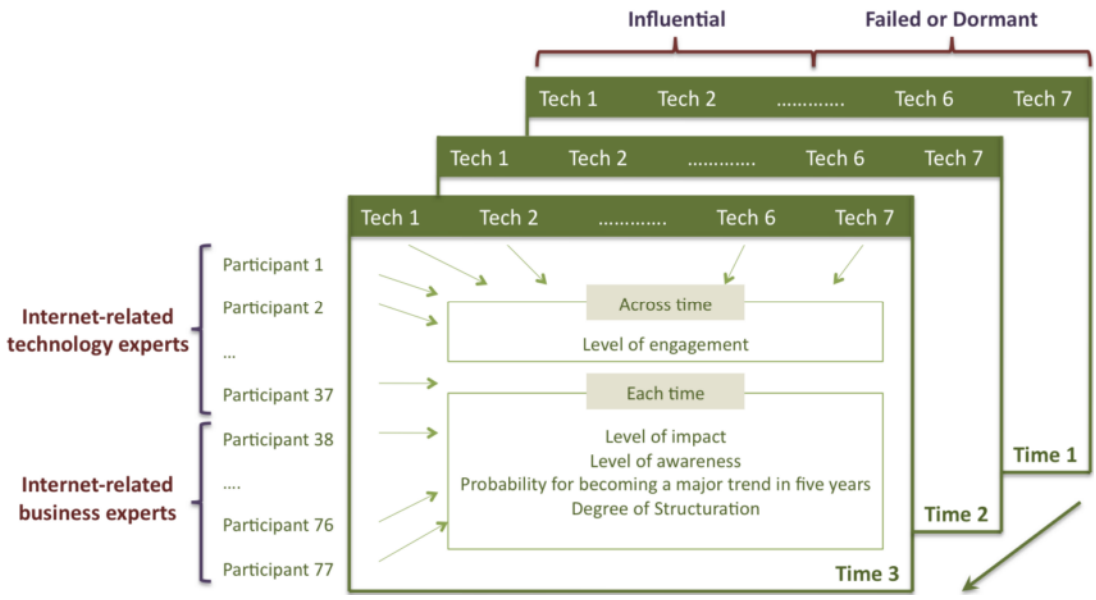

Figure 5-1 Visualization of the data structure

5.4. The Relationship Between Degree of Structuration and Type of Internet expert

The structurational model of emerging technologies (SMET) does not suggest the characterization of expertise based on a social attribute (i.e., a label such as *business* or *technology expert*). Instead, the SMET assumes that individuals display a level of engagement with respect to specific social practices such as the study, use, development, or commercialization of technologies. In fact, for this reason, the study relied on Internet business and technology experts. Nevertheless, we analyzed the relationship between the type of Internet expert (i.e., business or technology expert) and degree of structuration for two reasons. First, we wanted to investigate the potential difference between these two types of expertise labels because some authors in subfields of strategic management of technology[76] distinguish fundamental differences between business experts and technology experts

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[76] For example, technology foresight, technology intelligence, technology forecasting, environmental scanning and scenario planning, among others,

(e.g., Mitchell (1985)). Second, we wanted to know how we should conduct our analyses and interpret our results based on data from these two types of social categories.

Consequently, to statistically investigate if degree of structuration depends on type of expert, we performed two analyses using our data structure at the aggregated level of all technologies. First, we performed a repeated measures ANOVA analysis[77]. A repeated measures ANOVA[78] analysis enables us to examine the variance of between-subjects factors and within-subjects factors. Based on the data structure of our research design, while *type of expert* is a between-subjects factor, *degree of structuration* is a within-subjects factor. Figure 5-2 shows graphically the estimated marginal means of degree of structuration per type of expert at each time frame. Although it can be observed that these two factors do not interact, Appendix D Section D.3 provides complementary statistical details of the repeated measures ANOVA analysis and indicates that type of expert does not have a statistically significant effect on degree of structuration, F (1.642, 123.22) = 0.219 at $p = 0.759$. These results are based on the reported Greenhouse-Geisser[79] correction due to the violation of sphericity[80].

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77 A repeated measures ANOVA analysis is also known as "Split-Plot" ANOVA analysis, and it is found in the General Linear Model Repeated Measures option in SPSS.

78 Given the repeated measures in time for degree of structuration, a repeated-measures ANOVA approach or "split-plot" ANOVA test was indicated since it helps us to reduce the sources of variance by partitioning variance for repeated-measures – i.e., degree of structuration in this case. An independent ANOVA analysis or a traditional test of means method was not a reasonable approach because the repeated measures of our research design would produce a nested source of unwanted variation. Consequently, the F-ratios resulting from independent ANOVA analyses would be inflated due to unwanted variance in the data structure. In fact, the suggested hierarchical data structure resulted from taking care of this potential problem.

79 The Greenhouse-Geisser correction is more often recommended because it is a conservative correction (How2stats, 2011).

80 Sphericity should be estimated when a factor presents three or more repeated measures (Brace, Kemp, & Snelgar, 2009, p. 44). Sphericity assumes homogeneity of variance and covariance between the repeated measures (How2stats, 2011). That is, sphericity indicates that the variances of the differences between all pairs of repeated measures are equal (Field, 2009, p. 460). That is also, the correlations between all the repeated measures are roughly the same (Brace, Kemp, & Snelgar, 2009, p. 44).

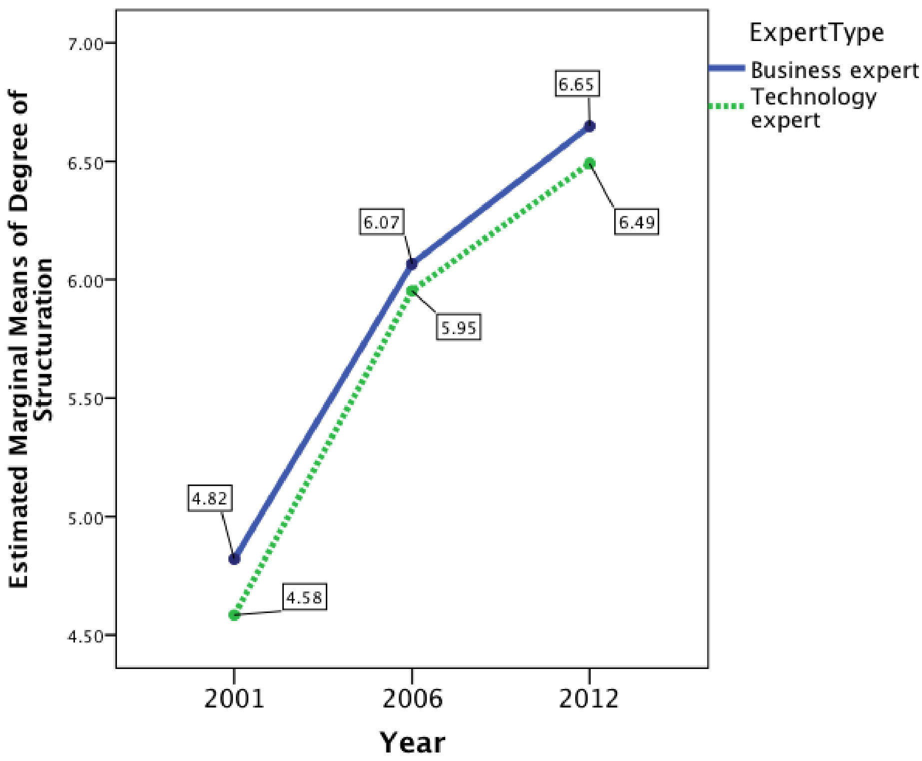

Figure 5-2 Estimated marginal means of degree of structuration per type of expert

Second, in order to examine if the magnitude of the difference of degree of structuration between these two groups at each time frame is statistically significant, Appendix D Section D.4 presents the results of an independent sample t-test analysis[81] per each time frame. At each time frame, the pairwise comparison of degree of structuration between Internet business experts and technology experts was clearly non-significant (i.e., in 2001, t (75) = 1.225 at p = 0.224; in 2006, t (75) = 0.638 at p = 0.525; and in 2012, t (75) = 0.974 at p = 0.333)[82]. Moreover, in similar analyses, under the same assumptions[83], the relationship between type of expert and level of impact was also found non-significant at each time frame (i.e., in 2001, t (75) = -.125 at p = 0.901; in 2006, t (75) = 0.321 at p = 0.749; and in 2012, t (75) = 0.011 at p = 0.922). Likewise, the relationship between type of expert and probability of a technology for becoming a major trend in five years was found non-

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81 An independent simple t-test analysis compares means between two groups.

82 These results are under the assumption of equal variance between groups.

83 That is, to have equal variance between groups.

significant at each time frame (i.e., in 2001, $t(75) = 1.153$ at $p = 0.253$; in 2006, $t(75) = 0.070$ at $p = 0.945$; and in 2012, $t(75) = 0.938$ at $p = 0.351$). Therefore, hereafter, in order to increase statistical power, we conducted our analyses considering both groups as one. That is, all participants were considered as only one group of Internet experts. Importantly, the aggregated level of engagement and the aggregated level of awareness of participants were variables that help us to produce between-subjects factors for some analyses (e.g., clusters of individuals with high and low level of engagement with Internet technologies or clusters of individuals with high and low level of awareness with Internet technologies).

The following sections present empirical results related to our set of hypotheses.

5.5. The Relationship Between Technological Outcome and Degree of Structuration

H1 predicted that over time influential technologies develop a higher degree of structuration than do failed or dormant technologies. To statistically examine H1, we aggregated per each participant technologies at technological outcome level (i.e., influential technologies and failed or dormant technologies). Then, we considered that technological outcome was a within-subject factor with two repeated measures and that degree of structuration was also a within-subject factor with three repeated measures. Thus, a repeated measures ANOVA analysis with two within-subject factors was performed.

Figure 5-3 shows the estimated marginal means of degree of structuration per each technological outcome over each time frame. Failed or dormant technologies displayed estimated marginal means of degree of structuration of 5.04, 5.47 and 5.24 across 2001, 2006, and 2012, respectively; influential technologies developed estimated marginal means of degree of structuration of 4.47, 6.42, and 7.58 over the same years, respectively.

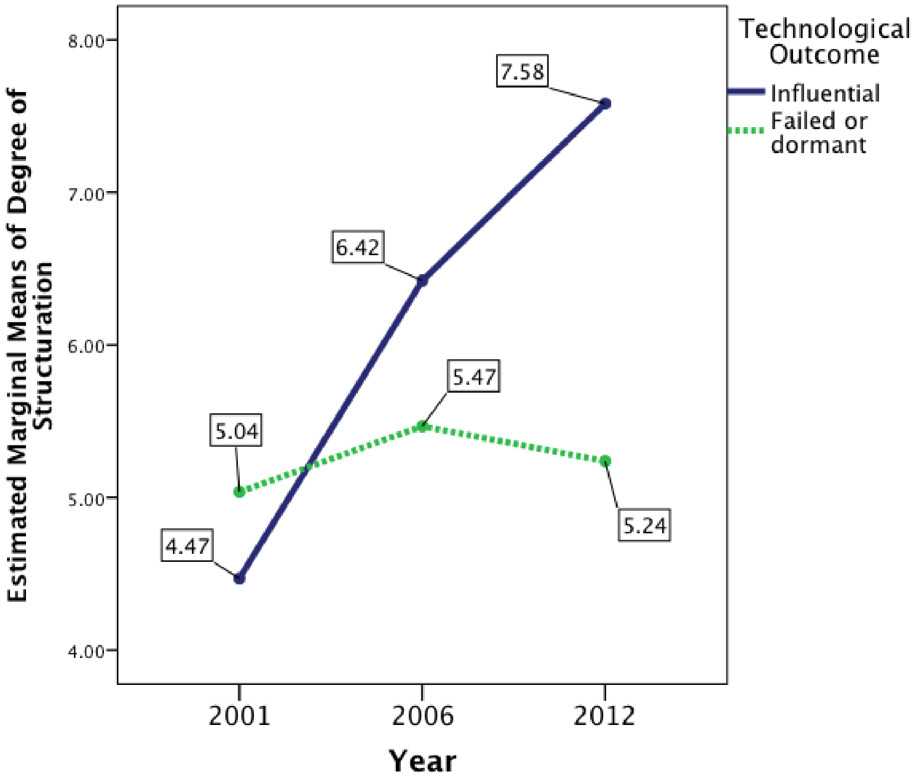

Figure 5-3 Estimated marginal means of degree of structuration per technological outcome

Figure 5-4 presents the statistical results of the repeated measures analysis between type of technological outcome and degree of structuration. The results reveal that the magnitude of degree of structuration depends on the type of technological outcome. That is, the type of technological outcome has a statistically significant effect on its degree of structuration, $F(1.642, 124.767) = 177.564$ at $p = 0.000$. These results were based on the reported Greenhouse-Geisser[84] correction due to the violation of sphericity[85].

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[84] The Greenhouse-Geisser correction is more often recommended because it is a conservative correction (How2stats, 2011).

[85] Sphericity should be estimated when a factor presents three or more repeated measures (Brace, Kemp, & Snelgar, 2009, p. 44). Sphericity assumes homogeneity of variance and covariance between the repeated measures (How2stats, 2011). That is, sphericity indicates that the variances of the differences between all pairs of repeated measures are equal (Field, 2009, p. 460). That is also, the correlations between all the repeated measures are roughly the same (Brace, Kemp, & Snelgar, 2009, p. 44).

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Technological_Outcome	Sphericity Assumed	95.682	1	95.682	87.405	.000	.535	87.405	1.000
	Greenhouse-Geisser	95.682	1.000	95.682	87.405	.000	.535	87.405	1.000
	Huynh-Feldt	95.682	1.000	95.682	87.405	.000	.535	87.405	1.000
	Lower-bound	95.682	1.000	95.682	87.405	.000	.535	87.405	1.000
Error(Technological_Outcome)	Sphericity Assumed	83.197	76	1.095					
	Greenhouse-Geisser	83.197	76.000	1.095					
	Huynh-Feldt	83.197	76.000	1.095					
	Lower-bound	83.197	76.000	1.095					
Degree_of_Structuration	Sphericity Assumed	224.814	2	112.407	158.663	.000	.676	317.326	1.000
	Greenhouse-Geisser	224.814	1.621	138.671	158.663	.000	.676	257.225	1.000
	Huynh-Feldt	224.814	1.651	136.132	158.663	.000	.676	262.023	1.000
	Lower-bound	224.814	1.000	224.814	158.663	.000	.676	158.663	1.000
Error(Degree_of_Structuration)	Sphericity Assumed	107.686	152	.708					
	Greenhouse-Geisser	107.686	123.211	.874					
	Huynh-Feldt	107.686	125.510	.858					
	Lower-bound	107.686	76.000	1.417					
Technological_Outcome * Degree_of_Structuration	Sphericity Assumed	163.144	2	81.572	177.564	.000	.700	355.127	1.000
	Greenhouse-Geisser	163.144	1.642	99.377	177.564	.000	.700	291.501	1.000
	Huynh-Feldt	163.144	1.673	97.510	177.564	.000	.700	297.082	1.000
	Lower-bound	163.144	1.000	163.144	177.564	.000	.700	177.564	1.000
Error(Technological_Outcome*Degree_of_Structuration)	Sphericity Assumed	69.828	152	.459					
	Greenhouse-Geisser	69.828	124.767	.560					
	Huynh-Feldt	69.828	127.156	.549					
	Lower-bound	69.828	76.000	.919					

Figure 5-4 Tests of differences of variance between type of technological outcome and their degree of structuration over time

Appendix D Section D.5 provides complementary details with respect to this analysis and includes a paired t-test analysis[86] that investigates, at each time frame, if the degree of structuration between influential and failed or dormant technologies is statistically different. The paired t-test analysis confirms that the magnitude of the difference of degree of structuration between these two types of technological outcomes at each time frame is statistically significant (i.e., in 2001, $t\ (76) = -4.223$ at $p = 0.000$; in 2006, $t\ (76) = 7.430$ at $p = 0.000$; and in 2012, $t\ (76) = 17.583$ at $p = 0.000$). Consequently, the empirical data support H1: influential technologies develop a higher degree of structuration than do failed or dormant technologies.

H2 posited that influential technologies increase their degree of structuration over time while failed or dormant technologies do not. Figure 5-3 shows graphically that influential technologies increase their degree of structuration over time while failed or dormant technologies do not. We examined statistically the magnitude of difference of the degree of structuration between each pair of time

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86 A paired t-test analysis compares the means of two variables for a single group.

frames for each technological outcome (i.e., influential technologies and failed or dormant technologies). Table 5-3 displays the results of a paired t-test analysis. The results support that at each pair of time frame in influential technologies, the magnitude of difference between all pairs of degree of structuration is statistically significant (i.e., in pair 2001-2006, t (76) = - 19.272 at p = 0.000; in pair 2006-2012, t (76) = - 13.331 at p = 0.000; in pair 2001-2012, t (76) = - 13.331 at p = 0.000). Thus, based on these statistical results and our graph in Figure 5-3, influential technologies show an increase in their degree of structuration over time and the magnitude of such changes is statistically significant between pairs of time frames. Conversely, in failed or dormant technologies, not only does Figure 5-3 suggest a decrease in pair 2006-2012 (i.e., t (76) = 2.344 at p = 0.022), but also the statistical results in Table 5-3 confirm that the magnitude of change in pair 2001-2012 (i.e., shaded cell) is not statistically significant[87] (i.e., t (76) = - 1.260 at p = 0.212). Thus, failed or dormant technologies do not develop a sharp and statistically significant degree of structuration over the entire time frame. Hence, H2 is supported.

Appendix D Section D.6 presents the overall results of the paired t-test analyses.

Technological outcomes	Degree of structuration		Mean differences	Std. deviation	t	Df	Sig. (2-tailed)
Influential technologies	Pair 1	2001-2006	-1.952	.889	-19.272	76	.000
	Pair 2	2006-2012	-1.159	.763	-13.331	76	.000
	Pair 3	2001-2012	-3.111	1.121	-24.366	76	.000
Failed or dormant technologies	Pair 1	2001-2006	-.431	1.295	-2.919	76	.005
	Pair 2	2006-2012	.229	.859	2.344	76	.022
	Pair 3	2001-2012	-.201	1.402	-1.260	76	.212

Table 5-3 Paired t-test analysis between each pair of time frame for each technological outcome

Additionally, Figure 5-5 shows the estimated marginal means of degree of structuration per each technology at each time frame. The upper part of this figure groups results for failed or dormant

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87 That is considering a significance level of $p <= 0.05$.

Internet technologies (i.e., P2P Music Sharing, Search Portals, and Virtual Worlds), whereas the lower part presents results for influential Internet technologies (i.e., Cloud Computing, Mobile Internet Technologies, Social Media/Networking and Video Conferencing). Figure 5-5 reveals that influential technologies increase their degree of structuration over time while failed or dormant technologies do not.

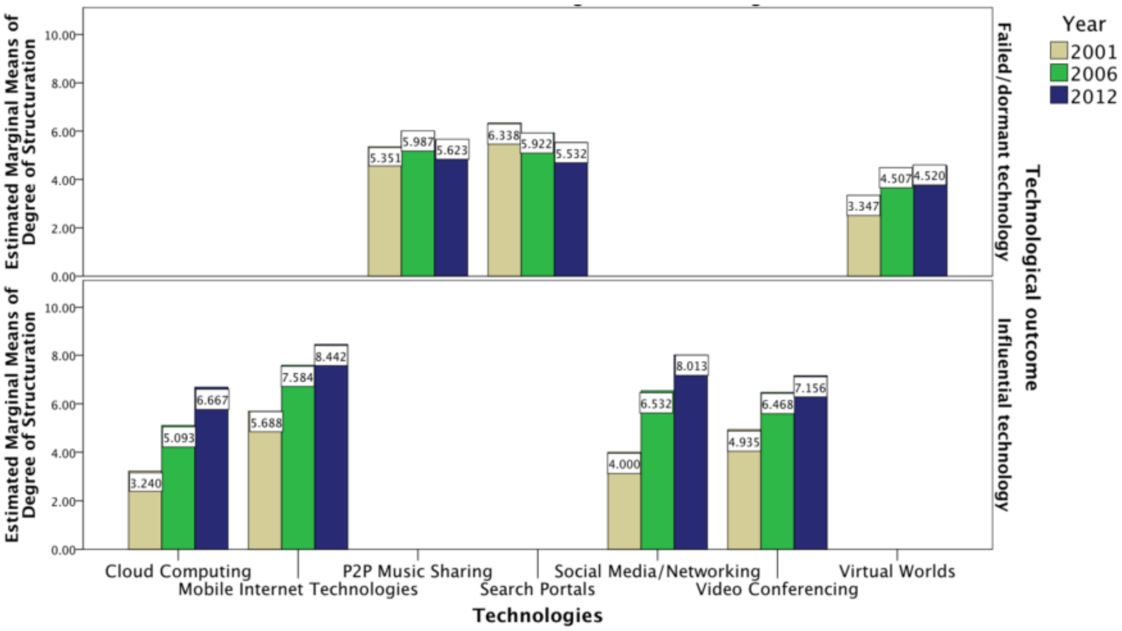

Figure 5-5 Degree of structuration means per technology and time frame

To statistically investigate each technology, we conducted two analyses: 1) a repeated measures ANOVA of the degree of structuration of each technology; and 2) a paired t-test analysis for each pair of time frames per each technology. Table 5-4 summarizes of the results of these two tests. Based on these results and Figure 5-5, H2 is supported at the technology level as well. All influential technologies show an increase in their degree of structuration along the three time frames, and the magnitude of such change is statistically significant (i.e., all negative t-values in the rectangle in bold are significant at $p <= 0.05$). Conversely, although failed or dormant technologies develop also a degree of structuration over time, the three time frame pairwise comparisons indicate that three magnitudes of change are not statistically significant (shaded cells).

Moreover, two of the three failed or dormant technologies present downward changes (i.e., the positive t-values in bold show decreases with respect to the development of degree of structuration). Thus, failed or dormant technologies do not have a sharp and statistically significant increase in their degree of structuration over the three time frames. Consequently, the empirical data support H2.

Past technologies		Repeated measures analysis results	Paired t-test results		
		2001-2006-2012	2001-2006	2006-2012	2001-2012
Failed or dormant Technologies	P2P Music Sharing	N = 77; F = (1.528, 116.128) = 5.303; p = 0.011	t = -2.975; df = 76; p = 0.004	**t = 2.757; df = 76; p = 0.007**	t = -1.194; df = 76; p = 0.236
	Search Portals	N = 77; F = (1.543, 117.265) = 7.917; p = 0.002	**t = 1.954; df = 76; p = 0.054**	**t = 2.764; df = 76; p = 0.007**	**t = 3.350; df = 76; p = 0.001**
	Virtual Worlds	N = 75; F = (1.735, 128.410) = 30.975; p = 0.000	t = -6.440; df = 74; p = 0.000	t = -.472; df = 76; p = 0.638	t = -6.079; df = 74; p = 0.000
Influential Technologies	Cloud Computing	N = 75; F = (1.792, 132.642) = 232.113; p = 0.000	t = -13.549; df = 75; p = 0.000	t = -10.448; df = 75; p = 0.000	t = -18.701; df = 74; p = 0.000
	Mobile Internet Technologies	N = 77; F = (1.452, 110.379) = 163.264; p = 0.000	t = -11.876; df = 76; p = 0.000	t = -8.233; df = 76; p = 0.000	t = -14.387; df = 76; p = 0.000
	Social Media/ Networking	N = 77; F = (1.783, 135.516) = 254.856; p = 0.000	t = -13.867; df = 76; p = 0.000	t = -9.963; df = 76; p = 0.000	t = -19.694; df = 76; p = 0.000
	Video Conferencing	N = 77; F = (1.574, 119.662) = 89.161; p = 0.000	t = -8.960; df = 76; p = 0.000	t = -5.474; df = 76; p = 0.000	t = -10.848; df = 76; p = 0.000

Table 5-4 Summary of the repeated measures analyses of the degree of structuration of each technology and summary of paired t-tests per each pair of time frame for each technology

Note that Appendix D Section D.7 and D.8 present the overall results of the repeated measures ANOVA and the paired t-test analyses respectively at the technology level.

5.6. The Relationship Between Level of Impact and Degree of Structuration

H3 indicated that the perceived level of impact of a technology is positively associated with the degree of structuration. Support for H3 emerges from thirty (30) bivariate correlation analyses. Table 5-5 displays correlation analyses between level of impact and degree of structuration, comparing results among technology groups[88] and technologies[89] in each time frame. To read Table 5-5, one must consider that each correlation coefficient corresponds to either a technology group or a technology in each time frame. For example, at the aggregated level of all technologies across participants (N=77), the correlation coefficient between level of impact and degree of structuration is 0.690 in the time frame of 2012. At the technology level, in the 2006 time frame, for *Social Media/Networking*, the correlation coefficient between level of impact and degree of structuration is 0.631.

In Table 5-5, it is interesting to note that two influential technologies (i.e., *Mobile Internet Technologies* and *Social Media/Networking*) decrease correlations over time (shaded cells). To further analyze this issue, Appendix D Section D.9 provides scatter/dot graphs depicting the relationship between these two variables for each technology and its time frames. Likewise, Appendix D Section D.10 presents descriptive analyses of the variance of the level of impact and degree of structuration for these two technologies along the three time frames. After these analyses, we conclude that for both technologies (i.e., *Mobile Internet Technologies* and *Social Media/Networking*), the measures (i.e., level of impact and degree of structuration) converge. Hence, a lack of variability among these measures prevents us from perceiving the strong relationship that these two measures show in the graphs. In other words, the correlation coefficient

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[88] *Technology group* refers to the level of aggregated data for each participant. Two levels of aggregated data can be distinguished: 1) all technologies together; and 2) either the group of influential technologies or the group of failed or dormant technologies.

[89] *Technology* refers to one of the seven technologies under analysis.

is not the best way to represent the strong relationship between these measures in these two technologies along the three time frames.

In essence, Table 5-5 indicates that all correlation coefficients were significant at $p < 0.01$. Twenty two correlation coefficients indicate a strong correlation between level of impact and degree of structuration (i.e., $r > 0.50$), while the remaining eight are close to 0.50. Consequently, the empirical data support that level of impact is positively associated with degree of structuration (H3).

Technology group	Correlations in time frames			Technology group	Correlations in time frames		
	2001	2006	2012		2001	2006	2012
All technologies	N=77 0.581	N=77 .687	N=77 .690	Failed or dormant technologies	N=77; 0.455	N=77; 0.572	N=77; 0.716
				Influential technologies	N=77; 0.666	N=77; 0.711	N==77; 0.692

Technology		Correlations in time frames		
		2001	2006	2012
Failed or dormant technologies	P2P Music Sharing	N=74; 0.499	N=77; 0.491	N=77; 0.631
	Search Portals	N=76; 0.454	N=76; 0.608	N=77; 0.722
	Virtual Worlds	N=72; 0.430	N=76; 0.472	N=75; 0.597
Influential technologies	Cloud Computing	N=74; 0.531	N=77; 0.655	N=75; 0.707
	Mobile Internet Technologies	N=77; 0.709	N=77; 0.626	N=77; 0.483
	Social Media/ Networking	N=77; 0.625	N=77; 0.631	N=77; 0.429
	Video Conferencing	N=75; 0.589	N=77; 0.773	N=77; 0.783

***Table 5-5 Summary of correlations between level of impact and degree of structuration comparing different time frames, technology groups, and technologies** (all correlation coefficients are significant at p<0.01)*

5.7. The Relationship Between Degree of Structuration and Level of Engagement

H4 postulated that individuals highly engaged with the enactment of a technology perceive more highly its degree of structuration.

To statistically investigate H4, we performed several analyses at the aggregated level of all technologies. First, based on the aggregated score of level of engagement, each participant was assigned to one of two empirically-valid clusters[90] of level of engagement (i.e., one cluster of individuals with relatively high level of engagement with Internet technologies and other cluster of individuals with relatively low level of engagement with Internet technologies). Second, we performed a repeated measures ANOVA analysis with degree of structuration as a within-subjects factor and cluster of level of engagement as a between-subjects factor. Figure 5-6 shows graphically the estimated marginal means of degree of structuration per cluster of level of engagement. The results of the repeated measure ANOVA analysis indicate that cluster of level of engagement does not interact with degree of structuration, $F\ (1.635,\ 122.622) = 0.271$ at $p = 0.781$. However, importantly, the direction of the relationship between degree of structuration and cluster of level of engagement is graphically consistent with our prediction.

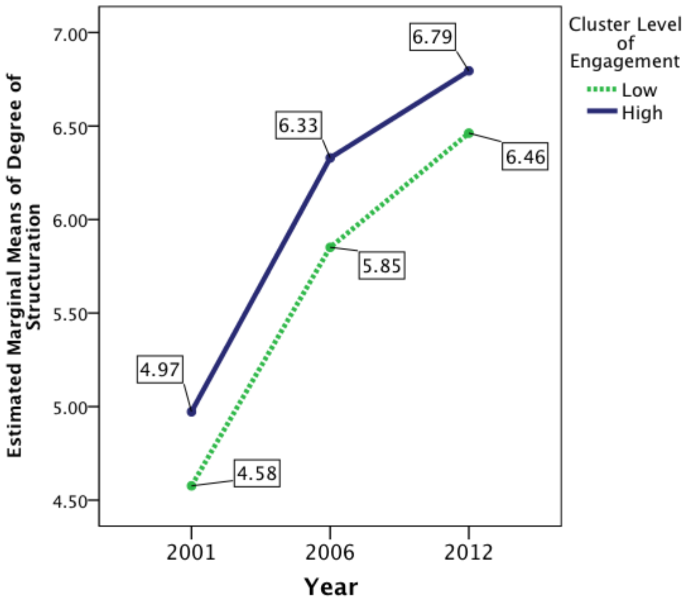

Figure 5-6 Estimated marginal means of degree of structuration per cluster of level of engagement

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[90] SPSS provides an option to create empirically-valid clusters. The K-means cluster procedure attempts to classify relatively homogeneous cases based on selected attributes. The procedure requires the user to specify the number of clusters.

Next, we performed a bivariate correlation analysis between level of engagement and degree of structuration at each time frame. The left column in Table 5-6 indicates that across the three time frames, these two variables have a positive moderate correlation that is close to statistically significant (i.e., p = 0.05). Next, the middle column in Table 5-6 presents the proportion of the variability in degree of structuration that is explained by level of engagement (i.e., in 2001, 4.8%; in 2006, 4.9%; and in 2012, 4.6%). On average, level of engagement explains about 5% of the variance of degree of structuration. Finally, for each time frame, we conducted a test of means of the degree of structuration between clusters of highly and lowly engaged individuals. The right column in Table 5-6 shows that the difference in means between highly and lowly engaged individuals is statistically significant in 2006 and 2012, and marginally significant in 2001. Hence, we cannot say that level of engagement is unrelated to degree of structuration. Thus, H4 is supported at least partially by the data at the aggregated level of all technologies.

Correlations in time frames between level of engagement and degree of structuration			**Proportion of the variability in degree of structuration explained by level of engagement – R squared**			**Test of means of the degree of structuration between clusters of individuals with high and low level of engagement**		
2001	**2006**	**2012**	**2001**	**2006**	**2012**	**2001**	**2006**	**2012**
N=77 r = 0.221; p = 0.053	N=77 r = 0.223; p = 0.052	N=77 r = 0.215; p = 0.061	4.8%	4.9%	4.6%	F = 3.908; df (75); p = 0.052	F = 7.018; df (75); p = 0.010	F = 3.963; df (75); p = 0.050

Table 5-6 Analyses of the relationship between degree of structuration and level of engagement – at the aggregated level of all technologies

To further investigate H4, we performed similar analyses at the technology level. That is, at the technology level, we produced clusters of individuals with high and low level of engagement with a technology. Later, for each technology at each time frame, we performed a test of means of the degree of structuration between clusters of highly and lowly engaged individuals. Table 5-7 shows the results. Interestingly, in certain technologies, the means of degree of structuration between individuals with high and low level of engagement is not significantly different (shaded cells). However, the difference in means of others technologies is statistically significant. Also, interestingly, in certain technologies H4 is supported but not in others. These results at the technology level suggest that the relationship between level of engagement and degree of structuration is moderated by other circumstances. This will be discussed later but for now, as stated earlier, the empirical data support H4 but just partially.

Technology		Test of means of the degree of structuration between clusters of individuals with high and low level of engagement		
		2001	2006	2012
Failed or dormant technologies	P2P Music Sharing	F = 4.325; df (75); p = 0.041	F = 4.325; df (75); p = 0.041	F = 5.917; df (75); p = 0.017
	Search Portals	F = 0.733; df (75); p = 0.395	F = 7.173; df (75); p = 0.009	F = 6.651; df (75); p = 0.012
	Virtual Worlds	F = 0.621; df (73); p = 0.433	F = 0.756; df (75); p = 0.387	F = 0.561; df (75); p = 0.456
Influential technologies	Cloud Computing	F = 6.448; df (74); p = 0.013	F = 11.477; df (75); p = 0.001	F = 5.698; df (74); p = 0.020
	Mobile Internet Technologies	F = 1.032; df (75); p = 0.313	F = 1.760; df (75); p = 0.189	F = 3.542; df (75); p = 0.064
	Social Media/ Networking	F = 0.000; df (75); p = 1.000	F = 1.262; df (75); p = 0.265	F = 0.200; df (75); p = 0.888
	Video Conferencing	F = 0.547; df (75); p = 0.462	F = 0.403; df (75); p = 0.527	F = 0.543; df (75); p = 0.464

Table 5-7 Test of means of the degree of structuration between clusters of individuals with high and low level of engagement at the technology level

5.8. The Relationship Between Degree of Structuration and Level of Awareness

H5 predicted that individuals with higher level of awareness with a technology perceive more highly its degree of structuration. As with H4, to examine statistically H5, we performed several analyses at the aggregated level of all technologies. First, each participant was assigned to one of two empirically-valid clusters of level of awareness based on their aggregated score (i.e., two clusters of individuals, one with high and the other with low level of awareness with Internet technologies). Second, we performed also a repeated measures ANOVA analysis with degree of structuration as a within-subjects factor and cluster of level of awareness as a between-subjects factor. Figure 5-7 shows graphically the estimated marginal means of degree of structuration per cluster of level of awareness. The results of the repeated measure ANOVA analysis confirm that cluster of level of awareness does not interact with degree of structuration, F (1.619, 121.459) = 1.017 at p = 0.351. Note that the direction of the relationship between degree of structuration and cluster of level of awareness is graphically consistent with our prediction.

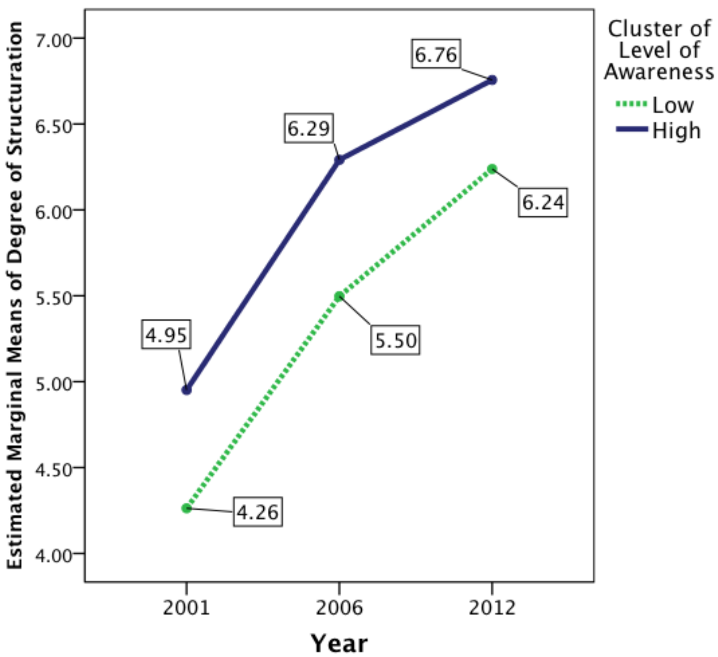

Figure 5-7 Estimated marginal means of degree of structuration per cluster of level of awareness

Then, for each time frame, we conducted a bivariate correlation analysis between degree of structuration and level of awareness. In Table 5-8, the left column shows that, across the three time frames, the relationship between degree of structuration and level of awareness is statistically significant (i.e., $p < 0.01$), positive, and strong. Next, the middle column in Table 5-8 shows that, on average over the three time frames, level of awareness explains about 15% of the variance of degree of structuration (i.e., in 2001, 16.6%; in 2006, 15.8%; and in 2012, 10.4%). Lastly, we performed at each time frame a test of means of the degree of structuration between clusters of highly and lowly aware individuals. In Table 5-8, the right column indicates that at each time frame, highly and lowly aware individuals differ significantly in their means of degree of structuration. Thus, the empirical data support H5 at the aggregated level of all technologies: individuals with higher level of awareness with a technology perceive more highly its degree of structuration.

Correlations in time frames between level of awareness and degree of structuration			Proportion of the variability in degree of structuration explained by level of awareness – R squared			Test of means of the degree of structuration between clusters of individuals with high and low level of awareness		
2001	**2006**	**2012**	**2001**	**2006**	**2012**	**2001**	**2006**	**2012**
N=77 $r = 0.407$; $p = 0.000$	N=77 $r = 0.398$ $p = 0.000$	N=77 $r = 0.322$ $p = 0.004$	16.6%	15.8%	10.4%	$F = 13.457$; df (75); $p = 0.000$	$F = 23.722$; df (75); $p = 0.000$	$F = 10.609$; df (75); $p = 0.002$

Table 5-8 Analyses of the relationship between degree of structuration and level of awareness – at the aggregated level of all technologies

Appendix D Section D.11 reports similar analyses at the technology level. Importantly, H5 is supported as well at the technology level.

5.9. The Relationship Between Probability of a Technology Becoming a Major Trend in Five Years and Level of Engagement

H6 indicated that individuals highly engaged with the enactment of a technology perceive higher probability of it becoming a major trend in five years. As with H4 and H5, several analyses were performed at the aggregated level of all technologies. Based on the two empirically-valid clusters of level of engagement produced in testing H4 (i.e., one cluster of individuals with high level of engagement with Internet technologies, and another cluster of individuals with low level of engagement with Internet technologies), a repeated measures ANOVA analysis was performed with probability of a technology becoming a major trend in five years (PTBMT) as a within-subjects factor and cluster of level of engagement as a between-subjects factor. Figure 5-8 presents graphically the estimated marginal means of PTBMT per cluster of level of engagement. The results of the repeated measure ANOVA analysis confirm that these two factors do not have interaction, $F(1.616, 121.212) = 0.367$ at $p = 0.649$. Note that the direction of the relationship between PTBMT and cluster of level of engagement is graphically consistent with our prediction.

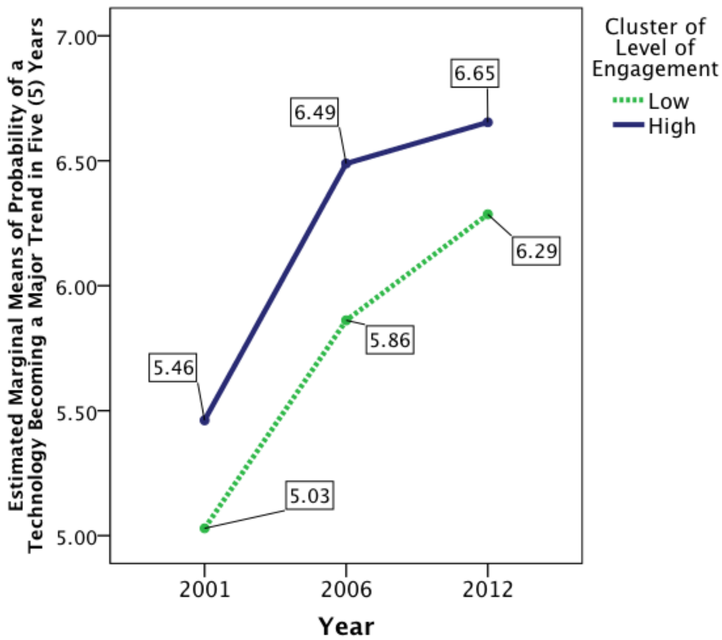

Figure 5-8 Estimated marginal means of probability of a technology becoming a major trend per cluster of level of engagement

Next, a bivariate correlation analysis was performed between PTBMT and level of engagement. In Table 5-9, the left column indicates that these two variables are statistically correlated in 2006 (i.e., $p < 0.05$) but the correlation in 2001 and 2012 is not statistically significant (i.e., $p > 0.05$). The middle column in Table 5-9 displays the proportion of the variability in PTBMT that is explained by level of engagement. On average over the three time frames, level of engagement explains about 4% of the variance of PTBMT. Lastly, we conducted at each time frame, a test of PTBMT means between clusters of highly and lowly engaged individuals. In Table 5-9, the right column shows that only in 2006, highly and lowly engaged individuals differ in their means of PTBMT. Hence, H6 is only partially supported at the aggregated level of all technologies.

Correlations in time frames between level of engagement and probability of a technology becoming a major trend			Proportion of the variability in probability of a technology becoming a major trend explained by level of engagement – R squared			Test of means of the probability of a technology becoming a major trend between clusters of individuals with high and low level of engagement		
2001	2006	2012	2001	2006	2012	2001	2006	2012
N=77 r = 0.151; p = 0.190	N=77 r = 0.232; p = 0.043	N=77 r = 0.201; p = 0.080	2.3%	5.4%	4.0%	F = 1.854; df (75); p = 0.177	F = 6.415; df (75); p = 0.013	F = 2.456; df (75); p = 0.121

Table 5-9 Analyses of the relationship between probability of a technology becoming a major trend in five years and level of engagement – at the aggregated level of all technologies

Additionally, although the relationship between PTBMT and level of awareness was not hypothesized, a similar set of analyses was performed to explore this relationship. Table 5-10 presents the results and suggests that level of awareness explains in 2001 and 2006 PTBMT. Further discussion is required in Chapter 6.

Correlations in time frames between level of awareness and probability of a technology becoming a major trend			Proportion of the variability in probability of a technology becoming a major trend explained by level of awareness – R squared			Test of means of the probability of a technology becoming a major trend between clusters of individuals with high and low level of awareness		
2001	2006	2012	2001	2006	2012	2001	2006	2012
N=77 r = 0.343; p = 0.002	N=77 r = 0.277; p = 0.015	N=77 r = 0.088; p = 0.444	11.7%	7.7%	0.7%	F = 9.342; df (75); p = 0.003	F = 8.334; df (75); p = 0.005	F = 1.119; df (75); p = 0.293

Table 5-10 Analyses of the relationship between probability of a technology becoming a major trend in five years and level of awareness – at the aggregated level of all technologies

5.10. The Alignment of Influential Technologies: The Degree of Structuration Effect

H7 predicted that over time, influential technologies decrease variance in the estimates of their degree of structuration whereas failed or dormant technologies do not. At the technological outcome level, Figure 5-9 shows evidence that failed or dormant technologies did not decrease variance in their perceived degree of structuration over time but influential technologies do. At the technology level, Figure 5-10 depicts that each influential technology decreases variance in its degree of structuration over time but failed or dormant technologies do not. Hence, the results in Figure 5-9 and Figure 5-10 support empirically H7.

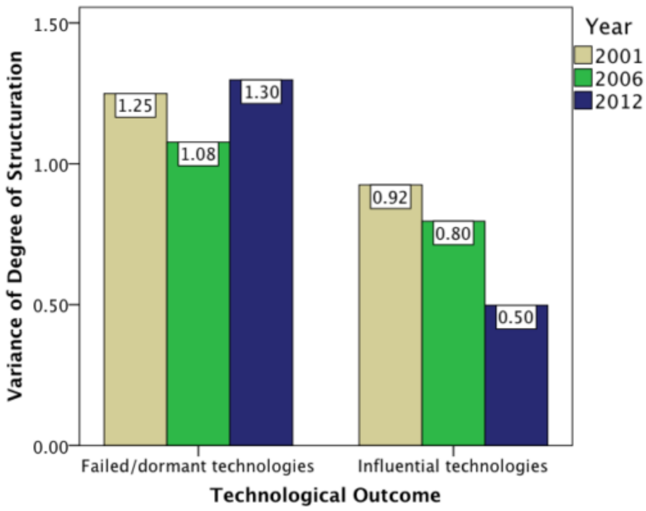

Figure 5-9 Degree of structuration variance over time at technological outcome level

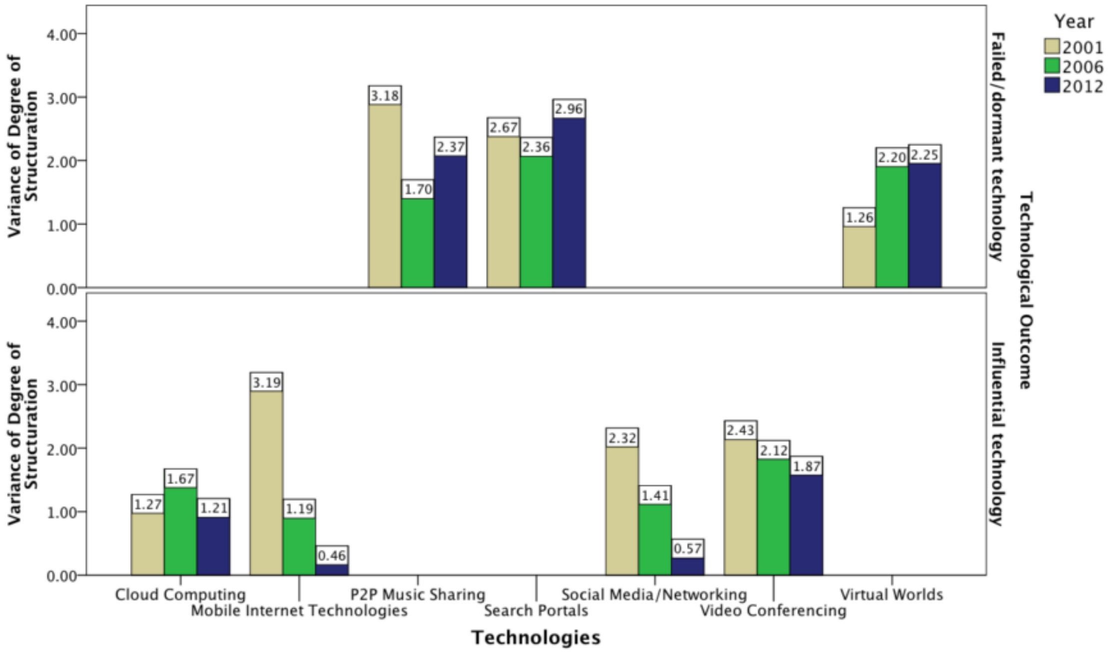

Figure 5-10 Degree of structuration variance over time at technology level

Similarly, **H8** posited that over time, influential technologies decrease variance in their probability of becoming a major trend in five years whereas failed or dormant technologies do not. In the same manner, Figure 5-11 reflects that at technological outcome level, the variance in the probability of influential technologies becoming a major trend in five year decreases significantly over time, while the variance in the probability of failed or dormant technologies becoming a major trend in five years does not.

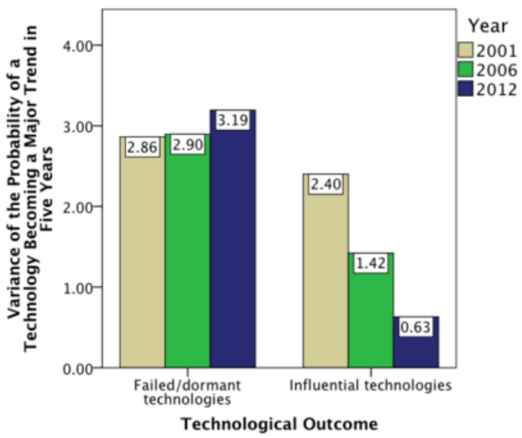

Figure 5-11 Probability of becoming a major trend in five years variance over time at technological outcome level

In Figure 5-12, at technology level, the variance in the probability of failed or dormant technologies becoming a major trend in five years does not appear to decrease consistently over time, while the variance in the probability of influential technologies becoming a major trend in five years does. Thus, Figure 5-11 and Figure 5-12 provides empirical support for H8.

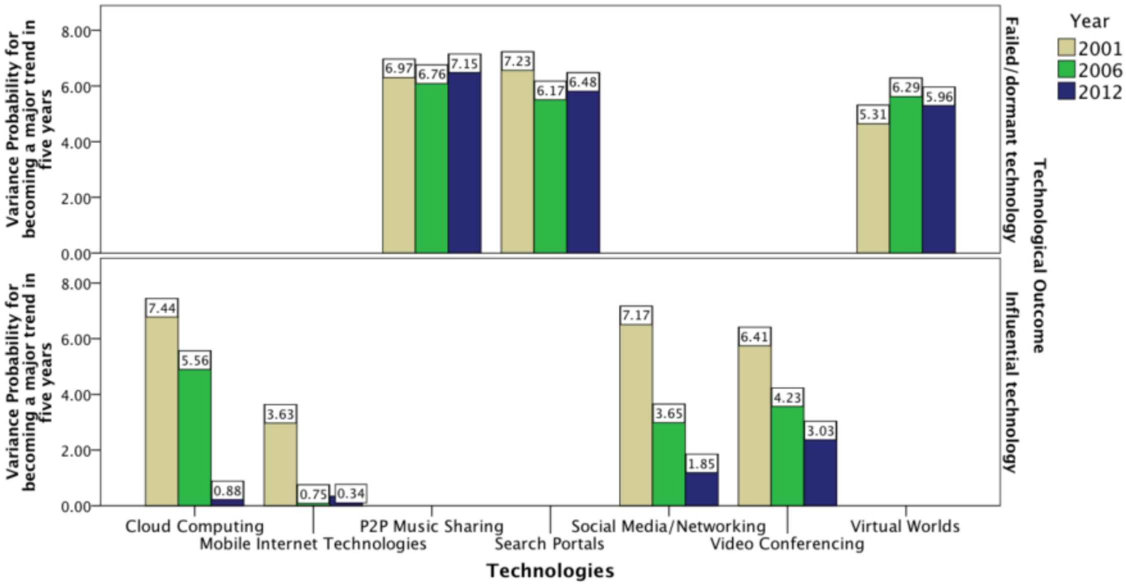

Figure 5-12 Probability of becoming a major trend in five years variance over time at technology level

5.11. The Operation of Hindsight Bias in the Study

Finally, a question probed the extent to which the self-reported personal hindsight bias of participants is lower than the perceived hindsight bias of other participants in the study. Figure 5-13 presents graphically the means of participant views between personal hindsight bias (5.07) and other participant hindsight bias (5.59). The difference in means is in the expected direction. Later, Figure 5-14 shows the results of a paired t-test analysis between the self-reported personal hindsight bias and the perceived hindsight bias of other participants. The results confirm that the difference in means between these groups is statistically significant, t (75) = 3.446 at p = 0.001.

Hence, by our preliminary probe of hindsight bias, participants assume that the reports of their contextual circumstances and experience might be considered with less distortion (bias) than reports from other participants. Moreover, this intriguing observation would seem to be consistent, not only with aspects of hindsight bias, but possibly with egocentric or overconfidence biases, empathy gaps and better-than-average effects, subjective interpretations in the social world, and self-awareness of competence and incompetence (Ross & Ward, 1996; Dunning, Johnson, Ehrlinger, & Kruger, 2003; Van Boven, Loewenstein, Dunning, & Nordgren, 2013). Clearly, further investigation is needed.

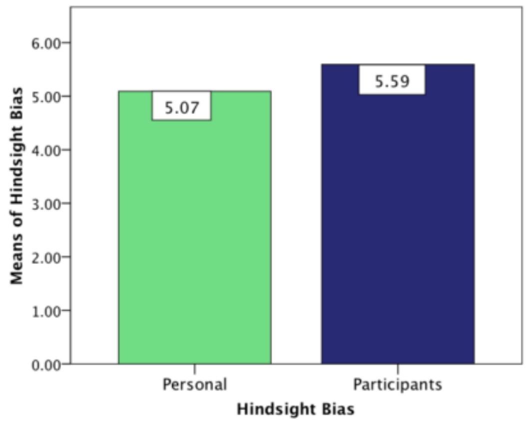

Figure 5-13 Means of participant views between personal and other participants hindsight bias

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Participant_HSB	5.59	76	1.877	.215
	Personal_HSB	5.07	76	2.016	.231

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Participant_HSB & Personal_HSB	76	.768	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Participant_HSB - Personal_HSB	.526	1.331	.153	.222	.831	3.446	75	.001

Figure 5-14 Paired t-test analysis between personal hindsight bias and other participants hindsight bias

5.12. Summary of the Results

Focus	Hypotheses		Results
The relationship between technological outcome and degree of structuration.	H1	Influential technologies develop a higher degree of structuration than failed or dormant technologies.	Supported
	H2	Influential technologies increase their degree of structuration over time but failed or dormant technologies do not.	Supported
The relationship between level of impact and degree of structuration.	H3	The perceived level of impact of a technology is positively associated with its degree of structuration.	Supported
The relationship between degree of structuration and level of engagement.	H4	Individuals highly engaged with the enactment of a technology perceive more highly its degree of structuration.	Partially supported
The relationship between degree of structuration and level of awareness.	H5	Individuals with higher level of awareness with a technology perceive more highly its degree of structuration.	Supported
The relationship between probability of a technology becoming a major trend in five years and level of engagement.	H6	Individuals highly engaged with the enactment of a technology perceive higher probability of it becoming a major trend in five years.	Partially supported
The alignment of influential technologies or the degree of structuration effect	H7	Over time, influential technologies decrease variance in their degree of structuration but failed or dormant technologies do not.	Supported
	H8	Over time, influential technologies decrease variance in their probability of becoming a major trend in five years but failed or dormant technologies do not.	Supported

Chapter 6. Discussion and Limitations

In the absence of strong systematic explanations of what technologies are, where technologies come from, how technologies evolve, and how new technologies emerge, the present study proposes an open framework that brings together different theories and perspectives (Porter M. , 1991; Geels, 2010). Rather than approaching the problem with a particular commitment to a philosophical system or reality (Creswell, 2009), the researcher suggests a pragmatic perspective that uses various research resources available to solve the research problem: How do we identify the emergence and development of new technologies, threatening or enhancing, the competence of a firm within an industry?

The reconceptualization of technologies through the lens of the Structuration Theory – a social process theory – permits one to embrace different technology definitions instead of aiming for the characterization of only one universal definition. The study makes explicit the multidimensional perspective of technologies and clarifies for technologies the relationship between their explicit or *material* forms and their social form or structure that enables and results from their instantiation (Orlikowski, 2000; 1992). Pragmatically, technologies exist only when they are recognized as technologies by someone. Otherwise, such explicit or *material* forms are only extra features of the environment with no meaningful role in social practices (Orlikowski, 1992). Technologies present then at least and simultaneously two dimensions. First, technologies are recursive physical or explicit forms that are socially constructed by designers. Second, technologies are ongoing social or abstract forms or entities that enable and result from users' practices. Technologies may have physical or *material* existence in nature, yet they are subjects of scientific study and development only through the analysis of the social structure lying within individuals' heads or the social structure instantiated in social practices. Thus, technologies are an endogenous feature of the social structure and virtual order distinctions that refer to a set of embedded procedures (rules) and institutionalized forms of activity (resources) instantiated in social practices.

Once technologies are reconceived as ongoing social or abstract entities, means and outcomes enabling and resulting from individuals interacting with their environments, the study focuses on technologies as social outcomes, assuming that variation in social outcomes (e.g., events, practices, trends, technologies) emerge from changes in social means (i.e., rules and resources within individuals' heads). That is the duality of the structure according to Giddens (1984). Hence, in the structurational model of emerging technologies (SMET), the study proposed to capture only analytically the process of emergence and development of new technologies by examining the extent of development of specific social outcomes that suggest the existence of a technology-related social structure in one of its three analytical dimensions: structures of meaning, structures of power, and structures of legitimacy. Specifically, the SMET assumes that the conceptual initiation of a new technology triggers new patterns of social activity – signals of technological change – and thus variation in social outcomes. Consequently, the emergence and development of new and existing technologies can be analyzed by modelling aspects of change that describe the sequence of events that technologies instantiate in society.

6.1. Technological Outcomes and Degree of Structuration

In Section 5.5, we confirm the relationship between the degree of structuration of a technology and its technological outcome. Thus, from these results, we draw five major observations. First, the results support the notion of *degree of structuration* by indicating that influential and failed or dormant technological outcomes can be explained by the degree of structuration of a technology (**H1**). Since degree of structuration refers to the extent of development of social structure enabling and resulting from the enactment of a technology, our results are in line with previous research suggesting that the development of a technological paradigm – i.e., cognitive structures of how to a solve problem – defines a technological trajectory (Dosi, 1982). Likewise, the results are consistent with Geels and Schot (2007) who indicate that technological niches present weak structuration and socio-technical regimes experience strong structuration. Geels and Schot (2007) refer to Giddens and suggest structuration in terms of stability of rules in the enactment of a technology.

Second, the results support the argument of social processes that take place and differentiate between influential and failed (or dormant) technological outcomes. By using the SMET as a scientific object that models the process of how technologies are created, altered and reproduced, we examine the extent of development of social structure instantiated in technology-related social practices (i.e., a degree of structuration). The degree of structuration of a technology is, thus, examined in three different time frames. That is, we capture the ongoing process. Consequently, we find that influential technologies increase consistently their degree of structuration over time but failed or dormant technologies do not (**H2**). Thus, our analytical approach captures the process perspective – the sequence of development – that technologies unfold in order to evolve in influential or successful technological outcomes. The argument of technologies as social processes is in agreement with previous research indicating the ongoing and gradual development of technological change – e.g., the social construction of technological systems (Bijker, Hughes, & Trevor, 1987; Bijker, 1995); and technological transitions as evolutionary reconfiguration processes (Geels, 2002; Foster, 1986). Hence, this study contributes to the literature by showing how to model scientifically the complex process of emergence and development of new technologies.

Third, our findings support the proposition that the degree of structuration and the emergence and development of new technologies can be tracked by examining the extent of development of specific social outcomes (i.e., ongoing processes). Interestingly, the study's approach is in line with previous research assuming that the analyses of specific social outcomes, such as academic papers and citations in science and technology databases and patents in patent databases, help to forecast emerging technologies (Porter A. L., 2005; Porter & Cunningham, 2005; Daim, Rueda, Martin, & Gerdsri, 2006; Bengisu & Nekhili, 2006; Kim, Suh, & Park, 2008). Certainly, these studies may refer to those specific outcomes in their explicit form. Nonetheless, our argument is valid because explicit outcomes exist only if social means and outcomes exist[91]. The study contributes, thus, to the literature from two perspectives. It provides a theoretical framework that supports hidden assumptions in previous studies, and extends the scope of social outcomes that should be considered in order to track the emergence and evolution of technologies.

Fourth, the results show evidence that the proposed integrative framework has the potential to reconcile theories and findings in the literature of technological change. The study develops an open framework based on a process theory that does not identify what social outcomes occur but enables the researcher to test for specific outcomes of systemic activity. Subsequently, the study relies on previous theories and findings to identify and propose what technology-related social outcomes to examine in order to estimate the degree of structuration of a technology. Thus, by finding support that the degree of structuration of a technology results from the reconceptualization of previous findings in the literature (i.e., suggested technology-related social outcomes), we find support to argue that the proposed theoretical framework is promising for studying and integrating the literature of technological change, currently fragmented for the most part. The study's approach is in agreement with Gidley (2010), who indicates that leading scientists and thinkers in many fields have identified an epistemological crisis suggesting that fragmented, mechanistic, and materialistic approaches are no longer sustainable to define and understand our complex reality.

Fifth, these results have also important managerial implications. We argue that the results shed light on essential attributes or aspects that individuals or organizations developing new technological propositions should consider. If the results support that influential technological outcomes develop over time the requisite structures of meaning, power, and legitimacy in their social and technological systems (i.e., a higher degree of structuration), new technological propositions should

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[91] The explicit or material form of certain resources does not affect the fact that they become resources in the manner in which Structuration Theory applies the term (Giddens, 1984, p. 33).

be considered in light of these structures. Of course, the question is, what features should new technological propositions have in order to fit with and develop the current social structure? What should individuals and organizations pay attention to in order to design new technological propositions that fit with the current technology-related social structure and encourage the creation and formation of a new technology-related social structure? The answers to these questions are not trivial, and go beyond the scope this study. We believe that the emerging field of design thinking (Martin R., 2009; Brown, 2009) aims to address these questions.

For now, we argue that new technological propositions should aim for designs and projects that consider the following: 1) inform and define individuals' actions, facilitating shared meaning among individuals – i.e., to develop structures of meaning; 2) enable individuals to fulfill their purposes, changing their contextual circumstances – i.e., to develop structures of power; and 3) inspire and generate agreement with respect to the enactment of social practices – i.e., to develop structures of legitimacy. Interestingly, the importance of structures of meaning, power and legitimacy is suggested by different theories and findings in the literature. Certainly, these theories and findings suggest structures of meaning, power, or legitimacy at different levels and domains of action. Moreover, such findings and arguments emphasize commonly only one of the three analytical dimensions of the social structure. Nonetheless, again, this study provides an integrative theoretical perspective. Table 6-1 presents seven examples of theories and findings in line with our results and argument. The size and weight of "X" in Table 6-1 indicates emphasis.

Theories and findings suggesting that structures of meaning, power or legitimacy are determinants for the growth of technological and business propositions	Suggested structure		
	Meaning	Power	Legitimacy
Absorptive capacity (AC) refers to the ability of individuals or organizations to identify and understand the value of new external information, and exploit it in order to fulfill their purposes (Cohen & Levinthal, 1990). According to Cohen and Levinthanl, AC is mainly a function of previous related knowledge.	**X**	x	
The technology acceptance model (TAM) indicates that perceived usefulness and perceived ease of use are determinant attributes for technology adoption (Davis, 1989; Kulviwat, Bruner, Kumar, Nasco, & Clark, 2007).	**X**	x	
The task-technology fit model (TTF) suggests that technology adoption depends on the perceived available functionality of the technology to fulfill (fit with) user task needs (Goodhue, 1995; Goodhue & Thompson, 1995).	**X**	**X**	
The concept of "customer value proposition" (VP) indicates that the success of business and technological propositions depends on the extent they construct and deliver value to customers, such as solving customers problems and needs, reducing customer cost, and providing complementary benefits to them (Osterwalder & Pigneur, 2010; Anderson, Narus, & Van Rossum, 2006).	x	**X**	
The notion of "creating shared value" (CSV) (Porter & Kramer, 2011) and "bottom of the pyramid" (BoP) (Prahalad, 2004) indicates that the new way to achieve economic and long-term success is determined by bringing together business and social progress, addressing social problems and needs first, in a way of creating wealth and value for individuals and society.	x	**X**	
Environmental scanning suggests that institutional events such as mergers, acquisitions, alliances, and technological agreements can signal the direction of technological trajectories. Trend detection techniques put special attention to identify this kind of institutional events (Wei & Lee, 2004; Yeh & Puri, 2009).	x		**X**
The social construction of technology (SCOT) suggests that consensus with respect to the enactment of social and technological practices emerge, once the interpretative flexibility of an artifact decreases. Consensus refers to an agreement among the relevant social groups about the dominant meaning and functioning of a technology (Bijker, 1995; Bijker, Hughes, & Trevor, 1987).	**X**	x	**X**

Table 6-1 Findings and arguments in line with our results

We believe, therefore, that influential or successful technological propositions may emerge from individuals and organizations with a deep understanding of the social structure that defines the domain of activity in question. Mastering the structures of meaning, power, and legitimacy that characterize the activities of a community seems to be a requirement for creating important technological propositions in any technology domain. To be knowledgeable about these structures implies the understanding of needs, motivations, and aspirations of such a community. To be knowledgeable about these structures also implies the ability to identify what is missing to develop new and more systemic technological propositions with sense of purpose, meaning, and value.

Technological propositions aiming to succeed should be, at least, meaningful, empowering, and respectful of fundamental social needs and values. Of course, all these arguments require further investigation. However, our findings provide a good starting point and guidance for technology developers.

6.2. Explaining Level of Impact by a Process Theory (ST)

The results in Section 5.6 confirm a strong positive relationship between level of impact and degree of structuration of a technology (**H3**). One could ask whether degree of structuration is not the same construct as level of impact. In fact, we argue that these results provide still more insights about our theoretical framework. In the study, the operational definition of level of impact refers to a concrete attribute of the social and technological system at a given point in time with respect to the effect of a technology (i.e., an overall magnitude of change). On the other hand, degree of structuration of a technology is an operational measure characterizing specific patterns of social activity – our unit of analysis – in different levels and domains. Thus, systematic measures of degree of structuration aim to capture evidence to explain technological change. Consequently, these two variables are different operational measures. *Level of impact of a technology* entails a variance theory perspective, whereas *degree of structuration* represents a process theory variable. We argue, therefore, that these findings not only provide more evidence of the explanatory power of our process theory, but also shed light on the strong relationship between variance theory variables and process theory variables (Poole, Van de Ven, Dooley, & Holmes, 2000, p. 22; Poole, 2004, p. 14). In this case, the overall magnitude of change created by a technology is strongly related to the extent of development of social structure with respect to such technology. Level of impact of a technology can be explained by changes in the technology-related social structure.

6.3. The Independent and Collective Nature of Degree of Structuration

In Section 5.7, the results support partially that individuals highly engaged with the enactment of a technology perceive more highly its degree of structuration (**H4**). The rationale for claiming a partial support is that at the aggregated level of all technologies, H4 is statistically significant in 2006 and 2012, and marginally significant in 2001. Additionally, at the technology level, in three specific technologies (i.e., in Table 5-7, the cases for *P2P Music Sharing*, *Cloud Computing*, and *Search Portals*), the prediction that individuals highly engaged with the enactment of a technology perceive more highly its degree of structuration is supported across all their time frames, except for only one time frame with one technology. However, as well, at the technology level, in the case of the other four technologies, our prediction is not statistically significant at any time frame (i.e., in Table 5-7, the cases for *Mobile Internet Technologies*, *Social Media/Networking*, *Video Conferencing*, and *Virtual Worlds*). Hence, these results not only support partially H4, but also provide more insight and support for our theoretical framework. Remarkably, it seems that the degree of structuration of a technology plays a role and moderates somehow its own relationship with level of engagement. Let us explain this next.

Appendix D Section D.12 indicates correlation coefficients between degree of structuration and individuals' level of engagement with a technology. For the same three cases of *P2P Music Sharing*, *Cloud Computing*, and *Search Portals* technologies, these two variables (i.e., degree of structuration, level of engagement) are correlated across all their time frames, except for one technology in one time frame. However, for the same four cases of *Mobile Internet Technologies*, *Social Media/Networking*, *Video Conferencing*, and *Virtual Worlds*, degree of structuration and level of engagement are not correlated, again except for one technology in one time frame. Moreover, in Appendix D Section D.13, *Mobile Internet Technologies*, *Social Media/Networking*, and *Video Conferencing* are technologies with the highest degree of structuration in the group and *Virtual Worlds* is a technology with the lowest degree of structuration in the group. It might be argued that the relationship between degree of structuration and level of engagement is affected when the technology in question has a very low degree of structuration or a very high degree of structuration. On one hand, the means of degree of structuration between highly and lowly engaged individuals are not significantly different when a technology has not developed enough structures of meaning, power, and legitimacy (i.e., the technology has a low degree of structuration). That is, the extent of development of social structure is not clearly perceived by individuals in the social group. Both individuals highly engaged and lowly engaged cannot perceive differences in the technology-related social structure. On the other hand, when a technology has developed broad structures of meaning, power, and legitimacy (i.e., the technology has a high degree of structuration), the means of degree of structuration between highly and lowly engaged individuals are also not significantly different because the extent of development of the social structure is shared among individuals in the whole social group in question. Both individuals highly engaged and lowly engaged are able to perceive the technology-related social structure in question.

Hence, these results suggest that degree of structuration of a technology is a somewhat independent process and does not depend on the level of participation that individuals experience in the enactment of the technology. Technologies are not products of any single person but are the result of collective patterns sustained by individuals (Giddens, 1984; Cohen I. J., 1989, p. 22). Perhaps, not surprisingly, when a technology shows a higher degree of structuration, highly and lowly engaged individuals with a technology are able to perceive the results of the enactment of such technology. In sum, technologies are not independent products of isolated individuals; technologies in their social form become collective outcomes.

6.4. The Difference Between Level of Engagement and Level of Awareness

Whereas the results in Section 5.7 support partially that individuals highly engaged with the enactment of a technology perceive more highly its degree of structuration (**H4**), the results in

Section 5.8 confirm that individuals with higher level of awareness with a technology perceive more highly its degree of structuration (**H5**). If both level of awareness and level of engagement with a technology refer to an ability to be knowledgeable and reflexive about the enactment of a technology, why can level of awareness explain better degree of structuration than level of engagement?

On one hand, *level of awareness* is focused on knowing the social and technological conditions – social outcomes – resulting from the enactment of a technology. Level of awareness refers to the ability to describe the physical and social aspects of individuals' contexts in the enactment of a technology. On the other hand, level of engagement is focused on knowing in practice the rules and resources – social means – that enable and constrain the production and reproduction of a technological proposition. *Level of engagement* refers to the ability to describe practically and perhaps theoretically the rules and resources that constitute the technology itself – i.e., what defines the technology and what the technology aims to do. In other words, while level of awareness is focused on *consequences* of use and design, level of engagement is focused on *rules* of use and design. Knowing the effect of a technology (level of awareness) is different from knowing the rules to enact the technology itself (level of engagement). The study did not hypothesize a relationship between level of engagement and level of awareness of individuals with a technology. Hence, the relationship between level of awareness and engagement requires further investigation.

Similarly, the results in Section 5.9 support that only in 2006 did individuals highly engaged with the enactment of a technology perceive more highly its probability of becoming a major trend in five years (**H6**). Although the direction of this relationship is consistent with our original prediction, the means of probability of a technology becoming a major trend in five years (PTBMT) between highly and lowly engaged individuals are not statistically different in 2001 and 2012. Individuals' engagement with a technology explains only on average about 4% of the variance of PTBMT. On the other hand, further analyses in Table 5-10 suggest that PTBMT may be better explained by level of awareness of individuals with such technology. In 2001 and 2006, individuals' awareness with a technology explains on average about 10% of the variance of PTBMT, although the means of PTBMT between highly and lowly aware individuals are not statistically different in 2012. Interestingly, it might be argued once again that when technologies have a low degree of structuration or a high degree of structuration, both individuals highly engaged and lowly engaged cannot perceive a difference in the technology-related social structure. Thus, the means of PTBMT between highly and lowly engaged individuals are not significantly different. On the other hand, the difference in means of PTBMT between highly and lowly engaged individuals is not statistically significant only when technologies present a higher degree of structuration (i.e., in 2012). Both individuals highly and lowly aware are able to perceive the technology-related social structure in question. The extent of development of the technology-related social structure is shared among individuals in the social group in question. Although these arguments require further investigation, this discussion brings to mind important considerations.

Interestingly, two major observations emerge from these results that are, in fact, consistent with ongoing discussions in the field of future studies. First, the results are in line with Tetlock's (2005) and Saffo's (2007) arguments indicating that experts are not more reliable forecasters than non-experts. Our study shows evidence that lowly engaged individuals with a technology – i.e., individuals with weak technical expertise – are able to perceive the extent of development of social structure of a technology in a manner similar to that of highly engaged individuals. Since the degree of structuration or the extent of development of social structure of a technology helps to explain its technological outcome and its level of impact, we concur with the argument that individuals with low level of engagement (i.e., less-experts) can make, perhaps not surprisingly, similar predictions about the future of a technology as experts can. In particular, this may occur in situations where technologies display a higher degree of structuration and both experts and less-experts are aware and able to perceive the technology-related social structure in question. As well, this may happen when technologies present a low degree of structuration and experts are less able to perceive differences about the future of such technology.

Second, the results are in line with findings and arguments that suggest the essential role of social awareness in order to identify and characterize new emerging technologies. The term *social awareness* is certainly not used. However, authors refer to the capability of individuals and organizations to understand and make sense of opportunities and threats in their technological and business environments. Day and Shoemaker (2006) describe *peripheral vision* as a capability to detect signals that can make or break a company. Halal (2007) enlists the importance of breadth of knowledge in selecting experts for technology foresight. Tsoukas (2004, p. 140) points out *foresighfulness* and describes “the ability to read the environment – to observe, to perceive – to spot subtle difference.” Patton (2005, p. 1084) asserts that “The most important tools for remaining afloat and thriving in the turbulence are a constant awareness of the changes going on around your organization and the ability to sense, make sense of, and adapt to these changes.” Neugarten (2006) highlights the need of asking oneself for alternative explanations in order to uncover blind spots and tacit assumptions in competitive intelligence and foresight activities. In this same vein, Saffo (2007), Ilmola and Kuusi (2006), Van der Heiden (2004), and Schoemaker and Day (2009) go further and provide guidelines and methods to help individuals and organizations to increase their ability to read the environment in order to take meaningful action in the present – e.g., six rules for effective forecasting (Saffo, 2007), how to open organizational filters for capturing weak signals (Ilmola & Kuusi, 2006), developing perceptual skills and organizational learning through scenario planning (Van der Heiden, 2004), and how to make sense of weak signals (Schoemaker & Day, 2009). In sum, level of awareness of individuals with a technology is an essential ability to identify the extent of development of social structure and, more precisely, social awareness is a key attribute to identify what may be next in technology.

Therefore, we do not suggest that expertise (i.e., engagement) is not important. In fact, we argue that expertise is a fundamental attribute to characterize the evolution and state-of-the-art of a technology field. However, we argue that this study contributes to the literature of future studies by highlighting that level of awareness is a key ability that experts involved in foresight activities should cultivate. According to our results, the ability of individuals to infer the future lies on individuals' capacity to observe collective patterns of behaviour instantiated in social outcomes but does not depend on individuals' engagement. Level of engagement (expertise) and level of awareness (social knowledge ability) may imply a different set of skills.

6.5. The Alignment of Individuals and Influential Technologies: The Structuration Effect

Perhaps, our previous arguments of the structurational process might be questioned as the result of potential hindsight bias experienced by our knowledgeable research participants. However, remarkably, the results in Section 5.10 provide more support to the argument of the structurational process experienced by individuals and influential technologies. Influential technologies not only increase consistently their degree of structuration over time (i.e., display social outcomes indicating the development social structure – **H1** and **H2**), but also decrease variance in their degree of structuration and probability of their becoming a major trend in five years (**H7** and **H8**). We argue that these results show evidence of the shaping process of individuals' perspectives with respect to a technology subject-matter (i.e., the results suggest a consensus in social means – rules and resources instantiated in the action of our knowledgeable research participants). The results indicate how at an early point in time, influential and failed formant technologies are subject to a higher variance (a higher level of uncertainty among our research participants). However, as time progresses, influential technologies indicate a gradual alignment in terms of how these technologies are perceived (the alignment of individuals and influential technologies). These findings provide a different view of the structurational process. We argue that our findings not only confirm that influential technologies achieve a lower variance over time (a lower level of uncertainty among our knowledgeable research participants), but also suggest the structuration effect among our research participants. Therefore, influential technologies shape their social and technological perspectives and yet, as stated earlier, this consensus of experts in a field may be the best indicator we can suggest to produce an acceptable approximation of the phenomenon (Simon, 1979, pp. 509-510; Popper, 1968).

6.6. Identifying Emerging New Technologies and the Future as a Collective Outcome

The study is focused on a retrospective analysis for practical and scientific reasons. However, the study can provide guidelines to create a foresight system in a real-time analysis. The study illustrates methodologically how to model systemically the complex and emergent dynamic of social and technological change. Since individuals' perspectives are bounded and limited, companies should create a collective interpretation of their technology-related industry. Because the unit in change is the industry itself, the systematic and collective perspective of such interpretation is an essential property in framing scientifically the study and problem of identifying signals of technological change. Weak signals of technological change are not a speculative or discursive description of a potential new technology, as commonly provided by a group of experts. Weak signals are not experts' judgments. Weak signals of technological change are initial real behavioral patterns producing socially and physically the development of a new technology. Hence, the study proposes how to capture and measure these behavioral patterns. The study not only clarifies the unit of analysis but also describes how to collect systematically data that lead us to address the question of: Change with respect to what? That is, change with respect to a degree of development of a technology-related social structure over time.

Technologies are both explicit and social forms labeled by designers, users and individuals in general. In their social form, technologies are rules and resources instantiated in patterns of activity – social outcomes – powered by purposive and knowledgeable individuals. Consequently, the degree of development of specific patterns of activity or social outcomes over time helps to determine the extent to which a technology in question has changed. Building on Structuration Theory, the study focuses on monitoring the extent of development of events and social patterns indicating structures of meaning, power, and legitimacy. In a real-time system, companies might establish time periods for data collection. Thus, weak signals of change might emerge from change in the slope – it might be argued speed – or trajectory that a technological proposition might take. Consequently, these types of change should be monitored seriously.

Our findings support the argument that the emergence and development of technologies are not the products of any single person but the result of a collective process sustained by patterns of human action (Cohen I. J., 1989, p. 22; Giddens, 1984). Future technologies are collective-driven outcomes. Social and technological breakthroughs are unpredictable and, moreover, the effects of those social and technological breakthroughs are unpredictable as well. However, it seems that the more we are aware of existing technologies and trends tapping problems in our social and technological domains and the more we are aware of the occurrence of social and technological breakthroughs, the better positioned we may be to read early indications of impending impactful events (Ansoff, 1975). The study shows not only evidence of the theoretical understanding of this phenomenon, but also methodological procedures of how to deal with it.

6.7. Implications for Technology Management Practices

Results from the present study suggest several important implications beyond identifying signals of technological change. First, as stated earlier, the results shed light on critical success factors that should be considered seriously by those individuals, organizations, industries, or governments that aim to develop successful technological innovations. Those involved with the development of new technological innovations should encourage the formation of social and technological structures that enable the emergence of structures of meaning, power, and legitimacy. That is, at least, new technological propositions should aim for designs and projects that have a simple sense of purpose and reason for being, and are easy to understand and use (Hanna P., 2012). Simultaneously, these new technological propositions should aim to expand the transformative capacity of individuals by addressing their needs and desires with a seamless technology fit to their essential social norms and values.

Second, the results suggest also a novel perspective of how to study and explain collaborative innovation networks, innovation communities, or swarms of creativity[92]. It is widely known that all these groups are highly engaged with the design, adaptation, or evolution of technological objects and trajectories. Collaborative innovation networks communicate and share ideas openly; collaborate under emergent social, technical and ethical codes; and innovate through massive collaborative creativity (Gloor, 2007). How can we explain the success or failure of collaborative innovation groups? Our results might indicate that successful technological innovations emerge from groups able to seed spaces for cultivating structures of meaning, power, and legitimacy. We might paraphrase Gloors' (2007) characteristics of collaborative innovation networks and argue the following. Collaborative innovation networks develop structures of meaning through communicating and sharing ideas openly, structures of power through providing and sharing advances and solutions to challenging problems and needs, and structures of legitimacy through creating social and technical norms within the group such as peer recognition and technical

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92 According to Gloor (2007), collaborative innovation networks, innovation communities or swarms of creativity refer to self-motivated individuals that innovate as a team with a collective vision of purpose. Commonly, these groups assemble outside organizational boundaries and aim to advance their fields by sharing ideas and information. The open source movement is only one example. These individuals do not work because they have been ordered to do so, but because they are committed to the goals of their community and because peer recognition is a worthy cause.

standards, respectively. This structurational perspective enables a different theoretical understanding of the phenomenon of collaborative innovation networks. Under this lens, further interesting questions emerge such as: What specific behaviours or actions facilitate the development of meaning among members? Is centrality of members or leadership associated with the development of structures of power for other members? Are membership and size associated with the development of structures of power? Do the most new innovative social and technological structures emerge from peripheral or central members? Are these social structures the so called *glue* of the network?

Third, the results support strongly the explanatory power of our theoretical framework that might suggests major implications for innovation policy at different levels (i.e., individuals, groups, organizations, industries, states, and nations). Our view places at the center of the innovation equation the ongoing and recursive interplay between individuals and their social systems. Technologies emerge naturally because individuals envision and engage in technological solutions and opportunities that aim to address their needs and problems. Individuals make use of their social and technological structures in order to intervene and change their social and technological circumstances (Sarason, Dean, & Dillard, 2006). Thus, this ongoing process of social construction is powered not only by individuals' motivation, but also by the available social and technological structures that individuals can access. For this reason, to foster innovation, groups, organizations, industries, states, and nations should encourage the development of spaces conducive to nurture dialogue and social interaction among individuals. The exchange and development of social and technological structures permit individuals the exploration of "the adjacent possible"[93], the edge of innovation possibilities that surround a domain of action (Johnson, 2010). In Johnson's words, "The trick to having good ideas is not to sit around in glorious isolation and try to think big thoughts.

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[93] Johnson (2010, p. 31) says "The adjacent possible is a kind of shadow future, hovering on the edges of the present state of things, a map of all the ways in which the present can reinvent itself."

The trick is to get more parts on the table.” Thus, the open playing field for new technological propositions is limited only by what individuals know and perceive, as well as by the transformative capacity they have.

Of course, learning plays a fundamental role in innovation (McKee, 1992; Alegre & Chiva, 2008; Calantone, Cavusgil, & Zhao, 2002; Hurley & Hult, 1998) because not only external and internal ideas or technologies are sources to advance technological initiatives and organizational profitability, but also internal and external channels are paths to create additional value for groups, companies, industries and governments (Chesbrough, 2003). This is an era of open innovation (Chesbrough, 2003b), and not surprisingly the positive effect of communication on technological innovation has been substantiated in many studies (Ebadi & Utterback, 1984; Tushman, 1979; Lievens, Moenaert, & S'Jegers, 1997). The interaction with users is an essential condition to foster successful technological propositions (Ries, 2011; Oudshoorn & Pinch, 2003; Von Hippel, 1986). The role of market and technological knowledge has been emphasized in recognizing entrepreneurial opportunities and organizational innovativeness (Siegel & Renko, 2012; Hult, Hurley, & Knight, 2004). Likewise, the effective transfer of tacit knowledge is a crucial process in the production of knowledge and entrepreneurial initiatives (Nonaka & Takeuchi, 1995; Leonard & Sensiper, 1998). Basically, our argument is the following: at all levels, policy makers, designers, and users should maintain proactive dialogues about their problems, resources, visions, capabilities, and opportunities. The development and exchange of social and technological structures may lead them to make sense of and embrace possible and desirable solutions. Enabling social interaction and openness should be, in essence, a key activity for creating technological innovation.

Fourth, the results indicate also some important insights for the technology transfer[94] literature. Technology transfer is associated with embodied technologies (i.e., equipment or physical artifacts)

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[94] Technology transfer is the process through which technology is moved from one place to another (Bessant & Rush, 1995; Guan, Mok, Yam, Chin, & Pun, 2006).

and is highly dependent on knowledge in tacit form (i.e., working practices or intangible assets) (Howells, 1996). Since technologies are multidimensional ongoing objects, technology transfer should not be limited by narrow assumptions about the nature of what is being transferred (Bessant & Rush, 1995). The recognition of tacit knowledge and types of knowledge – i.e., information, skills, judgments, and wisdom – provides a useful framework for studying and guiding how technology is transferred (Gorman, 2002). Yet, this perspective assumes that technology is a commodity or a black-box because there is not a clear link with the social process of learning. That is, the perspective treats technology as an external good that requires appropriation (e.g., information, skills, judgment, or wisdom).

Thus, we argue that the recognition of technology as part of our social structures (i.e., rules and resources) might deepen into a more powerful framework to study and deal with the process of technology transfer. For example, what are the key structures of meaning, power, and legitimacy that constitute the technology transfer process of a particular technology? Do technology recipients display a social structure (i.e., rules and resources) that fit with the social structure that constitutes the technology subject to transfer? Do technology recipients display a social structure (i.e., rules and resources) that come up against the social structure that defines the technology in question? How might technology proponents accelerate the development of a required social structure by technology recipients? We believe that the structurational perspective not only provides an integrative framework that accounts for the social process of learning, but also, and most importantly, raises our attention to think more deeply from a recipient perspective which is, perhaps, the most crucial dimension in a successful technology transfer initiative.

Lastly, the support for our theoretical framework has also meaningful implications for social and economic development policy for developing countries. Unless developing countries evolve their own social and technological structures based on structures of meaning, power, and legitimacy that constitute their country identity, the results of aid dependency[95] or technology *catching up* processes may continue to fall short (Perez & Soete, 1988; Hilary, 2010; Verspagen, 1991). The resulting social outcomes of a community emerge from the social and technological structure that defines the community. Thus, social change and sustainable transformation require social and technological engagement from their own communities. Only through social and technological engagement might developing countries be able to enact or change knowledge, technologies, or propositions that flow from technological leaders. Aid dependency and technology *catching up* initiatives may help to reduce the social and economic gap between wealthy and poor nations (Manca, 2009). However, how can we expect, for example, teaching-oriented institutions, with the very best but few researchers working in academic isolation, to come up with novel technological innovations that exploit dominant technological paradigms associated mainly with global knowledge networks? Technological breakthroughs might come from developing countries once their academic and business communities are embedded in the global knowledge networks that enact the rules and resources of dominant technological paradigms.

We believe that the real alternative of wealthy countries to aid developing countries lies in sharing their knowledge as a commonwealth (Kirkland, 2000). The sharing of knowledge might seed conditions to bring wealthy and developing communities closer. Importantly, leading countries' interventions should enact the role of honest brokers. Honest brokers integrate aid, science and technology with stakeholder concerns by expanding the range of choices and implications with respect to the values and preferences of the decision-makers (Pielke, 2007). The imposition of structural conditions and ideologies from leading countries (e.g., free market fundamentalism) (Moyo, 2009) undermine the development of appropriate polices and structures in developing

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[95] *Aid dependency* refers to an ongoing economic aid from wealthy countries or international institutions to poor countries. "A country is *aid dependent* when it cannot perform many of the core functions of government, such as delivering basic public services like schools and clinics, without foreign aid." (ActionAid, 2011).

nations (Hilary, 2010). Hence, we agree with Perez and Soete (1988, p. 459) who state "A real catching-up process can only be achieved through acquiring the capacity for participating in the generation and improvement of technologies as opposed to the simple 'use' of them." We argue that our framework provides a deeper understanding of the social process that underlies the development of social and technological structure. This framework might help policy and decision-makers from leading and developing countries to guide the development of the required social and technological structure across all levels and domains of action. Specifically, policy and decision makers might identify strategies that not only consider real concerns and needs from developing communities, but also allow communities to build meaning, realize power, and legitimate their own social and technological engagement.

6.8. Limitations

The limitations of the study can be observed in many aspects. First, for practical and scientific reasons, the study was focused deliberatively on self-reported retrospective measures which might raise some potential criticism with respect to the presence of hindsight bias. Although it can be argued that the study relied on highly engaged Internet experts and made use of effective procedural remedies suggested in the literature, further research should explore the structurational model of emerging technologies (SMET) by using a longitudinal study approach. The present study provides, conveniently, guidelines to frame a new study based on real-time analysis.

Second, the study relied on self-reported measures from Internet experts instead of a review of archival documentation. While the rationale behind this decision is explained in Section 4.1, we can argue here that the study aimed to characterize the extent of development of social and technological structure through the eyes of the beholders instead of a third party – i.e., the researcher. Conveniently, at the moment, our findings and insights might help us to propose a different measurement method to overcome the drawback of our data measurement process. For example, we could measure a technology-related social structure through the measurement of specific social outcomes free of human judgment. Moreover, we could create a systematic and systemic view of an industry by examining a set of specific social outcomes that define its social structure.

Third, like Structuration Theory, the study does not suggest a method of *how* to identify or classify outcomes of systemic activity. The study explains only a general process narrative about how technologies and trends unfold and produce technological outcomes. Although it can be argued that the study relied strongly on social outcomes suggested in the literature, further research is needed to suggest at least some guidelines to help researchers to identify factors of change that can be managed or manipulated in this type of research approach.

Fourth, the study relied on dependent and independent variable measures from a single-source (i.e., Internet experts). Although the dependent variables were assessed in a different time and place, and the study implemented several procedural remedies for controlling the effect of potential measurement bias for other variables, further research work is required to assess dependent and independent variables from different and multiple sources.

Fifth, the study employed three single-item measures due to the nature of the constructs, the exploratory stance of the study, and the time-sensitive interview method. Although the minimum reliability estimates for the three single-item measures were sufficiently reliable for data analysis purposes (i.e., estimates were above or close to 0.70), future research efforts need to consider and explore measures based on multiple-items and multiple-methods. Furthermore, future work should consider the development of measurement scales for all constructs in the study.

Sixth, the study was exploratory in nature and the results may not be generalizable to all geographic conditions, industries, or sectors. For convenience, the study focused on Southern Ontario and was restricted to seven Internet technologies with a dominant focus on end-user technologies. Hence, it is very important to explore and test our SMET across more geographic conditions, industries, and technology categories.

Lastly, the study's approach does not offer a highly rigorous process research strategy[96]. Although the results support the explanatory power of a process theory embedded into the SMET, the SMET is only an initial attempt to generalize first in terms of a process theory instead of the systemic activity of social outcomes (i.e., a variance theory). Certainly, this study gathers quantitative data assessing three different time frames and the results show evidence of how change takes place by observing the unfolding process of specific social outcomes over time. However, according to Poole, Van de Ven, Dooley and Holmes (2000, p. 12), a process research strategy should present narrative stories with detailed descriptions of the events that constituted change and development of the entity under study. In this study, we cannot provide additional evidence to support our argument of change and development of each technology under study. We had a significant time constraint during interviews and, only in few cases, participants were asked for evidence to support their numeric judgments. Thus, although we can declare that participants' arguments were coherent and supportive, further research and different research methods are needed to provide the narrative stories and evidence that a rigorous process research strategy should present.

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[96] Poole et all. (2000, p. 12) state "In this research strategy, investigators gather data that indicate how process unfolds over time. Some of this data could be in the form of quantitative measurements of key variables, but other data would consist of detailed descriptions of the events that constituted change and development of the entity under study. Based on these descriptions, researchers construct a timeline of events that were significant in the development of change process. Each case will have unique timeline, and real or apparent differences among cases are a major focus of the study. Instead of treating unique features of a case as sampling error, a process study attempts to identify circumstances that created the particular twists and turns in each case. The flow of events and the conjunctions of casual forces that move the developing entity through its sequence are captured in a narrative that explains the case."

Chapter 7. Conclusion and Future Research

The study extends previous research by developing pragmatically a systematic theoretical and methodological proposition to identify the emergence and development of new technologies in a technology domain in question. The study shows compelling evidence that supports its theoretical and methodological perspectives, and contributes to the literature in several theoretical and practical forms.

7.1. Theoretical Contributions

First, the study suggests that competitive perspectives and underlying hidden assumptions about the interpretation of reality may have constrained theory development in previous research. The study agrees with Aaltonen (2009; 2007) that cognitive frameworks enable and constrain what can be explained. Hence, the study highlights a research opportunity to create more powerful frameworks based on the complementariness of good theories (Poole & Van De Ven, 1989; Geels, 2010). While narrow and contextual analyses can provide more precise explanations of specific situations and events, integrative open frameworks can help us to deal better in practice with the complex social and organizational problems we have. The study shows how Structuration Theory provides a playing field for several cognitive, social, and organizational theories. Specifically, the study illustrates how theories work together and proposes a promising and novel theoretical framework that explains the emergence and development of new technologies.

Second, based on Whetten's (1989) argument of what constitutes a theoretical contribution, the study contributes to the literature of technology management with the structurational model of emerging technologies (SMET). Though the SMET is only a much simpler purposive conceptual representation of a complex social and technological process, it captures the key constructs and factors behind the emergence and development of new technologies. Initially, the SMET indicates what factors explain the emergence and development of new technologies. Next, the SMET explains not only *how* these factors produce specific social outcomes systematically, but also *why* the dynamic among these factors takes place. Lastly, at all times, the SMET recognizes the contextual limits of its propositions. Specifically, the SMET makes explicit the multidimensional perspective of technologies and understands technologies as products of social interaction. The SMET places individuals as creators, producers, carriers, and transformers of technologies, and also clarifies the role of individuals' engagement and awareness in the enactment of a technology domain. Likewise, the SMET characterizes the process of change and development that is undergone by the technology-related social structure of an industry in question. Lastly, the SMET demonstrates the relationship between technological outcomes and the extent of development of technology-related social structures.

Third, the study proposes an integrative description of technologies that clarifies two influential contributions from Orlikowski (2000; 1992). But most importantly, the study suggests and puts to work a dynamic view of technology that is grounded in ongoing social action. The study situates technology as an ongoing phenomenon and shows how a process theory such as Structuration Theory enables a powerful open framework for studying complex technology-related issues (i.e., tracking the emergence of technologies). The framework is not committed to only one definition of technology, but instead reconceptualizes technology in its multiple simultaneous dimensions. Technologies can be simultaneously physical artifacts, explicit social objects, abstracts rules, and social practices, among others. The study recognizes that although technologies may have physical or *material* existence in nature, technologies are subjects of scientific study and development only through the analysis of the social structure lying within individuals' heads or the social structure instantiated in social practices. Hence, the study proposes how the emergence and development of technologies can be tracked by examining the extent of development of specific social patterns that indicate the effect of a technology on society. The study shows evidence that the extent of development of specific social outcomes can explain, in the end, technological outcomes.

Fourth, this study contributes to the literature of weak signals in two ways. On one hand, the study advances the definition of weak signals by suggesting a clear unit of analysis. While previous research indicates that weak signals are early indications of change, this study suggests that a weak signal of technological change refers to the starting manifestation of a new pattern of social activity[97] that has been triggered by the conceptual initiation of a new technology. Weak signals are new patterns of activity powered by purposive and knowledgeable actors leading, seeding, and shaping the emergence of a new technological trend. On the other hand, the study clarifies that a systematic and collective perspective of the system in question is an essential property for framing scientifically the study and problem of identifying signals of technological change. Without the systematic and collective interpretation of the system, what is changing when it seems that only change is happening? The systematic approach is required because we must compare units of analysis in time, and the collective perspective of the system is essential because individual judgments do not reveal social patterns. Identifying weak signals of technological change lies on a systematic and collective perspective of the system but not on isolated individual observations.

Lastly, the study highlights the difference and complementariness between variance theory and process theory. This research shows the importance of both approaches to provide scientific and practical solutions to complex social and organizational problems. A variance theory is focused on studying the regularities in the production of specific social outcomes. What specific *independent* social outcomes lead us to terminate with a *dependent* specific social outcome? That is, it is focused on the prediction of social outcomes. A process theory is focused on studying the regularities in the production of social outcomes themselves. What processes underlie the production of all social outcomes? That is, it is focused on the identification of common processes involved in the production of any social outcome. Thus, to understand, scientifically, the processes that lead us to

…………………………….

[97] *New patterns of social activity* refers to new recurring situations and processes in a situated context (i.e., new social events or practices).

end with social outcomes of systemic activity, we must put to work both approaches in a creative research design that captures not only the power of a scientific view, but also the ongoing nature of social reality.

7.2. Practical Contributions

First, the study provides practical contributions for social researchers. Future research can take advantage of the pragmatic perspective employed in this study to address other social research problems. For example, the study illustrates how to apply ST scientifically. The study shows how the repertory grid technique can be adapted methodologically to explore variance approaches. The study illustrates the role of the researcher in transformative research designs.

Second, the study proposes a method of technology intelligence for firms, industries, and governments. The study presents a novel and systematic approach not only to identify emerging new technologies but also to trace them in their developmental process. Proposed and tested is a practical artifact that reduces the complexity in tracking the emergence and development of technologies. Consequently, this work provides guidelines for the potential implementation of a real-time foresight system based on real-time analysis of present technological trends – an evidence-based system to monitor the emergence and development of new technologies.

Third, by showing evidence that social and technological outcomes are not the result of any single person but the result of a collective process sustained by individuals' patterns, the study demonstrates that the identification of technologies requires the participation of a group of industry-engaged contributors. Only a participatory system approach may help to attenuate the pervasive and inherent phenomenon of bounded rationality. Identifying weak signals of technological change depends on a systematic and collective perspective of the system but not on isolated individual observations.

Fourth, the study presents serious implications for individuals, organizations, industries and governments involved in the development of new technologies or products. Since successful technological outcomes are explained by the extent of development of social structure, new technological propositions should aim for being simple and meaningful, should aim to enhance individuals' capacity of action, and should aim to address needs and desires with alignment to social norms and values.

Lastly, the study discusses insights and recommendations for several areas of study in the technology management literature. By reconceptualizing technology as both an ongoing product of human interaction and ongoing means of meaning, power, and legitimacy, the study not only supports several findings and arguments for open innovation, collaborative innovation networks technology transfer activities, and social and economic development initiatives, but also provides a better understanding of the underlying social processes that constitute all these activities. The study's framework helps to open new theoretical and practical perspectives for researchers and practitioners involved in these areas.

7.3. Further Research

Future research can proceed in several directions. Previously, each limitation in this study has suggested future research avenues. For example, future studies could explore (1) a longitudinal research design approach, or (2) a research design that can assess dependent and independent variables from multiple sources, or (3) a data measurement processes based on objective measures, or (4) an investigation based on different geographic conditions, industries, or technology categories. As well, future research could aim for (5) the development of guidelines to help researchers to identify and characterize social outcomes, or (6) the development of measurement scales for the study's constructs, or (7) the validation of the model through a complete process research strategy.

Likewise, as stated earlier, other areas in management of technology could be explored by using the theoretical framework of this study. Future research proposals could investigate the relationship between the development of structures of meaning, power, and legitimacy and (1) product innovation performance, or (2) successful collaborative innovation networks, or (3) technology transfer activities, or (4) social and economic development initiatives.

Another future research proposal could be to delve into the construct of degree of structuration. The study's framework assumes that structures of meaning, power, and legitimacy are simultaneously enacted, and only analytically can these three dimensions of the social structure be understood. Thus, this study does not provide analyses to compare differences and similarities among the extent of development of structures of meaning, power, and legitimacy. It would be interesting, therefore, to analyze which of these structures develops first in the life cycle of a technology. Should we expect that structures are balanced in their loading to the degree of structuration construct across all stages of the life cycle of a technology? Are structures of meaning, power, or legitimacy most important in a specific stage of the technology life cycle? For example, do structures of meaning define the creation phase, structures of power define the developmental phase, and structures of legitimacy define the sustainability phase? All of these questions are relevant and interesting for further research.

Finally, another interesting research avenue could be to analyze the relationship between level of engagement and the ability to propose successful radical technological innovations, as well as the relationship between level of awareness and the ability to propose successful radical technological innovations. Are highly engaged individuals more or less able to propose successful radical technological innovations? Are highly aware individuals more or less able to do so? Is a minimum level of engagement required to propose successful radical innovations? Can level of engagement and awareness help us to explain partly the ability to propose successful radical technological innovations? Moreover, future studies could explore the relationship between level of engagement and level of awareness. For example, over time, what is the effect of level of engagement on level of awareness? What is the effect of level of awareness on level of engagement? Do influential technological outcomes moderate the relationship between level of awareness and level of engagement? Several of these questions have been suggested in the literature, and we believe that this study's framework and approach could open interesting possibilities to conduct future empirical research on these issues.

Appendix A First Interview Protocol - Power Point Slides

1.

STUDY:

SIGNALS OF TECHNOLOGICAL CHANGE
IN THE INTERNET INDUSTRY

The purpose of this study is to analyze the phenomenon of technological transitions and, particularly, the emergence and development of technological trends in the Internet industry.

All information provided through this interview process is completely anonymous. There will be no attribution of any opinions shared. You may stop the interview at any time.

10/30/11 First Interview Protocol 1

1a. INITITAL INSTRUCTIONS

- This interview follows a systematic approach using a prescribed protocol for scientific purposes. I ask you for your patience and adherence to the procedure.
- To pace the interview, please consider:
  - some open-ended questions have suggested time limits.
  - most pages indicate a percentage of the progress of the interview in the upper corner of the slide.
- Thank you. We hope you enjoy it!

10/30/11 First Interview Protocol 2

2. NOMINATE INFLUENTIAL TECHNOLOGIES ENABLED BY THE INTERNET

10 %

The Internet has enabled the development of INFLUENTIAL and SOMETIMES UNEXPECTED technologies which have transformed how individuals and organizations operate in their technical, business and social life.

From your point of view, in the last 10 years, what are four (4) examples of technologies enabled by the Internet that have been INFLUENTIAL in terms of changing the way individuals or organizations fulfill their activities, needs or functions?

Influential Technology 1 [IT1] : ______________________________

Influential Technology 2 [IT2]: ______________________________

Influential Technology 3 [IT3]: ______________________________

Influential Technology 4 [IT4]: ______________________________

4 min

3a. DESCRIBE INFLUENTIAL TECHNOLOGIES ENABLED BY THE INTERNET

18 %

Assuming that technologies are created with an intended purpose, please provide your answers and share your experience.

What do you believe was the purpose of the inventors or creators who developed the [IT1]?

____

Please provide a brief example of where, by whom and how the [IT1] has been applied.

2 min

____

What do you believe was the purpose of the inventors or creators who developed the [IT2]?

____

Please provide a brief example of where, by whom and how the [IT2] has been applied.

2 min

____

3b. DESCRIBE INFLUENTIAL TECHNOLOGIES ENABLED BY THE INTERNET 26 %

What do you believe was the purpose of the inventors or creators who developed the [IT3]?

____

Please provide a brief example of where, by whom and how the [IT3] has been applied. 2 min

____

What do you believe was the purpose of the inventors or creators who developed the [IT4]?

____

Please provide a brief example of where, by whom and how the [IT4] has been applied. 2 min

____

4. NOMINATE FAILED OR DORMANT TECHNOLOGIES ENABLED BY THE INTERNET 35 %

While some technologies enabled by the Internet have significantly grown and disrupt old well-established social and organizational practices, other technologies enabled by the Internet have failed or have become dormant, which means that technologies exist but they are not actively growing.

From your point of view, in the last 10 years, what are two (2) examples of technologies enabled by the Internet which have been FAILURES in terms of changing the way individuals or organizations fulfill their activities, needs or functions?

Failed Technology 1 [FT1] : _______________________________

Failed Technology 2 [FT2]: _______________________________

3 min

5. DESCRIBE FAILED OR DORMANT TECHNOLOGIES ENABLED BY THE INTERNET

40 %

Assuming that technologies are created with an intended purpose, please provide your answers and share your experience.

What do you believe was the purpose of the inventors or creators who developed the [FT1]?

____

Please provide a brief example of where, by whom and how the [FT1] has been applied.

2 min

____

What do you believe was the purpose of the inventors or creators who developed the [FT2]?

____

2 min

Please provide a brief example of where, by whom and how the [FT2] has been applied.

____

6a. INDICATE THE LEVEL OF IMPACT OF TECHNOLOGAL TRENDS

To what extent has this technology transformed how individuals or organizations fulfill their activities, needs or functions?

Influential Technology 1	Not at All	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	A Great Deal
Influential Technology 2	Not at All	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	A Great Deal
Influential Technology 3	Not at All	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	A Great Deal
Influential Technology 4	Not at All	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	A Great Deal
Failure Technology 1	Not at All	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	A Great Deal
Failure Technology 2	Not at All	1 ○	2 ○	3 ○	4 ○	5 ○	6 ○	7 ○	8 ○	9 ○	A Great Deal

6b. EXPLORE THE EXPECTED LEVEL OF IMPACT OF TECHNOLOGAL TRENDS

As you became aware of its initial emergence, to what extent did you anticipate the level of impact of this technology on individuals or organizations?

Influential Technology 1	Not at All	1	2	3	4	5	6	7	8	9	A Great Deal
Influential Technology 2	Not at All	1	2	3	4	5	6	7	8	9	A Great Deal
Influential Technology 3	Not at All	1	2	3	4	5	6	7	8	9	A Great Deal
Influential Technology 4	Not at All	1	2	3	4	5	6	7	8	9	A Great Deal

6c. EXPLORE THE EXPECTED FAILURE OF TECHNOLOGAL TRENDS

As you became aware of its initial emergence, to what extent did you anticipate the failure of this technology?

Failure Technology 1	Not at All	1	2	3	4	5	6	7	8	9	A Great Deal
Failure Technology 2	Not at All	1	2	3	4	5	6	7	8	9	A Great Deal

7. ENVISION THE FUTURE

In the following two sections, we invite you to think of new technologies which might become influential in the next years.

8. INDICATE THREE (3) NEW INFLUENTIAL TECHNOLOGIES ENABLED BY THE INTERNET IN THE NEXT FIVE(5) YEARS

52 %

Drawing upon your understanding, knowledge and vision about current technological and social trends, what might be the three (3) most influential new technologies or new kind of activities enabled by the Internet that might come to the mainstream in the following five (5) years changing the way individuals or organizations fulfill their needs and functions?

First influential new technology or new kind of activity in the next five(5) years:

____

What would be the intended purpose of this new technology or new kind of activity?

____

2 min

Second influential new technology or new kind of activity in the next five(5) years:

____

What would be the intended purpose of this new technology or new kind of activity?

____

2 min

Third influential new technology or new kind of activity in the next five(5) years:

____

What would be the intended purpose of this new technology or new kind of activity?

____

2 min

9. SUGGEST TWO (2) NEW INFLUENTIAL TECHNOLOGIES ENABLED BY THE INTERNET IN THE NEXT TEN (10) YEARS

60 %

Drawing upon your understanding, knowledge and vision about current technological and social trends, what might be the two (2) most influential new technologies or new kind of activities enabled by the Internet that might come to the mainstream in the following ten (10) years changing the way individuals or organizations fulfill their needs and functions?

First influential new technology or new kind of activity in the next ten (10) years:

____

What would be the intended purpose of this new technology or new kind of activity?

____

2 min

Second influential new technology or new kind of activity in the next ten(10) years:

____

What would be the intended purpose of this new technology or new kind of activity?

____

2 min

10a. DEMOGRAPHIC INFORMATION

65 %

Which of the following options best describes your expertise in relation to Internet technologies?

1. **General knowledge as user** of some Internet technologies. ○
2. Specialized knowledge as scholar or researcher of some Internet technologies **without extensive technical and practical competence.** ○
3. Specialized knowledge as engineer, developer or scientist of some Internet technologies **with extensive technical and practical competence.** ○
4. Specialized knowledge either the one described in option 2 or option 3 but also focused on the judgment of technical and practical activities of other Internet experts **in order to commercialize and exploit particular Internet technologies.** ○
5. **Extensive social and behavioral knowledge** related to the Internet industry, focused on the judgment of technical and practical activities of Internet experts, in order to exploit Internet technologies. ○

10b. SOCIO-DEMOGRAPHIC INFORMATION

Which of the following options best describes your main role within the Internet industry?

- ○ Entrepreneur
- ○ Product Developer
- ○ Software Developer
- ○ Project Manager
- ○ Academic Researcher
- ○ Industrial Researcher
- ○ Other (please specify)

  ____
- ○ Business Manager
- ○ Market Developer / Marketing Coordinator
- ○ Consultant
- ○ Technician/Technical Adviser
- ○ Financial Adviser
- ○ Policy Adviser/Policy Maker
- ○ User

How many years have you worked in the role indicated in the last question? [ ]

What is (are) the technology (ies) or trend (s) of the Internet with which you are mainly focused on today?

1. ______________________________
2. ______________________________
3. ______________________________

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10c. SOCIO-DEMOGRAPHIC INFORMATION

70 %

What is your current job title?

- ○ Technician/Technical Adviser
- ○ Product Developer
- ○ Software Developer
- ○ Project Manager
- ○ Business Owner
- ○ Other (please specify)

  ____
- ○ Business Investor
- ○ Researcher/Professor
- ○ Consultant
- ○ Manager/Director/CEO
- ○ Legal Adviser

Which of the following roles have you experienced within the Internet industry?

- ☐ Entrepreneur
- ☐ Product Developer
- ☐ Software Developer
- ☐ Project Manager
- ☐ Academic Researcher
- ☐ Industrial Researcher
- ☐ Other (please specify)

  ____
- ☐ Business Manager
- ☐ Market Developer / Marketing Coordinator
- ☐ Consultant
- ☐ Technician/Technical Adviser
- ☐ Financial Adviser
- ☐ Policy Adviser/Policy Maker
- ☐ User

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10d. SOCIO-DEMOGRAPHIC INFORMATION

How many years of total experience did you have in the Internet industry?

What is your highest educational degree?

- Less than High School
- High School
- College Diploma
- Undergraduate Degree
- Other (please specify)

  ____

- MBA or Equivalent Degree
- Masters Degree or Equivalent Graduate Degree
- Doctorate Degree or Equivalent Graduate Degree

What is your professional educational background?

- Life Sciences
- Physical Sciences
- Engineering
- Mathematics
- Other (please specify)

  ____

- Computer Sciences
- Arts/Humanities
- Social Sciences
- Not Applicable

10e. SOCIO-DEMOGRAPHIC INFORMATION

75 %

Which of the following options best describes the organization for which you work within the Internet industry?

- My Own Organization
- Business Organization
- University / College
- Other (please specify)

  ____

- Standards Organization
- Nonprofit Organization
- Governmental Organization

Which of the following locations best describes where you work?

- Asia
- Europe
- North America (Canada/USA)
- Central America (including Mexico)
- Other (please specify)

  ____

- South America
- Africa
- Middle East
- Oceania-Australia

11a. LEVEL OF PARTICIPATION WITHIN THE INTERNET INDUSTRY

Please characterize your level of participation in ATTENDING seminars, symposiums, conferences, courses or programs to learn more about the Internet industry or a particular Internet technology.

Not at All Active	1	2	3	4	5	6	7	8	9	Highly Active
	○	○	○	○	○	○	○	○	○	

Please characterize your level of participation in DELIVERING seminars, conferences, publications, proposals or products contributing to the Internet industry or a particular Internet technology.

Not at All Active	1	2	3	4	5	6	7	8	9	Highly Active
	○	○	○	○	○	○	○	○	○	

Please characterize your level of participation in ORGANIZING seminars, courses, symposiums or conferences related to the Internet industry or a particular Internet technology.

Not at All Active	1	2	3	4	5	6	7	8	9	Highly Active
	○	○	○	○	○	○	○	○	○	

11b. LEVEL OF PARTICIPATION WITHIN THE INTERNET INDUSTRY

80 %

How many forums (i.e., groups, association, organizations or boards) related to the Internet or Internet technologies do you belong to?

What percentage of your current work time do you devote to studying, developing, promoting, or directing efforts related to Internet technologies?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
○	○	○	○	○	○	○	○	○	○	○

Please characterize your level of involvement with the development of Internet-based technologies.

Not at All Active	1	2	3	4	5	6	7	8	9	Highly Active
	○	○	○	○	○	○	○	○	○	

11c. LEVEL OF PARTICIPATION WITHIN THE INTERNET INDUSTRY

How many times have you been founder or co-founder of any organization related to the Internet industry or based on some Internet technologies?

- None
- 1 time
- 2 times
- 3 times
- 4 times
- 5 times
- 6 times
- 7 times
- 8 times
- 9 times
- 10 times
- More than 10 times

Could you share the name of one organization?

____

How many times have you developed or created a technology or a commercial application within the Internet industry or related to Internet technologies?

- None
- 1 time
- 2 times
- 3 times
- 4 times
- 5 times
- 6 times
- 7 times
- 8 times
- 9 times
- 10 times
- More than 10 times

Could you share the name of one technology or commercial application?

____

11d. LEVEL OF PARTICIPATION WITHIN THE INTERNET INDUSTRY

Where do you locate your level of knowledge with respect to the world's top Internet experts?

Not Knowledgeable	1	2	3	4	5	6	7	8	9	Highly Knowledgeable
	○	○	○	○	○	○	○	○	○	

What is your ability to make a call to the world's top Internet experts to discuss issues related to the development of Internet technologies with them?

Not at All	1	2	3	4	5	6	7	8	9	A Great Deal
	○	○	○	○	○	○	○	○	○	

12a. SHARE YOUR COGNITIVE FRAMEWORK AND VISION

85 %

What is your most frequent way of thinking about technology?

- A Set of Intangible Assets
- A Set of Tangible Assets

What is your most frequent way of thinking about the explanations of social and natural events? Do you think that they have multiple underlying and interrelated explanations OR they have a single determining explanation?

Multiple, Underlying Interrelated Explanations	1	2	3	4	5	6	7	8	9	A Single Determining Explanation
	○	○	○	○	○	○	○	○	○	

12b. SHARE YOUR COGNITIVE FRAMEWORK AND VISION

Which of the following options best describes the way you understand the term "technology"?

- Skills and disciplines of knowledge
- Organized set of activities and routines
- Collection of methods and procedures
- Certain classes of products or services

PLEASE INDICATE THE EXTENT OF YOUR AGREEMENT WITH THE FOLLOWING STATEMENTS.

12c. SHARE YOUR COGNITIVE FRAMEWORK AND VISION

90 %

Individuals can change the course of action within their technological, business and social environments to create their future and suit their needs and purposes.

Not at All	1	2	3	4	5	6	7	8	9	A Great Deal
	○	○	○	○	○	○	○	○	○	

New technologies result from a combination of existing previous technologies.

Not at All	1	2	3	4	5	6	7	8	9	A Great Deal
	○	○	○	○	○	○	○	○	○	

In the last ten (10) years, technologies enabled by the Internet have brought impressive changes for individuals or organizations.

Not at All	1	2	3	4	5	6	7	8	9	A Great Deal
	○	○	○	○	○	○	○	○	○	

My personal visions, opinions and actions have influenced the development of Internet-based technologies.

Not at All	1	2	3	4	5	6	7	8	9	A Great Deal
	○	○	○	○	○	○	○	○	○	

12d. SHARE YOUR COGNITIVE FRAMEWORK AND VISION

In the next <u>FIVE (5)</u> years, technologies enabled by the Internet will continue changing the way individuals or organizations fulfill their activities, needs or functions.

Not at All	1	2	3	4	5	6	7	8	9	A Great Deal
	○	○	○	○	○	○	○	○	○	

In the next <u>TEN (10)</u> years, technologies enabled by the Internet will continue changing the way individuals or organizations fulfill their activities, needs or functions.

Not at All	1	2	3	4	5	6	7	8	9	A Great Deal
	○	○	○	○	○	○	○	○	○	

My personal visions, opinions and actions will be influential for shaping the future of Internet-based technologies.

Not at All	1	2	3	4	5	6	7	8	9	A Great Deal
	○	○	○	○	○	○	○	○	○	

Do your visions about the future of Internet technologies come from integrating concerns and propositions of users and other Internet contributors OR from own personal intuition and inspiration?

Integrating Concerns and Propositions from Others	1	2	3	4	5	6	7	8	9	Own Personal Intuition and Inspiration
	○	○	○	○	○	○	○	○	○	

13. TWO REPRESENTATIVE INTERNET EXPERTS IN SOUTHERN ONTARIO

95 %

This research aims to interview Internet experts with an active role within the Internet industry, shaping different issues such as technical, business, academic, legal or regulatory among others.

Based on your knowledge and experience, in Southern Ontario, who would be two (2) of the most well-known and representative committed and knowledgeable contributors studying or working on Internet technologies who might bring interesting insights to this study?

First Name

Name ______________________________

Second Name

Name ______________________________

14. FINAL PAGE

Congratulations !

You have finished this questionnaire which corresponds to the first phase of the study "Signals of Technological Change in the Internet Industry".

Thank you for your time and participation!

Appendix B Second Interview Protocol

1. AN INITIAL INSTRUCTION

In the first phase of the study you indicated influential technologies and failed/dormant technologies from the Internet industry in the last 10 years.

Your input and the input of other Internet experts (contributors) made possible to create a collective interpretation of influential and failed/dormant technologies from this industry.

Now, we present a short list of influential or failed/dormant technologies from our collective interpretation. This short list is presented to you in random order.

Please examine our list and answer introductory questions to characterize the relationship that you have with each of the selected technologies.

Search Portals

Video Conferencing

Cloud Computing

Virtual Worlds

Social Media/Networking

P2P Music Sharing

Mobile Internet Technologies

Not At All	1	2	3	4	5	6	7	8	9	A Great Deal

Using this scale, please answer the following questions.

2. INTRODUCTORY QUESTIONS

2.1. To what extent would you describe yourself as user of …?

2.2. To what extent have you been involved with the study of technologies enabling or related to …?

2.3. To what extent have you been involved with the development of technologies enabling or related to …?

2.4. To what extent have you been involved with business activities (profit or nonprofit) enabling or related to …?

2.5. To what extent did the emergence of this technology impact the course of further Internet-related developments?

2.6. To what extent would you describe this technology as a physical system/artifact/structure?

2.7. Which of the following options – in the scale – best describes the way you perceived this technology when it emerged?

An Evolutionary Advancement (Incremental in Nature)	1	2	3	4	5	6	7	8	9	A Revolutionary Advancement (Radical in Nature)

3. CONTEXT FOR YOUR RETROSPECTIVE EXPERIENCE IN 2001

In the following section, we ask you to recall how you perceived several technologies and trends in 2001. For this reason, we ask you to answer these questions intuitively – seeking to locate yourself back in the year 2001.

Please take a minute to imagine yourself in 2001 when answering these questions.

- ✧ What was your main job in 2001?
- ✧ Where was your work office?
- ✧ To whom did you report in 2001?
- ✧ Which were the most critical projects you were involved in?
- ✧ Where did you live?

Here are some historical events in 2001:

- ✧ Jan 9th - Apple announced iTunes at the Macworld Expo in San Francisco, for organizing and playing digital music and videos.
- ✧ Jan 15th - Wikipedia, a free Wiki content encyclopedia, goes online.
- ✧ Sep 11th - Terrorists hijack two passenger planes crashing them into the World Trade Center in New York.
- ✧ Oct 23rd - Apple releases the iPod.
- ✧ Oct 25th - Windows XP first became available.

Without leaving this retrospective vision from 2001 – the context in which you have just located yourself in your job, in your office or in your critical projects in 2001 – please go to the next section and answer some questions with your best judgments.

Considering this list of technologies and the scale below, please answer the following questions.

Search Portals

Video Conferencing

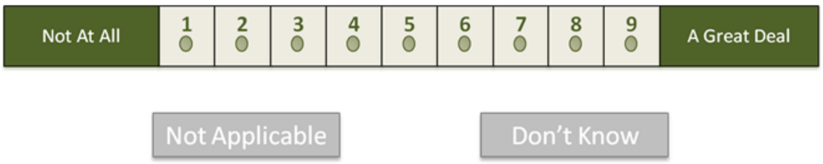
Cloud Computing

Virtual Worlds

Social Media/Networking

P2P Music Sharing

Mobile Internet Technologies



4. A RETROSPECTIVE EVALUATION AND FORECASTING OF TECHNOLOGICAL TRENDS IN 2001

4.1. By 2001, to what extent had this technology created impact on how individuals in organizations fulfill their activities, needs or functions?

4.2. By 2001, what was your level of awareness with respect to this technology?

4.3. By 2001, what was the probability that this technology would become a major trend in five years?

5. A RETROSPECTIVE EVALUATION OF TECHNOLOGICAL TRENDS IN 2001

5.1. By 2001, to what extent had this technology evolved from an idea to a functional system/application?

5.2. By 2001, to what extent had the usefulness of this technology become understood by individuals in the general public?

5.3. By 2001, to what extent had this technology empowered individuals to achieve their goals?

5.4. By 2001, to what extent had this technology enabled the creation of new businesses?

5.5. By 2001, to what extent had the reputation of this technology been damaged by illegal purposes?

5.6. By 2001, to what extent had this technology inspired new social norms within our society?

6. CONTEXT FOR YOUR RETROSPECTIVE EXPERIENCE IN 2006

In the following section, we ask you to recall how you perceived several technologies and trends in 2006. For this reason, we ask you to answer these questions intuitively – seeking to locate yourself back in the year 2006.

Please take a minute to imagine yourself in 2006 when answering these questions.

- ✧ What was your main job in 2006?
- ✧ Where was your work office?
- ✧ To whom did you report in 2006?
- ✧ Which were the most critical projects you were involved in?
- ✧ Where did you live?

Here are some historical events in 2006:

- ✧ Mar 1st - English-language Wikipedia reaches its one millionth article,.
- ✧ Apr 3rd - Google Local Maps is merged into the main Google Maps site after its first six months of official service.
- ✧ Jul 15th - The first version of the online social networking and micro-blogging service "Twitter" is launched to the public.
- ✧ Aug 25th – Amazon announced a new product development effort to provide cloud computing to external customers – a limited public beta version of Amazon Elastic Compute Cloud (EC2).
- ✧ Sep 26th – After two years of operation, the social networking service "Facebook" is opened to everyone over 13 years old with a valid email address.

Without leaving this retrospective vision from 2006 – the context in which you have just located yourself in your job, in your office or in your critical projects in 2006 – please go to the next section and answer some questions with your best judgments.

Considering this list of technologies and the scale below, please answer the following questions.

Search Portals

Video Conferencing

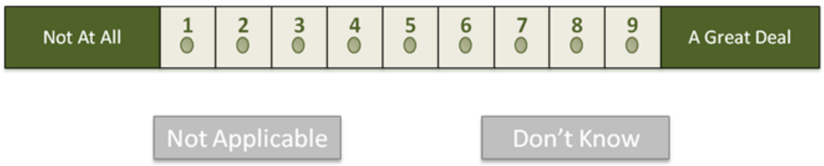
Cloud Computing

Virtual Worlds

Social Media/Networking

P2P Music Sharing

Mobile Internet Technologies



7. **A RETROSPECTIVE EVALUATION AND FORECASTING OF TECHNOLOGICAL TRENDS IN 2006**

   7.1. By 2006, to what extent had this technology created impact on how individuals in organizations fulfill their activities, needs or functions?

   7.2. By 2006, what was your level of awareness with respect to this technology?

   7.3. By 2006, what was the probability that this technology would become a major trend in five years?

8. A RETROSPECTIVE EVALUATION OF TECHNOLOGICAL TRENDS IN 2006

8.1. By 2006, to what extent had this technology evolved from an idea to a functional system/application?

8.2. By 2006, to what extent had the usefulness of this technology become understood by individuals in the general public?

8.3. By 2006, to what extent had this technology empowered individuals to achieve their goals?

8.4. By 2006, to what extent had this technology enabled the creation of new businesses?

8.5. By 2006, to what extent had the reputation of this technology been damaged by illegal purposes?

8.6. By 2006, to what extent had this technology inspired new social norms within our society?

9. CONTEXT FOR YOUR EXPERIENCE IN EARLY 2012

In the following section, we ask you to evaluate from today's perspective how you perceive several technologies and trends. We do not provide any recent historical event. We ask you to answer questions based on your current understanding and knowledge.

Please go to the next section and answer some questions with your best judgments.

Considering this list of technologies and the scale below, please answer the following questions.

Search Portals
Video Conferencing
Cloud Computing
Virtual Worlds
Social Media/Networking
P2P Music Sharing
Mobile Internet Technologies

Not At All	1	2	3	4	5	6	7	8	9	A Great Deal

Not Applicable   Don’t Know

10. EVALUATION AND FORECASTING OF TECHNOLOGICAL TRENDS IN EARLY 2012

10.1. **Up to now, to what extent has this technology created impact on how individuals in organizations fulfill their activities, needs or functions?**

10.2. **Up to now, what is your level of awareness with respect to this technology?**

10.3. **Up to now, what is the probability that this technology would become a major trend in five years?**

10.4. **Which of the following options best describes the way you perceive this technology?**

Influential   Failed   Dormant   Obsolete

11. EVALUATION OF TECHNOLOGICAL TRENDS IN EARLY 2012

11.1. **Up to now, to what extent has this technology evolved from an idea to a functional system/application?**

11.2. **Up to now, to what extent has the usefulness of this technology become understood by individuals in the general public?**

11.3. **Up to now, to what extent has this technology empowered individuals to achieve their goals?**

11.4. **Up to now, to what extent has this technology enabled the creation of new businesses?**

11.5. **Up to now, to what extent has the reputation of this technology been damaged by illegal purposes?**

11.6. **Up to now, to what extent has this technology inspired new social norms within our society?**

12. ENVISION THE FUTURE

In the first phase of the study you indicated potential influential new technologies or new kind of activities enabled by the Internet that might come to the mainstream in the following years changing the way individuals or organizations fulfill their activities, needs or functions.

For this section, we have selected seven (7) potential influential new technologies or activities enabled by the Internet that might come to the mainstream in the following years. This list of selected technologies or activities is presented to you in random order.

Please examine our list and answer introductory questions to characterize the relationship that you have with each of the selected technologies or activities.

Cloud Computing

Gamification

Virtual Personal Assistant

Wireless Body Area Networks

Natural Human Interfaces

Geo-Location Identification

Brain Computer Interface

Not At All	1	2	3	4	5	6	7	8	9	A Great Deal

Using this scale, please answer the following questions.

13. INTRODUCTORY QUESTIONS FOR POTENTIAL INFLUENTIAL NEW TECHNOLOGIES

13.1. **To what extent have you been involved with the study of technologies enabling or related to …?**

13.2. **To what extent have you been involved with the development of technologies enabling or related to …?**

13.3. **To what extent have you been involved with business activities (profit or nonprofit) enabling or related to …?**

13.4. **To what extent would the emergence of this technology have impact on the course of further Internet-related developments?**

13.5. **To what extent would you describe this technology as a physical system/artifact/structure?**

13.6. **Which of the following options – in the scale – best describes the way you perceive the emergence of this technology?**

An Evolutionary Advancement (Incremental in Nature)	1	2	3	4	5	6	7	8	9	A Revolutionary Advancement (Radical in Nature)

13.7. **To what extent has this technology led to inflated expectations, thereby overestimating the pace of its technological progress?**

14. CONTEXT FOR YOUR EXPERIENCE IN EARLY 2012

In the following section, we ask you to evaluate from today's perspective how you perceive these potential influential new technologies and trends.

Please go to the next section and answer some questions with your best judgments.

Considering this list of technologies and the scale below, please answer the following questions.

Cloud Computing

Gamification

Virtual Personal Assistant

Wireless Body Area Networks

Natural Human Interfaces

Geo-Location Identification

Brain Computer Interface

Not At All	1	2	3	4	5	6	7	8	9	A Great Deal

Not Applicable

Don't Know

15. EVALUATION AND FORECASTING OF TECHNOLOGICAL TRENDS IN EARLY 2012

15.1. **Up to now, to what extent has this technology created impact on how individuals in organizations fulfill their activities, needs or functions?**

15.2. **Up to now, what is your level of awareness with respect to this technology?**

15.3. **Up to now, what is the probability that this technology would become a major trend in five years?**

15.4. **What is your estimate (in years) that this technology would need to become a major trend?**

15.5. **What is your level of confidence with respect to your estimate?**

16. EVALUATION OF TECHNOLOGICAL TRENDS IN EARLY 2012

16.1. **Up to now, to what extent has this technology evolved from an idea to a functional system/application?**

16.2. **Up to now, to what extent has the usefulness of this technology become understood by individuals in the general public?**

16.3. **Up to now, to what extent has this technology empowered individuals to achieve their goals?**

16.4. **Up to now, to what extent has this technology enabled the creation of new businesses?**

16.5. **Up to now, to what extent has the reputation of this technology been damaged by illegal purposes?**

16.6. **Up to now, to what extent has this technology inspired new social norms within our society?**

17. CONTEXT FOR YOUR FORESIGTH BY ABOUT 2016

In the following section, we ask for your opinion about the status of these potential influential new technologies or trends as may unfold by about 2016.

Based on how you perceive patterns of social and technological developments today, we ask you to anticipate what could happen for these potential influential new technologies or trends by about 2016. What is likely to be the status of these technological trends by the year 2016?

Go to the next section and answer some questions with your best estimates.

Considering this list of technologies and the scale below, please answer the following questions.

Cloud Computing

Gamification

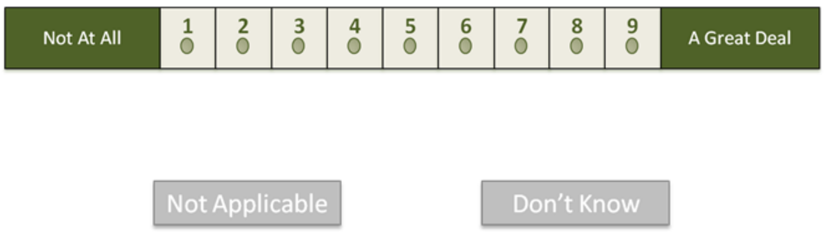
Virtual Personal Assistant

Wireless Body Area Networks

Natural Human Interfaces

Geo-Location Identification

Brain Computer Interface



18. FORECASTING OF TECHNOLOGICAL TRENDS BY 2016

18.1. **By 2016, to what extent will this technology have had impact on how individuals in organizations fulfill their activities, needs or functions?**

19. FORECASTING OF TECHNOLOGICAL TRENDS BY 2016

19.1. **By 2016, to what extent will this technology have evolved from an idea to a functional system/application?**

19.2. **By 2016, to what extent will the usefulness of this technology have become understood by individuals in the general public?**

19.3. **By 2016, to what extent will this technology have empowered individuals to achieve their goals?**

19.4. **By 2016, to what extent will this technology have enabled the creation of new businesses?**

19.5. **By 2016, to what extent will the reputation of this technology have been damaged by illegal purposes?**

19.6. **By 2016, to what extent will this technology have inspired new social norms within our society?**

20. LAST FOUR QUESTIONS

This study has considered some important recommendations as found in the literature from cognitive science and social psychology. The study has sought to reduce some forms of bias which can affect the assessment of past and future events.

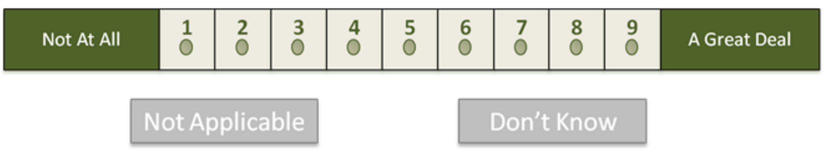
1) **Hindsight bias refers to the human tendency to overestimate judgments of past events based on cognitive factors of what happened rather than on evidence.**

2) **Foresight bias refers to an overconfidence and over-simplified view of the future resulting from a poor understanding of the past.**

Thus, we would like to know your view about the following:

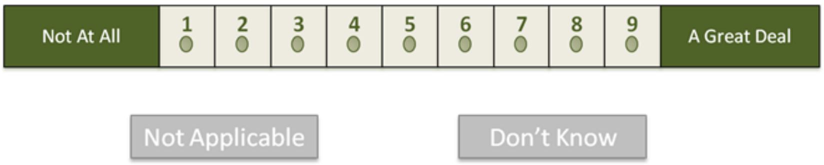
20.1. To what extent do you believe participants in this study (knowledgeable and committed Internet contributors like you) experience hindsight bias in recalling past technological trends retrospectively?

20.2. To what extent do you believe participants in this study (knowledgeable and committed Internet contributors like you) experience foresight bias in anticipating future technological trends?



20.3. **To what extent do you believe that you experienced hindsight bias in recalling past technological trends retrospectively?**

20.4. **To what extent do you believe that you experienced foresight bias in anticipating future technological trends?**



21. FINAL PAGE

Congratulations!

You have finished this questionnaire which comprises the second and final phase of the study "Signals of Technological Change in the Internet Industry".

Thank you for your time and participation!

Appendix C Results from the First Phase of the Study

With minor style corrections, this report was shared with our research participants under the name of:
"Signals of Technological Change in the Internet Industry" –
Executive Summary (Descriptive Statistics)

C.1 Introduction

This report summaries results from the first phase of the study "Signals of Technological Change in the Internet Industry", conducted from October 27, 2011 to January 30, 2012. The report does not yet include results and discussions from the second phase since concluding remarks and findings from the second phase can be shared once this doctoral dissertation is concluded.

The overall purpose of the study was to test a framework which may shed light on the process of emergence and development of new technologies. With the Internet industry as our case study, the first phase of the study aimed to characterize past and future technologies in this industry, while the second phase evaluated specific patterns of development constituting some reported technological trends.

Thus, the purpose of the first phase was to identify: influential technologies that have been enabled by the Internet in the last 10 years; failed/dormant technologies enabled by the Internet in the last 10 years; and suggest potential influential new technologies enabled by the Internet for the following five (5) and ten (10) years.

Two groups of Internet experts were invited to participate in this study: Internet business experts (IBEs) and Internet technology experts (ITEs). The region of study focused on Southern Ontario for convenience, although it included some international participation fulfilling the same selection categories.

IBEs and ITEs were located in one of five ways:

1) IBEs were invited due to references and position in their companies. Invitations and expert identifications were carried out through telephone calls by a research team. A total of 217 companies from 1096 companies in the Communitech[98] directory were the basis of this invitation phone call. The criteria for selecting companies were that they be:
    a. Conducting business enabled by Internet technologies.
    b. Having a website or webpage.
    c. Being oriented toward technology development instead of commercializing an existing third party solution.
2) ITEs were identified from Scopus[99] as authors of academic papers with a Southern Ontario affiliation discussing issues related to Internet or Web technologies in journals papers published from January 2006 to October 2011. From 80 identified academic papers, 31 authors' names[100] were selected based upon a review of their article title and geographic convenience. For all these cases, authors' email addresses were found and invitations were issued by this means.
3) ITEs and IBEs were also identified through Internet research (Im & Chee, 2004; Chua, 2007) and electronic references and reviews of academic workshops, conferences and

……………………………..

[98] Communitech is a nonprofit organization supporting technology companies in Waterloo Region and promoting the region as a technology cluster. http://www.communitech.ca

[99] According to Elsevier and librarians of the University of Waterloo, Scopus is the largest bibliographic database containing abstracts and citation of peer-reviewed research published after 1995.

[100] Authors' names were investigated and confirmed as scientists or researchers within an academic institution or a research organization.

publications[101]. About 80 experts' names were carefully investigated and confirmed as part of an educational institution or a well-established business organization. Experts for whom email addresses were found received an email invitation. Alternatively, an invitation phone call was made to their companies.

4) IBEs and ITEs were also invited due to a business or research relationship with a member of the research team. About 40 experts were identified in the LinkedIn[102] accounts of the research team. The criteria for selecting experts were the same to the one described for companies previously in point 1a, 1b and 1c.
5) IBEs and ITEs were invited as well based upon references from other IBEs or ITEs.

A total of 82 Internet experts were interviewed using a semi-structured questionnaire in order to satisfy the first step of the repertory grid technique: the elicitation of elements. Thus, the first interview – based on a semi-structured questionnaire – aimed to elicit the elements of two two-step repertory grids for each participant. While the elements for the first grid were past influential technologies and failed/dormant technologies in the Internet industry, the elements for the second grid were potential influential new technologies in the same industry.

This group of 82 experts does not represent a random sample of Internet experts, and our results do not claim to present a complete landscape of past and potential influential new technologies enabled by the Internet. Nevertheless, the resulting collective appreciative system of the Internet industry is believed to be systematic, replicable and thought-provoking in an exploratory manner.

This report is organized in the same four interview sections:

1) Influential technologies enabled by the Internet in the last 10 years
2) Failed/dormant technologies enabled by the Internet in the last 10 years
3) Potential influential new Internet trends in the coming five (5) and ten (10) years
4) Characterization of the Internet experts' group.

The elicitation of elements in this first phase of the study made it possible to identify and select elements – technologies – for the second phase of this study: the evaluation of elements or technologies.

C.2 Influential Technologies Enabled by the Internet in the Last 10 Years

Participants were prompted to respond the following questions:

The Internet has enabled the development of influential and sometimes unexpected technologies which have transformed how individuals and organizations operate in their technical, business and social life.

From your point of view, in the last ten (10) years, 1) what are four (4) examples of technologies enabled by the Internet that have been influential in terms of changing the way individuals or organizations fulfill their activities, needs or functions?

Influential Technology 1: ____________________

Influential Technology 2: ____________________

Influential Technology 3: ____________________

Influential Technology 4: ____________________

……………………………..

101 Some examples of workshops, conferences and publications are: Canada-EU Future Internet Workshop; Center for Advanced Studies Conferences; The Smart Internet and Networks for Pervasive Services books.

102 LinkedIn is a professional social network with a website which was used to carry out the systematic review of the selection criteria.

Assuming that technologies are created with an intended purpose, please provide your answers and share your experience.

> *2) What do you believe was the purpose of the inventors or creators who developed each of your suggested influential technologies?*
>
> *3) Please provide a brief example of where, by whom and how each technology has been applied?*

The first and main question was an open-ended question expecting precise and concrete identification of technologies. The second and third complementary questions, about the intended purpose of each technology and the example of their applications, were essential in order to deal with possible differences in terminology and meaning from experts' responses.

A total of 338 "past influential technologies" inputs[103] were received as part of the process of classifying responses or "the aggregation process". It is worth pointing out that the analysis of these 338 inputs did not aim at theory testing or theory development as content analysis typically aims in scientific studies (Creswell, 2009). In fact, the analysis was summative and focused only on one dimension: technology naming. Our three questions were already informed by the theoretical framework[104] of the study and designed carefully to facilitate the main objective: to identify past influential technologies enabled by the Internet in the last ten years.

The aggregation process made use of the strengths, recommendations and procedures of content analysis, a widely used qualitative research method(Baxter, 2009; Hsieh & Shannon, 2005). For this reason, the aggregation process followed a clear set of instructions and had a clear unit of analysis guiding the entire examination (Bryman, Teevan, & Bell, 2009). In this case, technology names were the unit of analysis and comprised the only dimension in analysis. Likewise, the rules of the aggregation process considered that every input must have a category or label (exhaustive) and each input must be assigned into only one category (mutually exclusive)(Frankfort-Nachimias & Nachimias, 1996).

With no constraints upon how many categories or labels to have, a coder with a background in computer systems applied the following written instructions of the aggregation process. Note that instructions emphasized that decisions should be made in the obvious or manifest content.

1) Write down the responses consistently.
2) Sort all responses in alphabetical order.
3) Group* under one label identical responses when purposes and examples of technologies refer to the same technology and they make intuitive sense of the technology in question. This means that a valid inference must be based on keywords used in purposes and examples.
4) Group* under existing labels the ungrouped responses which make use of keywords that are present in existing labels. Purposes and examples of such technologies must make intuitive sense of the technology in question. Keywords used in purposes and examples are the basis of a valid inference. If necessary, refine carefully the wording of existing labels.

……………………………..

103 There were 338 inputs because some participants provided five technologies instead of four.

* Group, collapse or create a label which can account for a set of influential technologies as entirely framed in the context and objective of the original question.

104 Technologies' names are seen as symbolic devices accounting for participant acceptance of a collective assignment of status function and constitutive rules of a particular institutionalized form in a social domain (Searle, 1998).

5) Collapse* existing related labels under an existing label or a new expanded or refined label when such "new" label can account for all responses under the original related labels[105]. Purposes and examples of technologies must be understood and must make intuitive sense related to the technology in question. A valid inference must be based on keywords used in purposes and examples. This step must be preformed carefully, bearing in mind the aim to identify generic names of technologies.
6) Group* under an existing label or a new label the ungrouped responses which make use of different words but which their purposes and examples refer to the same technology. All of them must make intuitive sense. Keywords used in purposes and examples are the basis of a valid inference.
7) If a grouped response makes better sense with an emerging label then change it. Purposes and examples of technologies must make increased intuitive sense as well.
8) Go to Step 4 until no more grouping of ungrouped responses make intuitive sense.
9) Create* one label for each of the ungrouped responses of influential technologies.

In the end, the purpose was not to describe an objective reality of past influential technologies in the Internet industry but to build a model, or a systematic collective interpretation – an appreciative system (Burt, 2010; Burt & van der Heiden, 2008; Checkland, 2005) – of past influential technologies in this industry. The following figures and tables describe our results.

Table C-1 shows the list of past influential technologies which were referred to more than two times in interviews. While inputs refer to a number of times in which a technology under such label was mentioned, participants refer to the number of experts suggesting at least one technology under such label or category in question.

Past influential technologies	Inputs	Inputs %	Participants	Participants %
Social Media/Networking	52	15.38%	47	57.32%
Mobile Internet Technologies[106]	49	14.50%	43	52.44%
Cloud Computing	25	7.40%	21	25.61%
Video Communication and Telephony over the Internet	22	6.51%	21	25.61%
Search Engines	19	5.62%	19	23.17%
WWW Technologies	17	5.03%	16	19.51%
Email	13	3.85%	13	15.85%
Wireless Technologies	10	2.96%	9	10.98%
Instant Messaging	8	2.37%	8	9.76%
Video Sharing	8	2.37%	8	9.76%
Content Delivery Technologies	7	2.07%	7	8.54%
File Sharing Technologies	7	2.07%	7	8.54%
Remote Collaboration Technologies	7	2.07%	7	8.54%
Wikis	7	2.07%	7	8.54%
Online Transactions	6	1.78%	6	7.32%
Broadband Technologies	5	1.48%	5	6.10%
Microprocessing Technologies	5	1.48%	5	6.10%
Online Mapping	5	1.48%	5	6.10%
Electronic Commerce	5	1.48%	4	4.88%
Crowdsourcing Technologies	3	0.89%	3	3.66%
E-Learning	3	0.89%	3	3.66%
Digital Processing Technologies	3	0.89%	2	2.44%
Health Care Technologies	3	0.89%	2	2.44%
Other	49	14.50%	49	59.76%
Total	338	100.00%		

Table C-1 Frequency of past influential technology inputs (inputs>2)

This is the list of past influential technologies in the category of "Other", mentioned equal or less than two times: API technologies, Human-Computer Interfaces Technologies, Location and Context Awareness Technologies, Mashups, Miniaturization Technologies, Network Virtualization, Open Source Software, Personal Publishing (as a Suit of Technologies), Video Streaming Technologies, Automated Resources Management Applications, Blogs, Broadcast Interaction Technologies, Business Analytics, Customer Relationship Management Technologies, Data Compression Technologies, Data Visualization Technologies, Databases, Gamification, Internet Access Technologies, Machine to Machine Applications, Multimedia Networking

……………………………..

105 The level of generalization and the level of specificity of labels depend on the overall goal of the study. This study aims to identify generic names of past influential technologies. Thus, labels are expected to be generic but not so broad that important differences are obscured (Frankfort-Nachimias & Nachimias, 1996).

106 Mobile Internet Technologies refer to the suit of technologies enabling Internet access through mobile devices (i.e., technologies like smartphones, tablets and mobile broadband fall under this label).

Applications, Off the Shelf Systems (Pre-packaged Systems), Online Gaming, Optical Networks, Pay-Per-Click Advertising Technology, Personal Computers, Personalized Applications and Services, Remote Desktop Connectivity, Reviews and Recommendations List, Security Technologies, SIP Technologies, Software Agency (Virtual Assistance), TCP/IP, Thin Client Technologies, Unified Communications, Virtual Worlds, VPN Virtual Private Network, Web Services, Webinars and Wireless Sensors Networks.

Figure C-1 shows the frequency distribution of past influential technologies referred to more than two times.

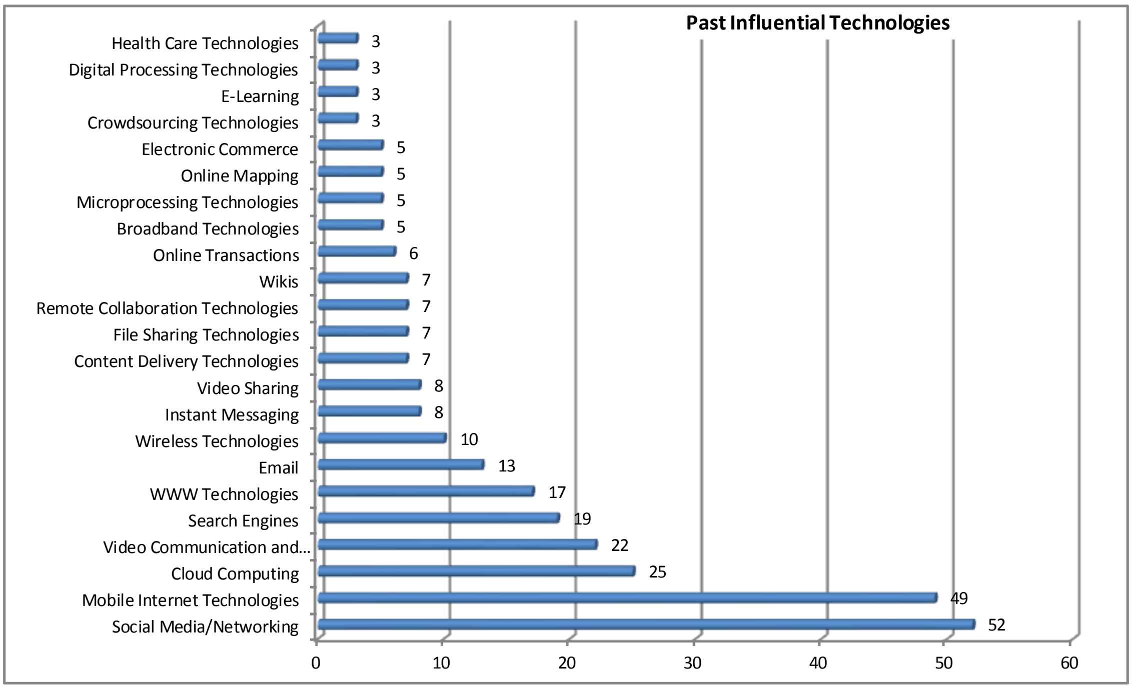


Figure C-1 Frequency distribution of past influential technology inputs (input>2)

Figure C-2 displays the percentage of participants suggesting a given past influential technology.

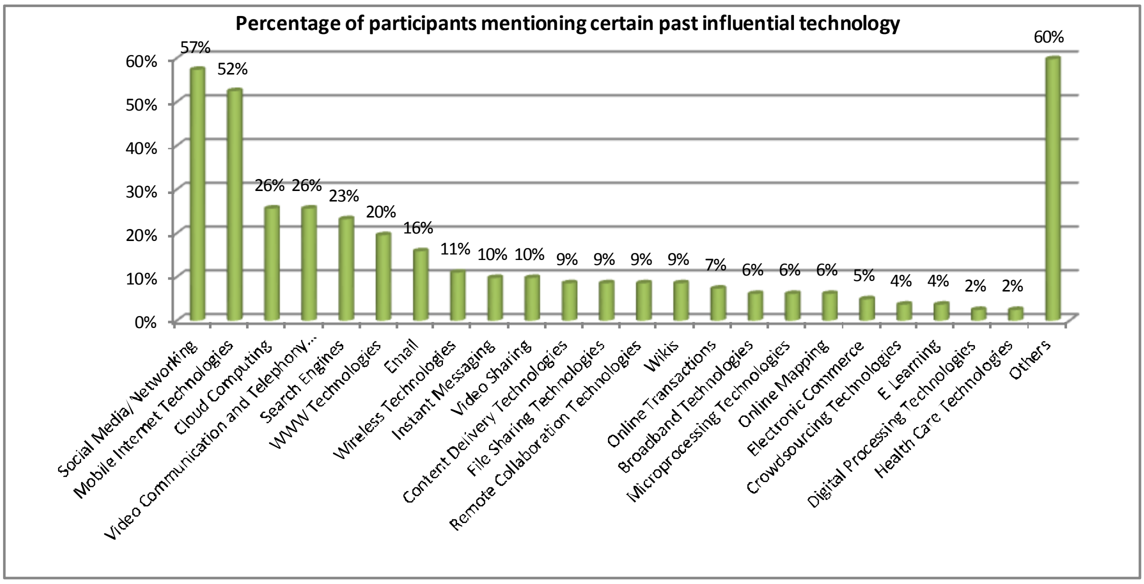


Figure C-2 Percentage of participants indicating a particular past influential technology

Figure C-3 shows percentage of references to past influential technologies. Technologies with less than 1.5 % of references were grouped under the category of other past influential technologies.

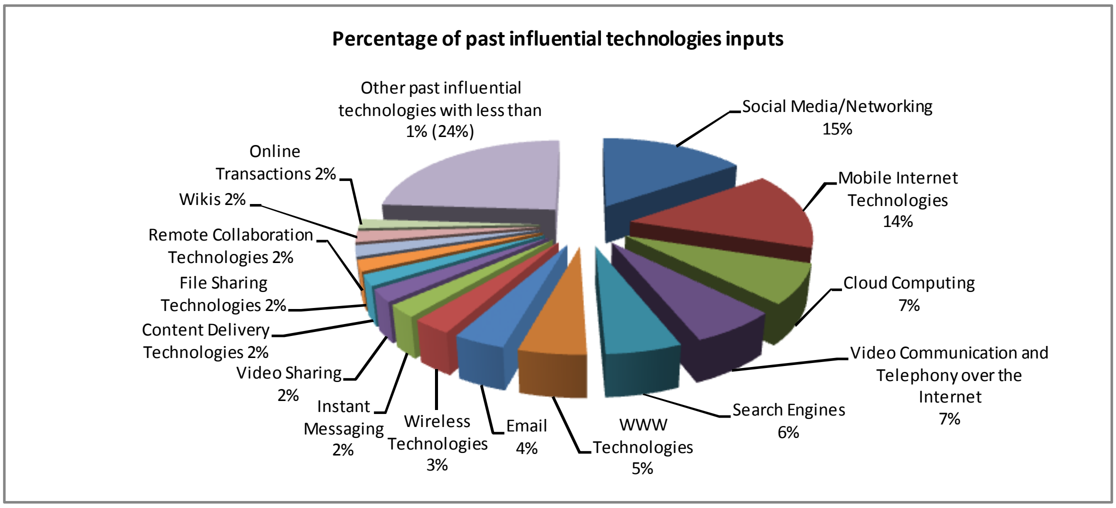


Figure C-3 Percentage of past influential technology inputs

From the previous tables, one can see that, although the Internet has enabled a long list of influential technologies in the last ten years, there seems to be strong agreement among experts with some influential technologies. For example, not only was "Social Media/Networking" mentioned by the 57% of this group of experts, but also at least one of two technologies – "Social Media/Networking" or "Mobile Internet Technologies" – was mentioned by the 80% of these experts (Note: this percentage cannot be estimated directly from previous figures). Another way to look at this outstanding agreement is that only five technologies account for almost 50 % of the total number of inputs (i.e., "Social Media/Networking" (15%), "Mobile Internet Technologies" (14%), "Cloud Computing" (7%), "Video Communication and Telephony over the Internet" (7%) and "Search Engines" (6%)).

With respect to participants' reaction to answer this question of past influential technologies, it is worth pointing out the percentage of experts completing the task and the percentage of experts having some questions or hesitations (see Figure C-4 and Figure C-5).

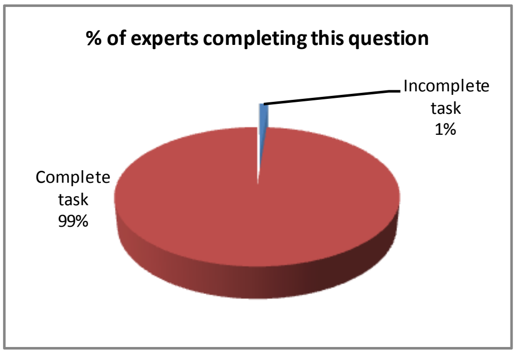


Figure C-4 Experts completing the first question

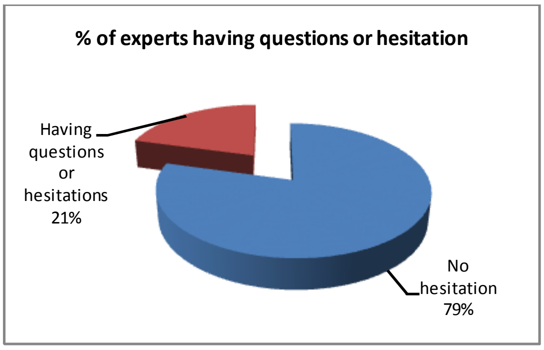


Figure C-5 Experts having questions or hesitation

Only one participant opted for providing three past influential technologies instead of four, the rest completed this question fully. Some 21% of participants expressed clearly some questions and hesitations. Figure C-6 illustrates categories of questions and hesitations from participants. The remaining 79% of them provided their responses without deviation.

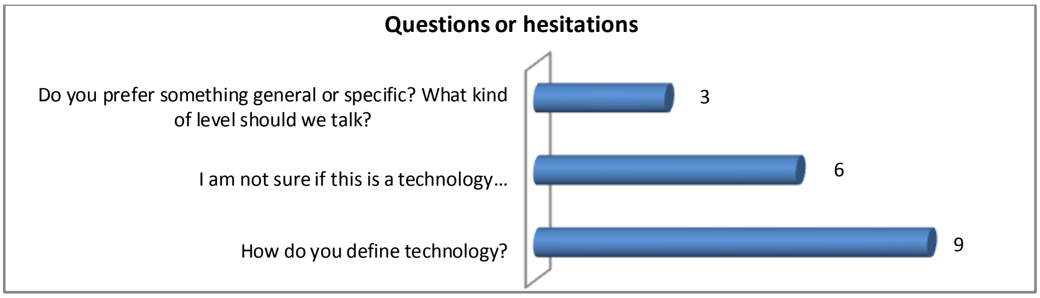


Figure C-6 Questions or hesitations from participants

Before this probe of questions or hesitations during interviews, researchers avoided providing definitions or asserting a particular view. Participants were encouraged to respond this question in the way they could make sense of the question. In few cases, participants highlighted that some of their inputs were referring to not only technologies but technological applications.

Thus, the list of ten most frequent past influential technologies was comprised of "Social Media/Networking", "Mobile Internet Technologies", "Cloud Computing", "Video Communication and Telephony over the Internet", "Search Engines", "WWW Technologies", "Email", "Wireless Technologies", "Instant Messaging" and "Video Sharing". Technologies are presented in descending order of mentions. Additionally, one can say that, although some participants expressed questions and hesitations, they provided answers without major difficulty.

C.3 Failed/Dormant Technologies Enabled by the Internet in the Last 10 years

In this section, participants were prompted to respond the following questions:

While some technologies enabled by the Internet have significantly grown and disrupt old well-established social and organizational practices, other technologies enabled by the Internet have failed or have become dormant, which means that technologies exist but they are not actively growing.

From your point of view, in the last ten (10) years, 1) what are two (2) examples of technologies enabled by the Internet which have been failures in terms of changing the way individuals or organizations fulfill their activities, needs or functions?

Failed/Dormant Technology 1: ______________________

Failed/Dormant Technology 2: ______________________

Assuming that technologies are created with an intended purpose, please provide your answers and share your experience.

2) What do you believe was the purpose of the inventors or creators who developed each of your suggested failed/dormant technologies?

3) Please provide a brief example of where, by whom and how each technology has been applied?

Although the main objective of this section shifted to identify past failed/dormant technologies enabled by the Internet the last ten (10) years, the three questions were also informed by our theoretical framework and they anticipated precise and concrete identification of such technologies.

A total of 146 failed/dormant technologies were elicited as inputs. Next, responses were processed by applying the same aggregation procedure as described in page 183. In this section, inspired by

Cheng and Leu (2011) and Elo and Kyngäs (2007), Figure C-7 shows a flowchart of our aggregation process.

After the aggregation of inputs, Table C-2 presents the list of past failed/dormant technologies which were nominated more than two times in the interviews. As well, the footnote of this table lists other technologies mentioned only one time.

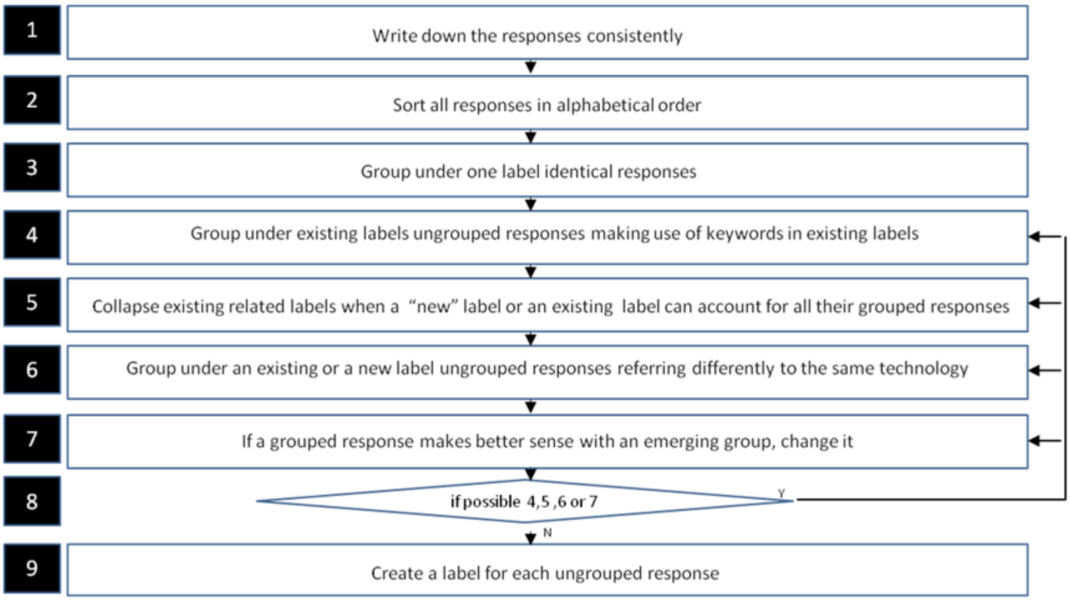


Figure C-7 Aggregation process flowchart

Failed/dormant technologies	Inputs	Inputs %
Music Sharing Technologies	8	5.48%
Google Wave	6	4.11%
MySpace	6	4.11%
Search Portals	5	3.42%
ATM- Asynchronous Transfer Mode Protocol	4	2.74%
Email	4	2.74%
Search Engines previous to Google	4	2.74%
Virtual Worlds	4	2.74%
Electronic Voting	3	2.05%
Internet TV	3	2.05%
PC Tablet	3	2.05%
Artificial Intelligence	2	1.37%
Blogging	2	1.37%
EDI - Electronic Data Integration	2	1.37%
Online Gaming	2	1.37%
Quality of Services Technologies	2	1.37%
Video Phones	2	1.37%
Voice Recognition	2	1.37%
WAP Wireless Application Protocol	2	1.37%
Other	80	54.79%
Total	146	100.00%

Table C-2 Frequency of failed/dormant technologies

This is the list of "Other" failed/dormant technologies mentioned only one time: Analog TCC Cameras, Cables to Connect Devices, Calendaring, Collaborative Filtering Technology with Explicit Data, Common Identity Online, Consistent Broadband Technology, Dial Up Internet (Free Internet), Digital Signatures, Digital Video Distribution, Dumb Terminals, E-Commerce, E-Commerce previous to e-Bay, Effective Security Technologies, Electronic Health Records Systems, Electronic Signatures, Failed Internet/Web Protocols, Failed Web/Internet Languages, File Transfer Systems, Flash, Floppy Disk, Friendster, Google Health, Google PowerMeter, Grid Computing, Image Recognition, IMS - IP Multimedia Subsystem, IPSEC (Secure Internet), IRC Internet Relay Chat, ISDN, Java Bins - J2EE Development, Java Pages and Java Script Language, Large Centralized Computer, Medmanager, Micropayment Technologies, Microsoft HealthVault, Microsoft Unified Communication, Mobile Electronic Payments, MPLS- Multi Protocol Labour Switching, Multicast, NAPLS Communication Protocol, New Emails Standards/Protocols, News Groups, Nomad, Object Oriented Databases, Open Internet, Open PC Architectures, Optical Networks, Palm PDA, Paperless Office, Personal Portals, Physical Media (Hard Media), Picture Sharing Platforms (focus on pictures), Podcasting, PointCast (push technology), Previous versions to HTML, Pure Video Conference (Pure Real

Time Video Interaction), Robotics Technologies, RSVP Bandwidth, Satellite-based Networks, Search (current model), Semantic Web, Services Oriented Architecture, Social Websites previous to Facebook, Static Internet Web 1.0, Table Top Display, TCP Protocols, Tele Medical Consultation, Telepresence, Tele-Surgery, Tetherless Computing (Delay Tolerance Network Applications), Video Chat, Virtual Electronic Consumer Banking (Non-branches), Virtual Reality Interactions, Virtual Reality Mark up Language, VNC - Virtual Network Connection and VPNs, Webvan, Wikis, Windows CE, Word Perfect as an Applet, Yahoo Advertising Model (Display Advertising).

Next, Figure C-8 indicates the frequency distribution of failed/dormant technologies with at least two mentions.

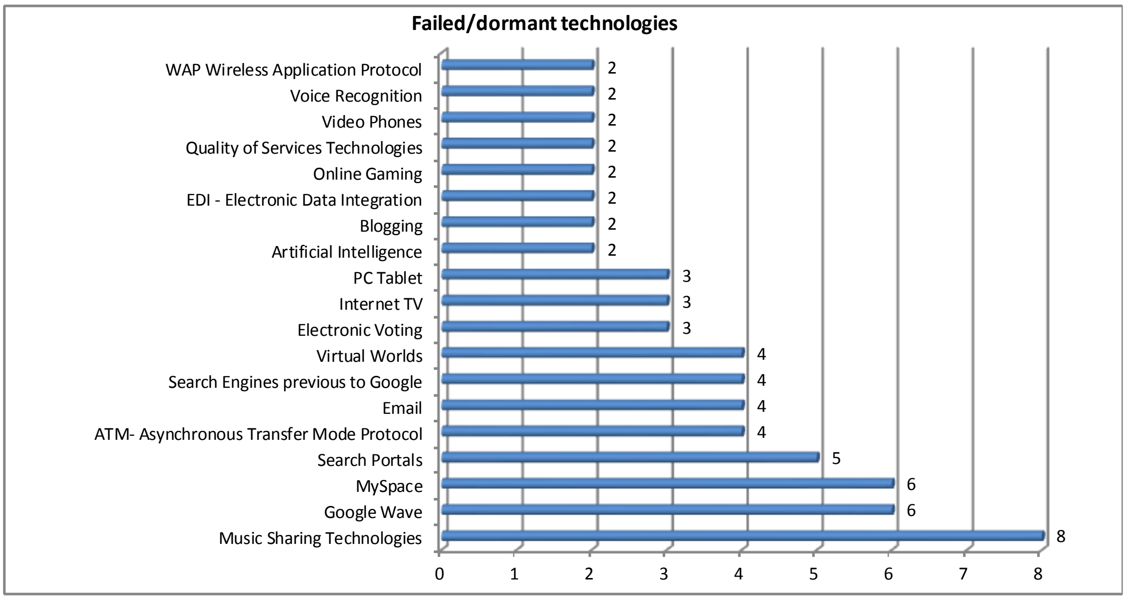


Figure C-8 Frequency distribution of failed/dormant technologies

In comparison to the first question, participants' reactions to the question of failed/dormant technologies revealed differences of possible interest. Even though asking about past influential technologies and past failed/dormant technologies seemed to be similar and straightforward, the percentage of experts without completing the later question was almost 20 % higher (Figure C-9). Further, the percentage of experts with suggestive comments was worth of attention (Figure C-10) and the types of commentaries (Figure C-11) were aligned in an interesting way with our theoretical framework. Additionally, there seems to be lack of agreement among experts in terms of past failed/dormant technologies and it is believed that suggested technologies were more specific rather than generic. Why were responses and reactions to failed/dormant technologies so different? This discussion goes beyond the scope of this report but our commitment is to deal with a potential explanation at the end of this research work.

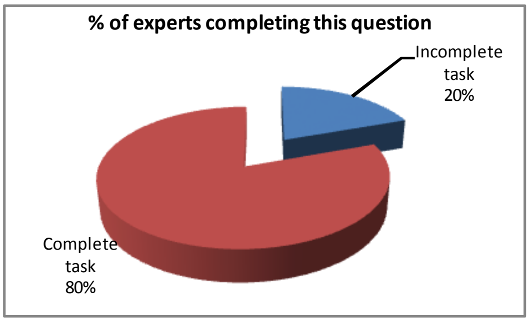


Figure C-9 Experts completing the second question

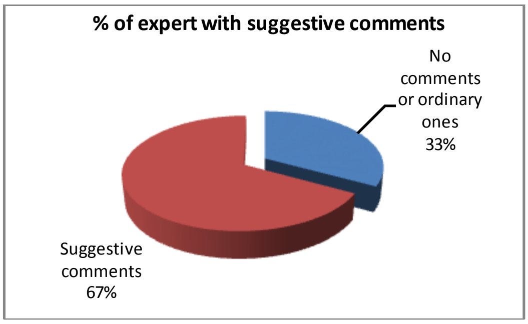


Figure C-10 Experts with suggestive comments

The 20% of respondents without completing the question was comprised of twelve experts with only one input and four experts with no answer to this question of failed/dormant technologies. The 67% of experts with suggestive comments involved 55 experts making 72 commentaries. Figure C-11shows the frequency and type of commentaries.

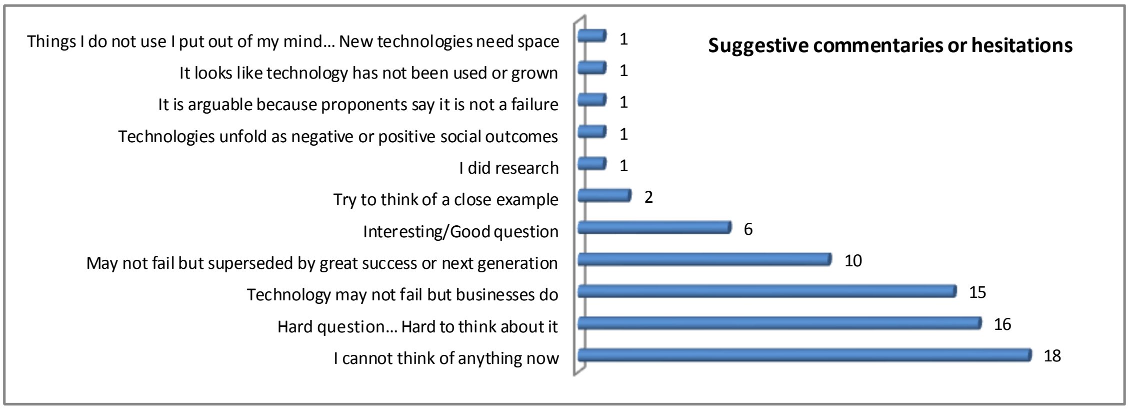


Figure C-11 Suggestive commentaries from participants

In contrast to the question of past influential technologies, the question of past failed/dormant technologies did not achieve high levels of agreement among respondents. The list of eight most frequent past failed/dormant technologies was comprised of "Music Sharing Technologies", "Google Waves", "MySpace", "Search Portals", "ATM-Asynchronous Transfer Mode Protocol", "Email", "Search Engines previous to Google" and "Virtual Worlds". Furthermore, the evidence suggests that some participants experienced difficulties answering this question; this will be explored further as the work continues toward dissertation defense.

C.4 Potential Influential New Internet Trends in the Next Five and Ten Years

In this section, participants were prompted to respond for potential influential new technologies considering two time frames. The first prompt was the following question:

Drawing upon your understanding, knowledge and vision about current technological and social trends, what might be the three (3) most influential technologies or new kind of activities enabled by the Internet that might come to the mainstream in the following five (5) years changing the way individuals or organizations fulfill their need and functions?

From your view, what would be the intended purpose of each of your suggested new technologies or new kind of activities?

The second prompt shifted the time frame to ten years ahead and asked for the two (2) most influential technologies or new kind of activities enabled by the Internet in the next ten years. Likewise, the possible intended purpose was probed for technologies/activities in the ten year time frame.

Inputs from both time frames were collected in the same file, tagging to which time frame each input belonged. The rationale behind the use of only one file – or collection – of potential influential new technologies was to frame consistently the creation of labels, categories and domains in a way that facilitates comparison between both time frames. The comparison of technologies and domains was important because our theoretical framework assumed that technologies and their technology-related activities evolve gradually. Thus, early signals of some technological trends in ten years might have been reported in the five-year time frame. Hence, the aggregation process can be seen as based on the ten-year time frame.

Figure C-12 shows an adapted aggregation and classification process used in this section. Steps 1 to 8 repeat our already explained aggregation process. However, the total number of inputs referring to technologies or new activities – which do not yet exist or have a known name – brought considerable challenge to the sense making process of participants' declarations. Adding a meta-label called "domain of activity" facilitated the review process of ungrouped responses and, in our view, increased the reliability of this aggregation and categorization process. Particularly, Steps 9 to 11 addressed the additional task of dealing better with classifying ungrouped responses in domains of activity.

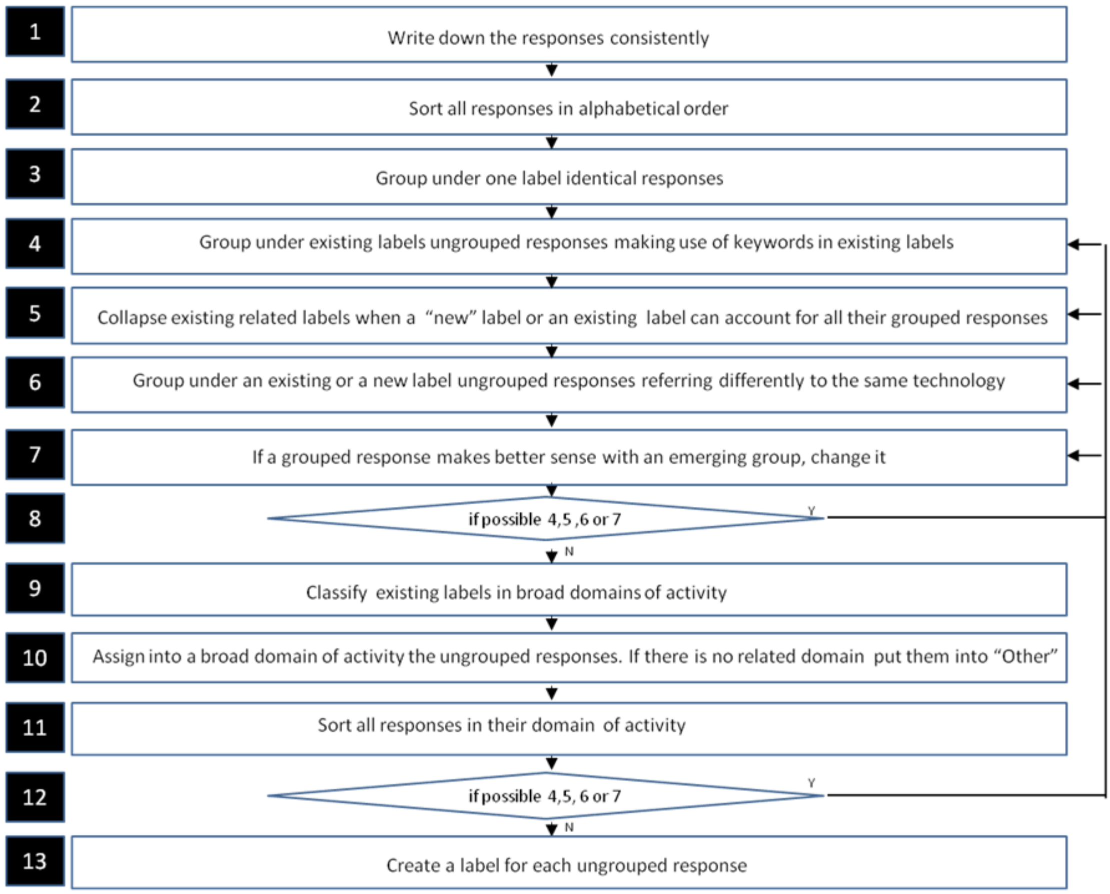


Figure C-12 Adapted aggregation and classification process

A total of 445 inputs were elicited as responses to both time frames. There were 268 inputs as part of the five-year time frame question and 177 inputs as for the ten-year time frame. Table C-3 displays the resulting summary after the aggregation and categorization process was applied.

At this point it is worth restating that the aim of this first phase was to build a model, a systemic view, which describes technologies and trends enabled by the Internet in a conceptual form. There is no claim for an objective characterization of such technologies but a systematic one. There is no single way to describe technologies in the Internet industry; the Internet technological landscape can be described in multiple ways depending on purpose. However, the overall goal of this section was to look generically for potential influential new domains of human activity enabled by the Internet. For this reason, the "domains of activity" emerged from manifest content and sense making of the experts' inputs.

Domain	Potential influential new technologies	Inputs per time frame	
		5 years	10 years
Business	Mobile Transactions and Payments	6	
	Business Analytics and Data Visualization	1	2
	Internet-based Shipping Services	1	
	Online Transactions Technologies	1	
	Business Model Processes Platforms		1
	Investment Management Systems		1
	New Trade Technology (Bit Coin)		1
	Outsourcing enabled by Internet Services		1
	Reducing the Cost of Transaction		1
	Sentiment Analysis Technologies		1
	Technologies Exploiting Aggregated Data		1
Collaboration	Content Management Technologies	2	
	Crowd Source Surveillance	1	1
	Crowd Sourcing	1	1
	Online Collaboration Technologies	1	1
	Collaborative Web Conferencing Platforms	1	
	Distributed Collaborative Video Technologies	1	
	Mobile Collaboration Technologies	1	
Computer Network	Internet of Things	5	3
	Machine to Machine Technologies	4	
	Wireless Networks	4	
	Broadband Technologies	3	5
	Ubiquitous Network	1	1
	Wireless Sensors Technologies	1	1
	Communication Protocols Technologies	1	
	RFID - Radio Frequency Identification	1	
	Sensor Networks Technology	1	
	New Internet		2
	Ad-hoc Network		1
	Ad-hoc Sensors Networks		1
	Clothing with Sensors		1
	Network Awareness of Content		1
	Smart Radios - Cognitive Radios		1
	Wearable Technology		1
Computing Resources	Cloud Computing	24	2
	Computer Virtualization	2	
	Utility Computing	2	
	Display Technologies	1	1
	Open Operative Systems	1	1
	"Green" Computing Technologies	1	
	Consumerization of IT technologies	1	
	Moving Data into the Cloud	1	
	Extended Cloud		1
	Ubiquitous Computing Devices (Hardware)		1
	Ubiquitous Computer Power		1
Education	E-learning	3	2
	Interactive e-books	1	
	Online Conferences	1	
	Own Learning Sharing	1	
	Self-monetized E-learning	1	
	Personalized E-learning		2
	Access to Total Knowledge		1
	Learning Management Systems		1
	Mobile Learning		1
Gamification	Scientific Gaming	1	1
	Gamification	1	
Government	E-democracy	1	3
	Government Services (applications)	1	
	Digital Citizen		1
	New Kinds of Surveillance		1
	Privacy and Transparency Systems		1
Health	Health Care Monitoring Systems	5	7
	Telemedicine	5	3
	Body Area Network	1	4
	Electronic Health Records	1	1
	Health Care Preventing Systems	1	1
	Nanorobotics in Medical Care	1	1
	Neuro-Interfacing	1	1
	Biomedical Health Science Technologies	1	
	Health Care Information Systems		4
	Bioelectronics		2
	Bio-Identification		1
Human-Computer Interaction	Voice Recognition	6	4
	New Human-Computer Interfaces	4	2
	Natural Language Human-Computer Interaction	3	4
	Augmented Reality	3	
	Sensing Technologies	2	
	Haptic Technologies enabling direct interaction	1	
	Touch Screen Computing Everywhere	1	
	Brain Computer Interface		2
	Human Sensing Technologies		1
Intelligence	Smart Systems and Applications	8	10
	Software Agency (Virtual Assistance)	3	3
	Smart and Sensing Environments	1	2
	Assisted Intelligence	1	1
	Personal Virtual Presence	1	1
	Intelligence Dust (Wireless Sensor Technologies)	1	
	Voice Activated Search Engine	1	
	Road Traffic Engineering		1
Personal Web	Personalized Web Services and Applications	7	1
	Personal Resource Management Applications	2	1
	Narrow Casting	1	
	Real Time Search		1
	Sense Technologies (personalize Web)		1
	Smart Searching		1

Domain	Potential influential new technologies	Inputs per time frame	
		5 years	10 years
Mobile Internet	Mobile Devices	8	
	Mobile Broadband	7	3
	Mobile Services and Applications	7	1
	Location-based Services and Applications	5	2
	Location-based Internet Marketing	4	
	Near Field Communications Technologies	4	
	Mobile Technologies	2	1
	Smartphones	2	
	Wi-Fi Geo Location Technology	2	
	E-Reading using tablets or other mobile devices	1	
	Multi-Protocol Support-Software Radio-Network Convergence	1	
	QR Quick Response Applications	1	
	Qualitative Changes in Mobile Computer to the Next Level	1	
	Technologies bringing applications and networks together	1	
	Unified Identification Technology	1	
	Single Computing Devices (hardware)		1
Resource Management	Automated Resource Management Systems	4	6
	Environmental Monitoring Systems	4	1
	Computer Sensors	1	
	Industrial Control Systems (Internet of Things)	1	
	Participatory Sensors	1	
	Adaptive Systems		1
	Cyber Physical Systems (Robots) - Robotics		1
Security	Secure Identity Technologies	6	1
	Email Spam Filter Technologies	1	
	Evolution in Privacy Policies…	1	
	Identity Credential Access Management	1	
	Locking Technologies for Content	1	
	Secure Network and Applications		2
	Internet Regulatory Technologies		1
	Personal Privacy Firewalls		1
	Self-anonymization technology		1
Semantic Web and Data Integration	Mashups of Web-based Applications	3	1
	Big Data Technologies	3	
	Semantic Web Search	3	
	Semantic Web	2	1
	Data Integration Technology	1	1
	Semantic Technologies	1	1
	The Web as a Database	1	
	Web 3.0		1
Social Media/ Networking	Social Media Analytics	3	
	Social Media/Networking	3	
	Context Emerging Social Network (Context Organic Marketing)	1	
	Micro Broadcasting	1	
	One to Many Instant Private Messaging	1	
	Self-Publishing	1	
	Software to find Networks	1	
	Unified Social Platform	1	
	Continuous Use of Social Web		1
	Selfcasting for Infotainment		1
	Social Search Technologies		1
Software Resources	Better Tools for combining existing functionality	1	
	HMTL files	1	
	Rapid Programming Platforms for Websites	1	
	Machine-based Translation from one Language to another		1
	Open Source Development		1
Video and Content	Content Delivery Technologies	4	
	Internet TV	3	1
	Real Time Video Communication	1	1
	Digitalization of Content	1	
	High Definition Video Conferencing	1	
	Human Electronic Representation	1	
	Real Time Broadcasting over the Internet	1	
	Remix Content	1	
	Video Chatting	1	
	Video Technologies	1	
	Telepresence		3
	New TV Standard		1
	Personal Media Consumption		1
	Superior Modes of Compression and Decompression		1
	True 3D Holograms		1
Virtual Reality	Virtual Reality in Business, Education, Health & Entertainment	3	6
	Individual Virtual Presence on the Web	1	
	Virtualization of the Real World (pervasive computing)	1	
	Online Gaming for Conflict Resolution		1
	Virtual Presence in Simulated Real Worlds (Virtual Worlds)		1
	Virtual Workplace		1
Other	Nanotechnology	1	1
	Contextual Content Delivering	1	
	Invisible Computing	1	
	Open Source Networks and Infrastructure	1	
	Real Life	1	
	Real Remote Network Physical Interactions Technologies	1	
	Shift from Push Market to a Pull Market Paradigm	1	
	Quantum Computing		4
	Behavioral Change Technologies		1
	Pharmacologically Enhance Media		1
	Citizen Science		1
	Cyberwarfare		1
	Internet-based 3D Printing		1
	Joint Artistic Productions		1
	Power Supply Technologies		1
	Teleportation		1
	Watching the World remotely		1
TOTAL		**268**	**177**
		445	

Table C-3 Frequency distribution of potential influential new technologies in the next five and ten years

A total of 20 domains resulted from the aggregation and categorization process of the 445 inputs. Table C-3 summaries the 445 inputs organized by domain of activity, technology labels and time frame in question.

Next, Figure C-13 and Figure C-14 show the frequency distribution of potential influential new technologies mentioned more than 2 and 1 time respectively for the five and ten-year time frames.

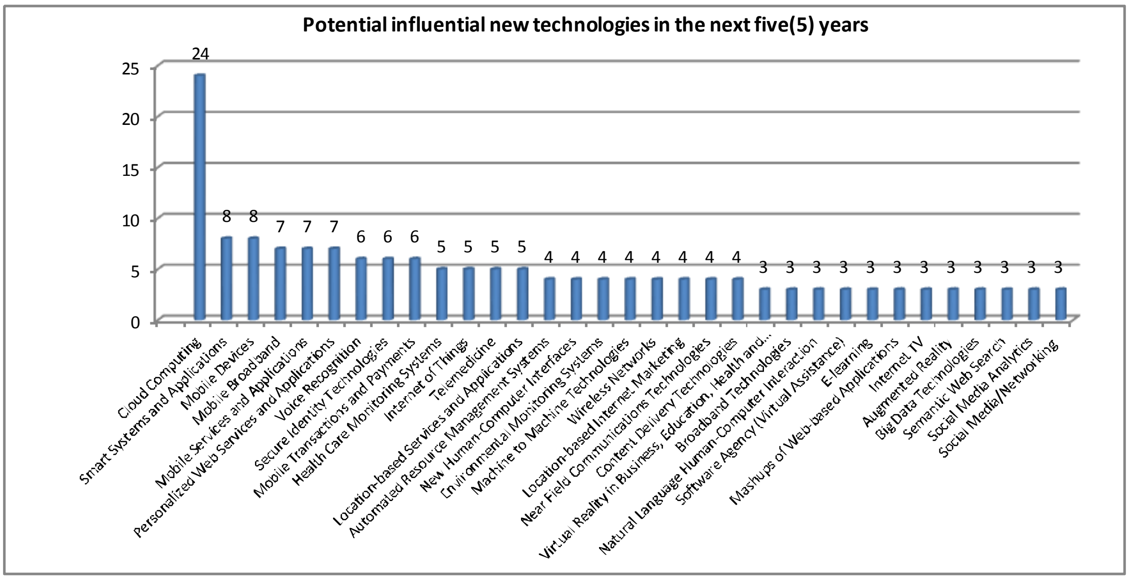


Figure C-13 Frequency distribution of potential influential new technology in five (5) years (inputs>2)

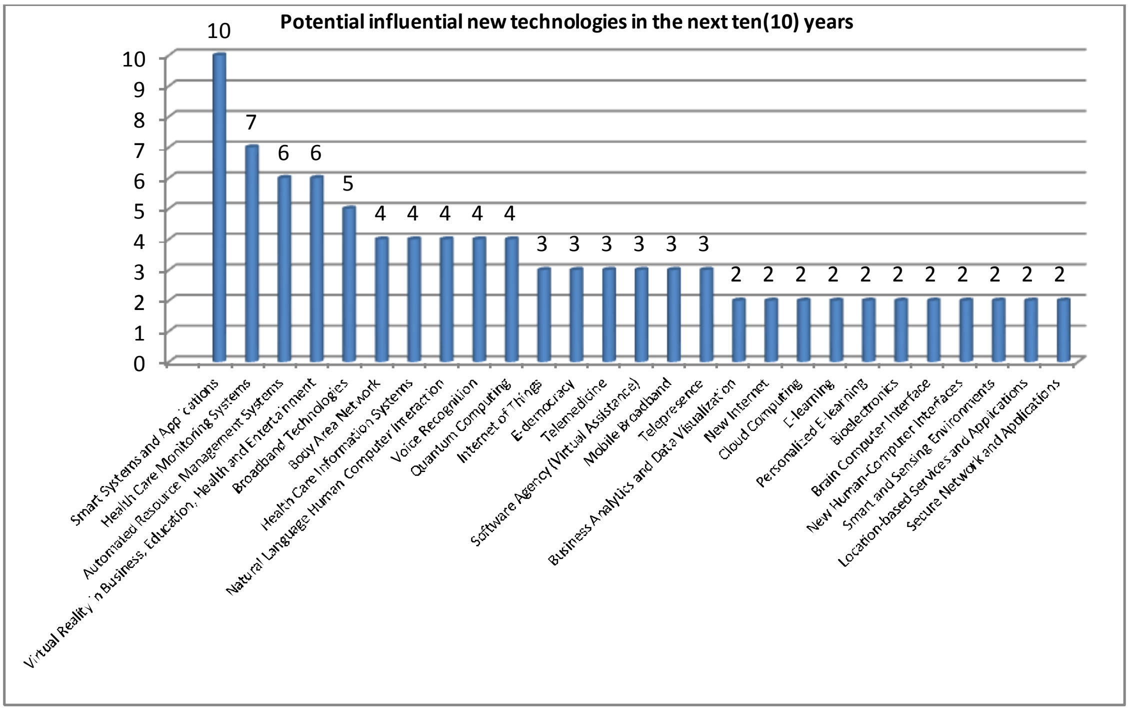


Figure C-14 Frequency distribution of potential influential new technology in ten (10) years (inputs>1)

Towards having a collection of potential influential new technologies suggesting a hierarchical and categorical organization based on "domain of activity", our analysis included the use of a Treemap visualization tool called "Treemap 4.1" (University of Maryland, 2003). Treemaps enable a compact visualization of hierarchical and categorical data structures facilitating comparisons between categories and helping to achieve the understanding and recognition of patterns (Shneiderman & Plaisant, 2009). Figure C-15 displays one of the Treemap visualization analyses.

Figure C-15 groups categorically the whole collection of potential influential new technologies in both time frames at the first-level rectangle called "Potential Influential New Technologies". In the second-level rectangles, the "5Y" and the "10Y" titles separate the elicited inputs for each time frame. At the third-level, rectangles refer to domains of activity which comprise not only aggregated inputs but also single inputs under the domain in question – both rectangles at the fourth-level. Note that each white rectangle corresponds to an expert input.

Despite the fact that the amount of inputs in both time frames was different[107], the Treemap visualization analysis depicts a proportional difference in terms of domains of activity for potential influential technologies in the two time frames. For example, while the "Mobile Internet" (17.54%) and "Computing Resources" (12.31%) domains comprised the most frequently mentioned potential influential technologies in the five-year time frame, "Health" (14.12%), "Computer Network" (10.17%) and "Intelligence" (10.17%) domains were the counterpart in the ten-year time frame. Likewise, taking into consideration a higher number of IBEs inputs[108] with respect to the ITEs inputs, a proportional difference was revealed in comparing inputs from these two groups of experts in different domains of activity and time frames. For example, in the five-year time frame, while ITEs suggested higher percentage of "Computer Network" (10.34%), "Intelligence" (8.62%) and "Education" (5.17%) technology inputs, IBEs indicated higher percentage of "Mobile Internet" (22.37%), "Security" (5.92%) and "Business" (5.26%) technology inputs (see Table C-4).

Inspired by the Treemap visualization analyses, Table C-4 presents percentage distributions of potential influential technology domains. Relative frequencies of technology domains are shown by comparing not only IBEs inputs with ITEs inputs in each time frame, but also inputs per domain between both time frames. Differences over 2% are highlighted in gray color. Not surprisingly, it is reasonable to think of these differences in terms of our theoretical framework and the hypotheses guiding the empirical investigation. Again, this discussion goes beyond the scope of this report. Nevertheless, percentage differences create interesting questions which this research will addressed at the end.

Figure C-16 and Figure C-17 show graphically the percentage distribution of potential influential technology domains in the next five and ten years respectively. In analyzing these figures, readers can refer to Table C-3 to clarify the set of potential influential new technology inputs under the technology domain in question. For example, in Figure C-16, the 18% of "Mobile Internet" is composed of the set of technologies under the "Mobile Internet" domain in the five-year time frame column in Table C-3 (i.e., Mobile Devices (8), Mobile Broadband (7) Mobile Services and Applications (7), Location-based Services and Applications (5), Location-based Internet Marketing (4), Near Field Communications (4), Mobile Technologies (4), Smartphones (2), Wi-Fi Geo Location Technology (1), E-reading using mobile devices (1), Multi-protocol Support-Network Convergence (1), QR Quick Response Applications(1), Qualitative changes in mobile computer (1), Technologies bringing applications and networks together (1) and Unified Identification Technology (1)).

……………………………..

107 While the five-year time frame question asked for three potential influential new technologies, the ten-year time frame question asked for only two.

108 A total of 45 interviews comprised IBEs and 37 interviews comprised ITEs – for a total of 82 interviews.

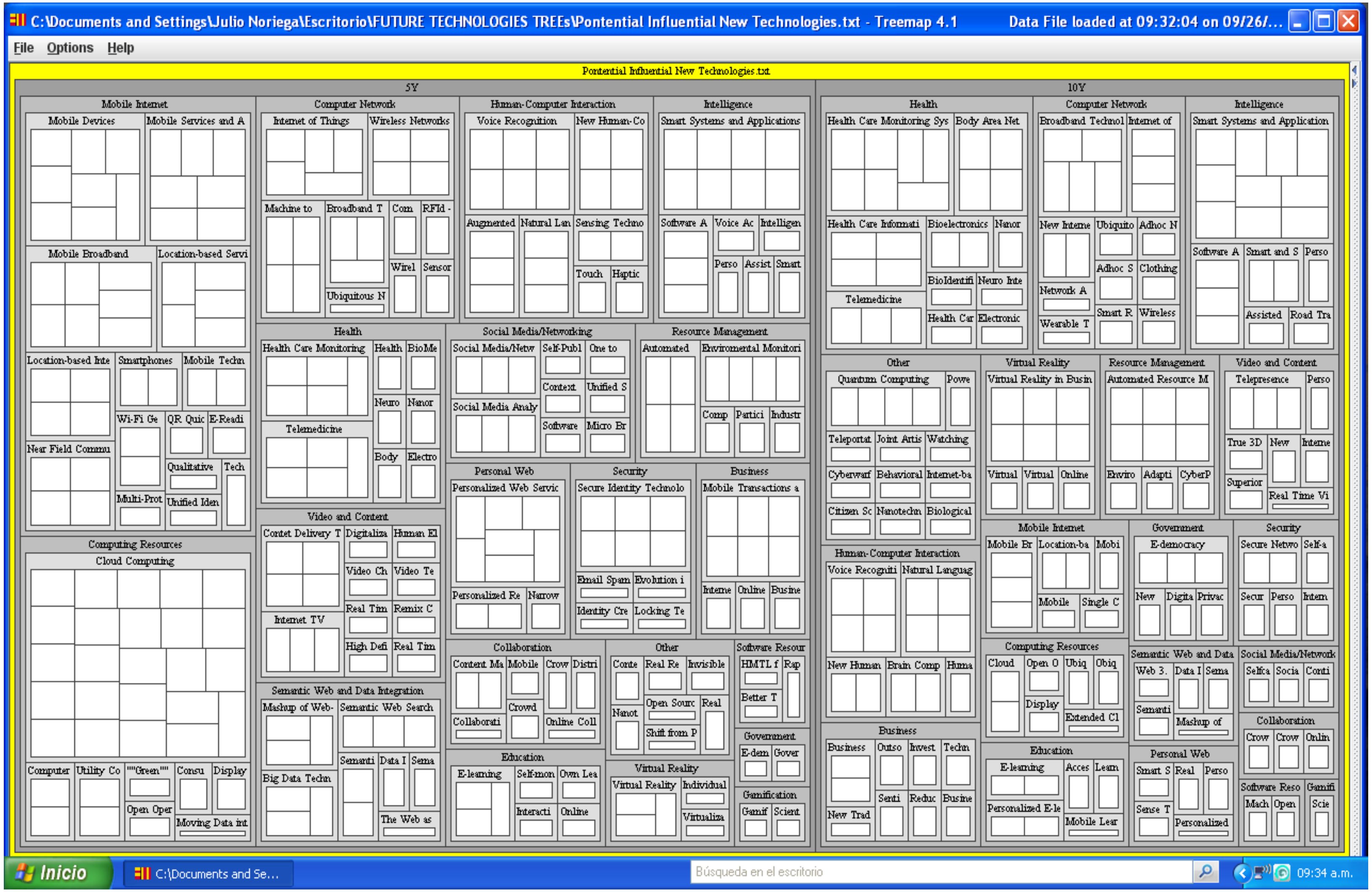


Figure C-15 Treemap visualization for potential future new technologies enabled by the Internet in the next five (5) and ten (10) years

Domain	5 years			10 years					
	IBEs	ITEs	Dif	IBEs	ITEs	Dif	5 years	10 years	Dif
Business	5.26%	0.86%	4.40%	5.10%	5.06%	0.04%	3.36%	5.08%	1.73%
Collaboration	2.63%	3.45%	0.82%	0.00%	3.80%	3.80%	2.99%	1.69%	1.29%
Computer Network	5.92%	10.34%	4.42%	8.16%	12.66%	4.49%	7.84%	10.17%	2.33%
Computing Resources	11.84%	12.93%	1.09%	4.08%	3.80%	0.28%	12.31%	3.95%	8.36%
Education	0.66%	5.17%	4.51%	3.06%	5.06%	2.00%	2.61%	3.95%	1.34%
Gamification	0.66%	0.86%	0.20%	0.00%	1.27%	1.27%	0.75%	0.56%	0.18%
Government	1.32%	0.00%	1.32%	4.08%	2.53%	1.55%	0.75%	3.39%	2.64%
Health	5.92%	6.03%	0.11%	18.37%	8.86%	9.51%	5.97%	14.12%	8.15%
Human-Computer Interaction	7.89%	6.90%	1.00%	7.14%	7.59%	0.45%	7.46%	7.34%	0.12%
Intelligence	3.95%	8.62%	4.67%	9.18%	11.39%	2.21%	5.97%	10.17%	4.20%
Mobile Internet	22.37%	11.21%	11.16%	7.14%	1.27%	5.88%	17.54%	4.52%	13.02%
Personal Web	3.29%	4.31%	1.02%	2.04%	3.80%	1.76%	3.73%	2.82%	0.91%
Resource Management	3.29%	5.17%	1.88%	5.10%	5.06%	0.04%	4.10%	5.08%	0.98%
Security	5.92%	0.86%	5.06%	4.08%	2.53%	1.55%	3.73%	3.39%	0.34%
Semantic Web and Data Integration	4.61%	6.03%	1.43%	2.04%	3.80%	1.76%	5.22%	2.82%	2.40%
Social Media/Networking	5.26%	3.45%	1.81%	2.04%	1.27%	0.77%	4.48%	1.69%	2.78%
Software Resources	0.66%	1.72%	1.07%	1.02%	1.27%	0.25%	1.12%	1.13%	0.01%
Video and Content	5.92%	5.17%	0.75%	5.10%	5.06%	0.04%	5.60%	5.08%	0.51%
Virtual Reality	1.97%	1.72%	0.25%	5.10%	5.06%	0.04%	1.87%	5.08%	3.22%
Other	0.66%	5.17%	4.51%	7.14%	8.86%	1.72%	2.61%	7.91%	5.30%
	100.00%	100.00%	0.00%	100.00%	100.00%	0.00%	100.00%	100.00%	0.00%

Table C-4 Distribution of potential influential technology domains comparing experts' type and time frames

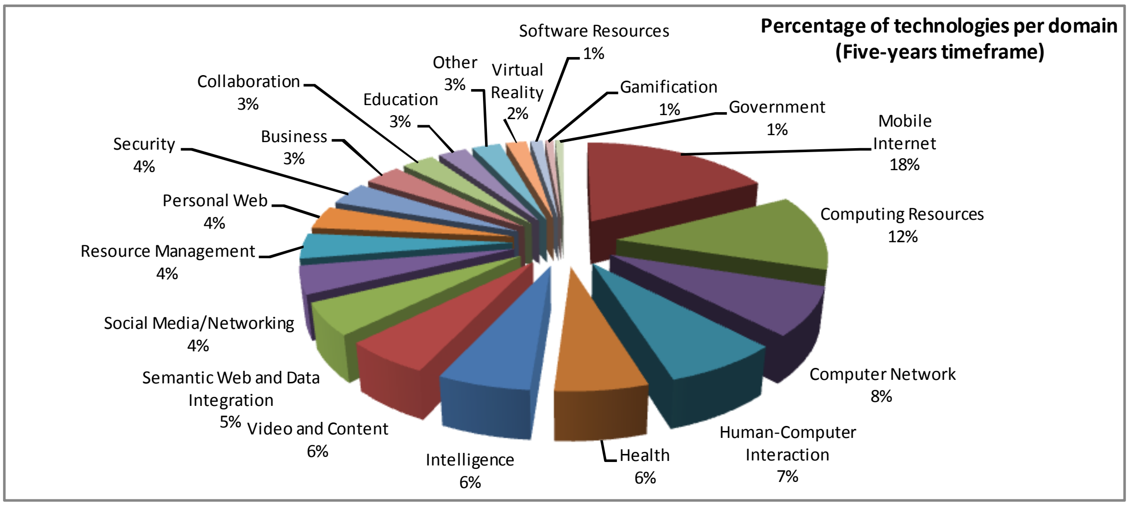


Figure C-16 Percentage distribution of potential influential technology domains in the next five years

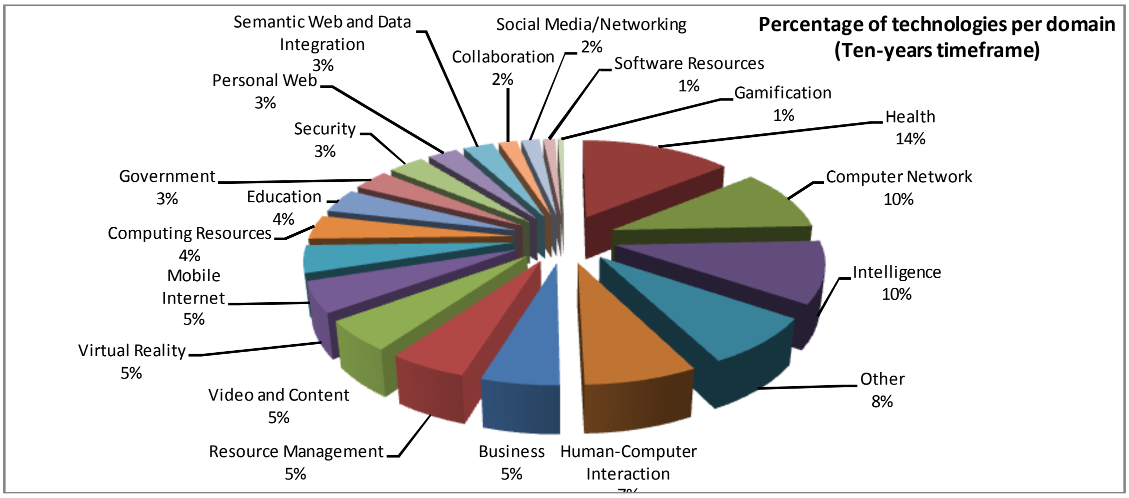


Figure C-17 Percentage distribution of potential influential technology domains in the next ten years

C.5 Characterization of the Internet experts' Group

This last section aimed to characterize our group of 82 Internet experts. Only the first statement was based on the researcher information. The remaining statements result from self-report answers collected during interviews.

According to our previously mentioned selection categories, the 55% of the experts were invited as IBEs (45) and the rest (45%) were invited as ITEs (37).

The 95% of participants described their expertise as being with specialized knowledge either as scholar, scientist, engineer or developer (Figure C-18). The rest (5%) described their expertise as being with extensive social and behavioral knowledge related to the Internet industry (e.g., Internet laws or business). Likewise, the 68% of participants described their expertise focused on the commercialization or exploitation of Internet technologies, while the rest (32%) were mainly focused on studying or development of Internet technologies (Figure C-19).

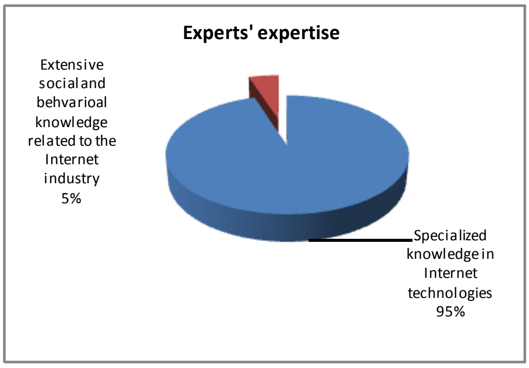


Figure C-18 % distribution of experts' expertise

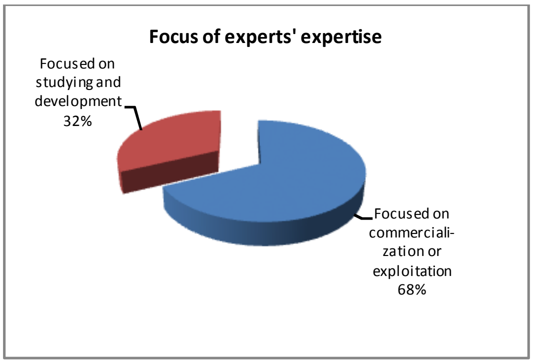


Figure C-19 % distribution of experts' expertise focus

As for the experts' job title, experts reported a title of researcher/professor (41%), manager, director or CEO (37%), consultant (4%), business owner (2%) and product manager (2%). The rest (14%) differed from business investor, chief technology officer, content marketing consultant, knowledge mobilizer, PhD student, project manager, retired, sales manager, software developer, system analyst to VP admin (1 per each case).

The average of total years of experience in the Internet industry among this group of experts was the 19 years; the mode was 15 years and the median was 17 years.

Participants were asked about their highest educational degree. Figure C-20 displays the percentage distribution of the highest degree of education in our sample: habilitation + doctorate degree (1%), doctorate degree (42%), master degree (25%), MBA degree (4%), undergraduate degree (22%), college diploma (5%), and high school diploma (1%).

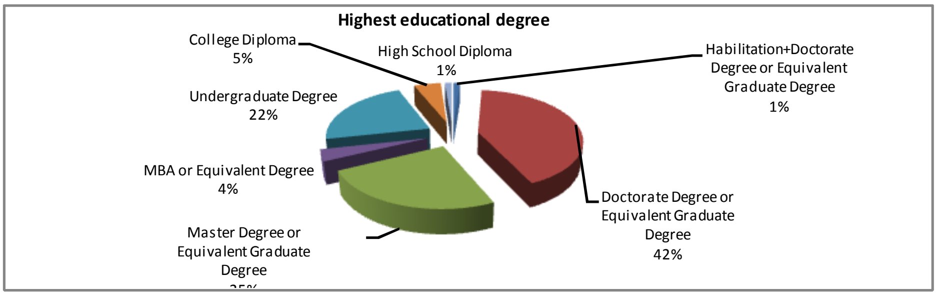


Figure C-20 Percentage distribution of experts' highest educational degree

The distribution of professional background in our sample was the following (Figure C-21): computer sciences (42%), engineering (30%), both computer sciences and engineering (2%), social sciences (7%), business (5%), and others (14%). Others included arts and humanities, life sciences, environmental sciences, law, economics, physical sciences and biology.

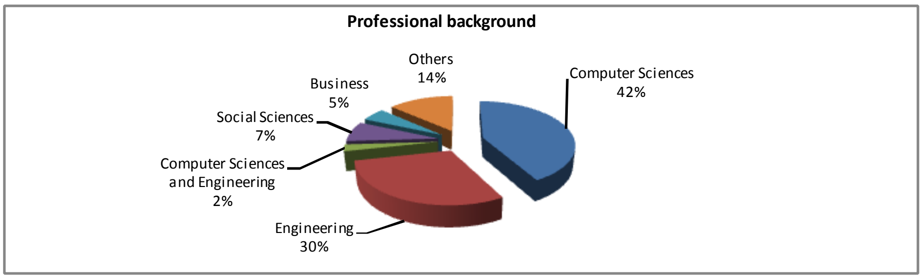


Figure C-21 Percentage distribution of experts' professional background

As for the type of organization for which our group of experts work, Figure C-22 presents the percentage distribution of experts' type of organization: university/college (45%), business organization (26%), my own organization (22%), non-profit organization (5%) and governmental organization (2%).

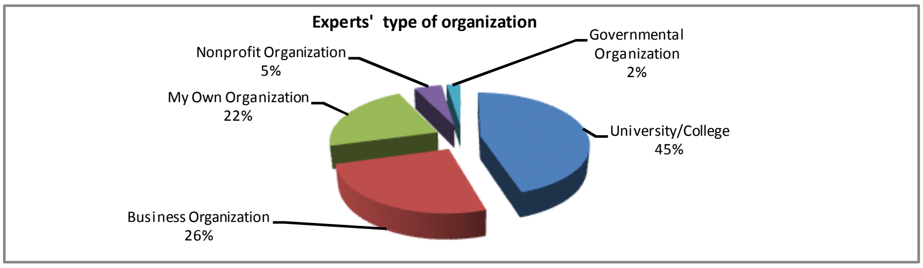


Figure C-22 Percentage distribution of experts' organization type

C.6 Conclusion and Further Research

This report presents a systematic and replicable procedure to create a collective view of technological trends in the Internet industry. Although the study was limited by its geographic conditions, selection categories of experts and number of participants, the report is disciplined, extensive and thought provoking.

While the results identified five past influential technologies as responsible for almost 50% of experts' inputs (i.e., "Social Media/Networking", "Mobile Internet Technologies", "Cloud Computing", "Video Communication and Telephony over the Internet" and "Search Engines"), the results suggested also that past failed/dormant technologies varied among experts' perceptions. In this later case, "Music Sharing Technologies", "Google Waves", "MySpace" and "Search Portals" were at the top of the frequency list. The question is: why do past influential technologies reach strong agreement among experts while past failed/dormant technologies do not? This is to be examined further.

Despite of the fact that asking about past influential technologies or failed/dormant technologies seems similar, significant differences appeared when experts answered these two questions. In particular, experts provided answers for past influential technologies without major problems but significant number of experts experienced some difficulties answering for past failed/dormant technologies. Why were past influential technologies easy to respond while past failed/dormant technologies were problematic? This work continues.

On the other hand, the section of potential influential new technologies not only shows an interesting aggregated view of the possible future, but also brings to our attention intriguing results about important differences between aggregated results from IBEs and ITEs responses, as well as differences between the aggregated results in both time frames. Why in some specific domains did aggregated results differ between IBEs and ITEs? Why in other domains did aggregated results differ between ITEs and IBEs? Why did we observe some specific domains of aggregated results in the five-year time frame but not in the ten-year time frame? Why did we observe other domains of aggregated results in the ten-year time frame but not in the five-year time frame?

We believe that the answers for some or all of these questions are not trivial. Moreover, we believe that there is a relationship between the process of emergence and development of new technologies as related to some or all of these questions. Although we are not going to be able to answer this entire set of questions in the dissertation, in the second phase we have tested interesting propositions from a theoretical framework which may account for some aspects of these phenomena.

We offer a brief excerpt of what the theoretical framework and second phase is about. Based on the Structuration Theory(Giddens, The Constitution of Society, 1984), we assume that individuals in their practice of living develop and build "structure"[109] which enable and constrain their activities (including thinking). Thus, individuals produce, reproduce and explain social phenomena by drawing upon their own structures created through their history of interactions. We assume that they cannot produce or account for activities or events for which they have not had a social experience. Social experience does not refer to a physical interaction necessarily but at least an abstract social interaction with the event, thing or phenomenon in question. In other words, individuals rely on rules and resources which have learned through their social interactions to reproduce and explain their experiences. We propose that the level of engagement of individuals with such rules and resources matters substantially. In particular, we argue that technologies and technological trends are social forms resulting from applying such rules and resources – particular patterns of human activity. We assume that both are products of grown structures in the practice of living by individuals. While failed/dormant technologies have relatively less developed or accumulated particular type of individuals' "structure" in a particular moment in time, influential technologies have relatively more.

Therefore, in the second phase of the study, we have proposed a model characterizing what type of structures we are talking about (e.g., meaning, power and legitimacy). Without knowing the model, our group of Internet experts have evaluated and indicated specific patterns of development of structure constituting some selected technological trends resulting from this report. In this way, we not only rely on Internet experts experience to assess structural differences among technological trends, but also probe for the effect that experts' level of engagement bring to the evaluation process. We anticipate presenting evidence of the suggested connections with questions emerged from this report and that this will enable us to tell a novel story explaining growth or lack of growth in new technologies and application trends. We believe that results can have practical and theoretical implications not only for tracing signals of technological change in an industry but also for guiding initiatives of technological developments. We look forward to sharing findings and insight in the near future.

……………………………..

[109] "Structure" refers to the set of embedded procedures (rules) and institutionalized forms (resources) applied by social actors in the performance of social practice. These rules and resources are organized recursively to produce and reproduce structural properties of the social system. Structure is not an external or independent entity but refers to individuals' knowledge instantiated in social practices.

Appendix D Additional Statistical Analyses

D.1 Reliability Analyses

Scale: Degree of Structuration

Case Processing Summary

		N	%
Cases	Valid	77	100.0
	Excluded[a]	0	.0
	Total	77	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.872	.872	6

Item Statistics

	Mean	Std. Deviation	N
Functional system	6.538	.943	77
Usefulness understanding	5.230	.857	77
Empowered individuals	5.018	.941	77
Enabler of new business	5.418	.982	77
Damaged reputation	2.848	.943	77
Inspired new social norms	4.788	1.047	77

Inter-Item Correlation Matrix

	Functional system	Usefulness understanding	Empowered individuals	Enabler of new business	Damaged reputation	Inspired new social norms
Functional system	1.000	.528	.527	.430	.177	.403
Usefulness understanding	.528	1.000	.776	.640	.291	.692
Empowered individuals	.527	.776	1.000	.707	.432	.754
Enabler of new business	.430	.640	.707	1.000	.420	.737
Damaged reputation	.177	.291	.432	.420	1.000	.465
Inspired new social norms	.403	.692	.754	.737	.465	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Functional system	23.302	15.387	.500	.321	.879
Usefulness understanding	24.610	14.342	.754	.658	.838
Empowered individuals	24.823	13.340	.836	.730	.821
Enabler of new business	24.422	13.533	.758	.608	.835
Damaged reputation	26.992	15.836	.433	.259	.889
Inspired new social norms	25.052	12.919	.792	.680	.828

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
29.840	19.974	4.469	6

Table D-1 Reliability of degree of structuration

Scale: Level of Engagement

Case Processing Summary

		N	%
Cases	Valid	77	100.0
	Excluded[a]	0	.0
	Total	77	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.820	.821	4

Item Statistics

	Mean	Std. Deviation	N
User	4.699	1.214	77
Study	4.874	1.450	77
Developer	3.269	1.473	77
Marketer	3.291	1.565	77

Inter-Item Correlation Matrix

	User	Study	Developer	Marketer
User	1.000	.554	.367	.548
Study	.554	1.000	.630	.587
Developer	.367	.630	1.000	.513
Marketer	.548	.587	.513	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
User	11.434	14.448	.579	.385	.802
Study	11.260	11.858	.732	.546	.729
Developer	12.865	12.723	.606	.430	.790
Marketer	12.842	11.704	.664	.448	.764

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
16.134	21.268	4.612	4

Table D-2 Reliability of level of engagement

D.2 Factor Analysis Including All Items from All the Constructs in the Study

Factor Analysis

Communalities

	Initial	Extraction
User	1.000	.640
Study	1.000	.782
Developer	1.000	.693
Marketer	1.000	.646
Impact on technology	1.000	.628
Physical system	1.000	.478
Type of innovation evol/revol	1.000	.635
Level of impact	1.000	.724
Level of awareness	1.000	.651
Probability of becoming a major trend in five years	1.000	.592
Functional system	1.000	.656
Usefulness understanding	1.000	.806
Empowered individuals	1.000	.788
Enabler of new business	1.000	.757
Damaged reputation	1.000	.768
Inspired new social norms	1.000	.766
Participant_HSB	1.000	.887
Personal_HSB	1.000	.881

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.253	34.739	34.739	6.253	34.739	34.739
2	2.296	12.753	47.492	2.296	12.753	47.492
3	1.936	10.758	58.250	1.936	10.758	58.250
4	1.302	7.235	65.485	1.302	7.235	65.485
5	.991	5.506	70.991	.991	5.506	70.991
6	.937	5.203	76.194			
7	.753	4.185	80.378			
8	.640	3.557	83.936			
9	.549	3.050	86.986			
10	.458	2.545	89.532			
11	.435	2.414	91.946			
12	.310	1.724	93.670			
13	.264	1.466	95.137			
14	.233	1.295	96.431			
15	.208	1.158	97.589			
16	.162	.898	98.487			
17	.142	.787	99.274			
18	.131	.726	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component				
	1	2	3	4	5
User	.565	.499	-.156	.209	.063
Study	.552	.545	-.422	.014	.047
Developer	.404	.575	-.349	-.041	-.274
Marketer	.549	.471	-.289	.124	.154
Impact on technology	.583	.020	-.123	.387	.351
Physical system	.187	.135	.207	.479	-.390
Type of innovation evol/revol	.253	-.400	-.076	.599	.216
Level of impact	.809	-.243	.008	.045	-.092
Level of awareness	.595	.181	-.119	-.439	.241
Probability of becoming a major trend in five years	.688	-.300	-.142	-.011	.093
Functional system	.591	-.165	-.069	-.524	-.015
Usefulness understanding	.714	-.508	.148	-.075	-.101
Empowered individuals	.848	-.222	.108	-.073	-.045
Enabler of new business	.801	-.177	.278	-.026	.074
Damaged reputation	.510	.213	.308	.035	-.605
Inspired new social norms	.844	-.197	.096	.042	-.055
Participant_HSB	.205	.517	.725	-.119	.197
Personal_HSB	.083	.345	.828	.074	.252

Extraction Method: Principal Component Analysis.
a. 5 components extracted.

D.3 Complementary Results for the Repeated Measures Analysis Between Type of Expert and Degree of Structuration

General Linear Model

Within-Subjects Factors

Measure:MEASURE_1

Degree_of_Structuration	Dependent Variable
1	Degree_of_ structuration_ 2001_ ALLTech
2	Degree_of_ structuration_ 2006_ ALLTech
3	Degree_of_ structuration_ 2012_ ALLTech

Between-Subjects Factors

		N
ExpertType	Business expert	41
	Technology expert	36

Descriptive Statistics

	ExpertType	Mean	Std. Deviation	N
Degree_of_ structuration_2001_ ALLTech	Business expert	4.82055746	.722298298	41
	Technology expert	4.58412699	.966360046	36
	Total	4.71001854	.847790702	77
Degree_of_ structuration_2006_ ALLTech	Business expert	6.06620206	.796098591	41
	Technology expert	5.95238097	.763603467	36
	Total	6.01298700	.778049301	77
Degree_of_ structuration_2012_ ALLTech	Business expert	6.64808363	.647678343	41
	Technology expert	6.49074076	.769420409	36
	Total	6.57452073	.706867811	77

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Degree_of_Structuration	.782	18.225	2	.000	.821	.848	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept + ExpertType
Within Subjects Design: Degree_of_Structuration

Tests of Within-Subjects Effects

Measure:MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Degree_of_Structuration	Sphericity Assumed	140.771	2	70.385	208.404	.000	.735
	Greenhouse-Geisser	140.771	1.642	85.751	208.404	.000	.735
	Huynh-Feldt	140.771	1.696	83.009	208.404	.000	.735
	Lower-bound	140.771	1.000	140.771	208.404	.000	.735
Degree_of_Structuration * ExpertType	Sphericity Assumed	.148	2	.074	.219	.803	.003
	Greenhouse-Geisser	.148	1.642	.090	.219	.759	.003
	Huynh-Feldt	.148	1.696	.087	.219	.767	.003
	Lower-bound	.148	1.000	.148	.219	.641	.003
Error(Degree_of_Structuration)	Sphericity Assumed	50.660	150	.338			
	Greenhouse-Geisser	50.660	123.122	.411			
	Huynh-Feldt	50.660	127.189	.398			
	Lower-bound	50.660	75.000	.675			

D.4 Independent Sample t-test Analyses of the Degree of Structuration Between the Two Type of Experts at Each Time frame

Note that "TE" refers to type of expert, "Business" refers to business expert, and "Technolo" refers to technology expert.

T-Test

Group Statistics

	TE	N	Mean	Std. Deviation	Std. Error Mean
Degree_of_structuration_2001_ALLTech	Business	41	4.82055746	.722298298	.112804042
	Technolo	36	4.58412699	.966360046	.161060007
Degree_of_structuration_2006_ALLTech	Business	41	6.06620206	.796098591	.124329711
	Technolo	36	5.95238097	.763603467	.127267244
Degree_of_structuration_2012_ALLTech	Business	41	6.64808363	.647678343	.101150363
	Technolo	36	6.49074076	.769420409	.128236735

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Degree_of_structuration_2001_ALLTech	Equal variances assumed	3.001	.087	1.225	75	.224	.236430468	.193003459	-.14805213	.620913075
	Equal variances not assumed			1.202	64.235	.234	.236430468	.196634376	-.15636417	.629225111
Degree_of_structuration_2006_ALLTech	Equal variances assumed	.157	.693	.638	75	.525	.113821088	.178406298	-.24158248	.469224660
	Equal variances not assumed			.640	74.395	.524	.113821088	.177918039	-.24065710	.468299286
Degree_of_structuration_2012_ALLTech	Equal variances assumed	.395	.532	.974	75	.333	.157342870	.161504937	-.16439146	.479077203
	Equal variances not assumed			.963	68.798	.339	.157342870	.163328063	-.16850477	.483190520

D.5 Complementary Results for the Repeated Measures Analysis Between Technological Outcome and Degree of Structuration

General Linear Model

Warnings

The HOMOGENEITY specification in the PRINT subcommand will be ignored because there are no between-subjects factors.

Within-Subjects Factors

Measure:MEASURE_1

Technological_Outcome	Degree_of_Structuration	Dependent Variable
1	1	Degree_of_structuration_2001_INF
	2	Degree_of_structuration_2006_INF
	3	Degree_of_structuration_2012_INF
2	1	Degree_of_structuration_2001_FAIL
	2	Degree_of_structuration_2006_FAIL
	3	Degree_of_structuration_2012_FAIL

Descriptive Statistics

	Mean	Std. Deviation	N
Degree_of_structuration_2001_INF	4.469697	.9617036	77
Degree_of_structuration_2006_INF	6.4221	.89246	77
Degree_of_structuration_2012_INF	7.5812	.70529	77
Degree_of_structuration_2001_FAIL	5.036797	1.1175839	77
Degree_of_structuration_2006_FAIL	5.467532	1.0376815	77
Degree_of_structuration_2012_FAIL	5.23809523	1.13922249	77

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

					Epsilon[a]		
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Technological_Outcome	1.000	.000	0	.	1.000	1.000	1.000
Degree_of_Structuration	.766	19.959	2	.000	.811	.826	.500
Technological_Outcome * Degree_of_Structuration	.782	18.468	2	.000	.821	.837	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Technological_Outcome + Degree_of_Structuration + Technological_Outcome * Degree_of_Structuration

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Degree_of_ structuration_2001_INF	4.469697	77	.9617036	.1095963
	Degree_of_ structuration_2001_FAIL	5.036797	77	1.1175839	.1273605
Pair 2	Degree_of_ structuration_2006_INF	6.4221	77	.89246	.10170
	Degree_of_ structuration_2006_FAIL	5.467532	77	1.0376815	.1182548
Pair 3	Degree_of_ structuration_2012_INF	7.5812	77	.70529	.08038
	Degree_of_ structuration_2012_FAIL	5.23809523	77	1.13922249	.129826452

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Degree_of_ structuration_2001_INF & Degree_of_ structuration_2001_FAIL	77	.365	.001
Pair 2	Degree_of_ structuration_2006_INF & Degree_of_ structuration_2006_FAIL	77	.325	.004
Pair 3	Degree_of_ structuration_2012_INF & Degree_of_ structuration_2012_FAIL	77	.266	.019

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Degree_of_ structuration_2001_INF - Degree_of_ structuration_2001_FAIL	-.5670996	1.1784368	.1342953	-.8345719	-.2996272	-4.223	76	.000
Pair 2	Degree_of_ structuration_2006_INF - Degree_of_ structuration_2006_FAIL	.9545455	1.1273566	.1284742	.6986669	1.2104240	7.430	76	.000
Pair 3	Degree_of_ structuration_2012_INF - Degree_of_ structuration_2012_FAIL	2.34307359	1.16932450	.133256895	2.07766948	2.60847770	17.583	76	.000

D.6 Paired t-test Analysis Between Each Pair of Time frame for Each Technological Outcome

Note that "INF" refers to influential technologies and "FAIL" refers to failed or dormant technologies.

T-Test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Degree_of_ structuration_2001_INF	4.469697	77	.9617036	.1095963
	Degree_of_ structuration_2006_INF	6.4221	77	.89246	.10170
Pair 2	Degree_of_ structuration_2006_INF	6.4221	77	.89246	.10170
	Degree_of_ structuration_2012_INF	7.5812	77	.70529	.08038
Pair 3	Degree_of_ structuration_2001_INF	4.469697	77	.9617036	.1095963
	Degree_of_ structuration_2012_INF	7.5812	77	.70529	.08038
Pair 4	Degree_of_ structuration_2001_FAIL	5.036797	77	1.1175839	.1273605
	Degree_of_ structuration_2006_FAIL	5.467532	77	1.0376815	.1182548
Pair 5	Degree_of_ structuration_2006_FAIL	5.467532	77	1.0376815	.1182548
	Degree_of_ structuration_2012_FAIL	5.23809523	77	1.13922249	.129826452
Pair 6	Degree_of_ structuration_2001_FAIL	5.036797	77	1.1175839	.1273605
	Degree_of_ structuration_2012_FAIL	5.23809523	77	1.13922249	.129826452

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Degree_of_ structuration_2001_INF & Degree_of_ structuration_2006_INF	77	.542	.000
Pair 2	Degree_of_ structuration_2006_INF & Degree_of_ structuration_2012_INF	77	.565	.000
Pair 3	Degree_of_ structuration_2001_INF & Degree_of_ structuration_2012_INF	77	.123	.287
Pair 4	Degree_of_ structuration_2001_FAIL & Degree_of_ structuration_2006_FAIL	77	.280	.014
Pair 5	Degree_of_ structuration_2006_FAIL & Degree_of_ structuration_2012_FAIL	77	.692	.000
Pair 6	Degree_of_ structuration_2001_FAIL & Degree_of_ structuration_2012_FAIL	77	.228	.046

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	Degree_of_ structuration_2001_INF - Degree_of_ structuration_2006_INF	-1.9523810	.8889786	.1013085	-2.1541544	-1.7506076	-19.272	76	.000
Pair 2	Degree_of_ structuration_2006_INF - Degree_of_ structuration_2012_INF	-1.15909	.76295	.08695	-1.33226	-.98592	-13.331	76	.000
Pair 3	Degree_of_ structuration_2001_INF - Degree_of_ structuration_2012_INF	-3.1114719	1.1205329	.1276966	-3.3658016	-2.8571421	-24.366	76	.000
Pair 4	Degree_of_ structuration_2001_FAIL - Degree_of_ structuration_2006_FAIL	-.4307359	1.2947687	.1475526	-.7246124	-.1368595	-2.919	76	.005
Pair 5	Degree_of_ structuration_2006_FAIL - Degree_of_ structuration_2012_FAIL	.229437231	.858837342	.097873598	.034505066	.424369397	2.344	76	.022
Pair 6	Degree_of_ structuration_2001_FAIL - Degree_of_ structuration_2012_FAIL	-.20129869	1.40184132	.159754645	-.51947765	.116880253	-1.260	76	.212

D.7 A Repeated Measures Analysis of Degree of Structuration per Each Technology

General Linear Model

Within-Subjects Factors

Measure:MEASURE_1

Degree_of_Structuration	Dependent Variable
1	Degree_of_ structuration_ 2001
2	Degree_of_ structuration_ 2006
3	Degree_of_ structuration_ 2012

Descriptive Statistics

Technology		Mean	Std. Deviation	N
Cloud Computing	Degree_of_ structuration_2001	3.24	1.125	75
	Degree_of_ structuration_2006	5.09	1.307	75
	Degree_of_ structuration_2012	6.67	1.095	75
Mobile Internet Technologies	Degree_of_ structuration_2001	5.69	1.786	77
	Degree_of_ structuration_2006	7.58	1.092	77
	Degree_of_ structuration_2012	8.44	.678	77
P2P Music Sharing	Degree_of_ structuration_2001	5.35	1.783	77
	Degree_of_ structuration_2006	5.99	1.303	77
	Degree_of_ structuration_2012	5.62	1.539	77
Search Portals	Degree_of_ structuration_2001	6.34	1.635	77
	Degree_of_ structuration_2006	5.92	1.537	77
	Degree_of_ structuration_2012	5.53	1.721	77
Social Media/Networking	Degree_of_ structuration_2001	4.00	1.522	77
	Degree_of_ structuration_2006	6.53	1.187	77
	Degree_of_ structuration_2012	8.01	.752	77
Video Conferencing	Degree_of_ structuration_2001	4.94	1.559	77
	Degree_of_ structuration_2006	6.47	1.456	77
	Degree_of_ structuration_2012	7.16	1.368	77
Virtual Worlds	Degree_of_ structuration_2001	3.35	1.121	75
	Degree_of_ structuration_2006	4.51	1.492	75
	Degree_of_ structuration_2012	4.52	1.465	75

Mauchly's Test of Sphericity[b]

Measure:MEASURE_1

Technology	Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[a] Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Cloud Computing	Degree_of_Structuration	.884	8.983	2	.011	.896	.917	.500
Mobile Internet Technologies	Degree_of_Structuration	.623	35.499	2	.000	.726	.737	.500
P2P Music Sharing	Degree_of_Structuration	.691	27.710	2	.000	.764	.777	.500
Search Portals	Degree_of_Structuration	.704	26.346	2	.000	.771	.784	.500
Social Media/Networking	Degree_of_Structuration	.878	9.727	2	.008	.892	.912	.500
Video Conferencing	Degree_of_Structuration	.730	23.629	2	.000	.787	.801	.500
Virtual Worlds	Degree_of_Structuration	.847	12.084	2	.002	.868	.887	.500

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b. Design: Intercept
Within Subjects Design: Degree_of_Structuration

Tests of Within-Subjects Effects

Measure:MEASURE_1

Technology	Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Cloud Computing	Degree_of_Structuration	Sphericity Assumed	441.307	2	220.653	232.113	.000	.758
		Greenhouse-Geisser	441.307	1.792	246.201	232.113	.000	.758
		Huynh-Feldt	441.307	1.834	240.614	232.113	.000	.758
		Lower-bound	441.307	1.000	441.307	232.113	.000	.758
	Error(Degree_of_Structuration)	Sphericity Assumed	140.693	148	.951			
		Greenhouse-Geisser	140.693	132.642	1.061			
		Huynh-Feldt	140.693	135.722	1.037			
		Lower-bound	140.693	74.000	1.901			
Mobile Internet Technologies	Degree_of_Structuration	Sphericity Assumed	305.697	2	152.848	163.264	.000	.682
		Greenhouse-Geisser	305.697	1.452	210.483	163.264	.000	.682
		Huynh-Feldt	305.697	1.473	207.490	163.264	.000	.682
		Lower-bound	305.697	1.000	305.697	163.264	.000	.682
	Error(Degree_of_Structuration)	Sphericity Assumed	142.303	152	.936			
		Greenhouse-Geisser	142.303	110.379	1.289			
		Huynh-Feldt	142.303	111.971	1.271			
		Lower-bound	142.303	76.000	1.872			
P2P Music Sharing	Degree_of_Structuration	Sphericity Assumed	15.697	2	7.848	5.303	.006	.065
		Greenhouse-Geisser	15.697	1.528	10.273	5.303	.011	.065
		Huynh-Feldt	15.697	1.553	10.107	5.303	.011	.065
		Lower-bound	15.697	1.000	15.697	5.303	.024	.065
	Error(Degree_of_Structuration)	Sphericity Assumed	224.970	152	1.480			
		Greenhouse-Geisser	224.970	116.128	1.937			
		Huynh-Feldt	224.970	118.029	1.906			
		Lower-bound	224.970	76.000	2.960			
Search Portals	Degree_of_Structuration	Sphericity Assumed	24.970	2	12.485	7.917	.001	.094
		Greenhouse-Geisser	24.970	1.543	16.183	7.917	.002	.094
		Huynh-Feldt	24.970	1.569	15.916	7.917	.002	.094
		Lower-bound	24.970	1.000	24.970	7.917	.006	.094
	Error(Degree_of_Structuration)	Sphericity Assumed	239.697	152	1.577			
		Greenhouse-Geisser	239.697	117.265	2.044			
		Huynh-Feldt	239.697	119.228	2.010			
		Lower-bound	239.697	76.000	3.154			

Social Media/Networking	Degree_of_Structuration	Sphericity Assumed	634.208	2	317.104	254.856	.000	.770
		Greenhouse-Geisser	634.208	1.783	355.675	254.856	.000	.770
		Huynh-Feldt	634.208	1.823	347.887	254.856	.000	.770
		Lower-bound	634.208	1.000	634.208	254.856	.000	.770
	Error(Degree_of_Structuration)	Sphericity Assumed	189.126	152	1.244			
		Greenhouse-Geisser	189.126	135.516	1.396			
		Huynh-Feldt	189.126	138.550	1.365			
		Lower-bound	189.126	76.000	2.488			
Video Conferencing	Degree_of_Structuration	Sphericity Assumed	199.022	2	99.511	89.161	.000	.540
		Greenhouse-Geisser	199.022	1.574	126.403	89.161	.000	.540
		Huynh-Feldt	199.022	1.602	124.226	89.161	.000	.540
		Lower-bound	199.022	1.000	199.022	89.161	.000	.540
	Error(Degree_of_Structuration)	Sphericity Assumed	169.645	152	1.116			
		Greenhouse-Geisser	169.645	119.662	1.418			
		Huynh-Feldt	169.645	121.759	1.393			
		Lower-bound	169.645	76.000	2.232			
Virtual Worlds	Degree_of_Structuration	Sphericity Assumed	68.062	2	34.031	30.975	.000	.295
		Greenhouse-Geisser	68.062	1.735	39.223	30.975	.000	.295
		Huynh-Feldt	68.062	1.773	38.382	30.975	.000	.295
		Lower-bound	68.062	1.000	68.062	30.975	.000	.295
	Error(Degree_of_Structuration)	Sphericity Assumed	162.604	148	1.099			
		Greenhouse-Geisser	162.604	128.410	1.266			
		Huynh-Feldt	162.604	131.222	1.239			
		Lower-bound	162.604	74.000	2.197			

Estimated Marginal Means

1. Grand Mean

Measure:MEASURE_1

Technology	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Cloud Computing	5.000	.100	4.800	5.200
Mobile Internet Technologies	7.238	.113	7.012	7.464
P2P Music Sharing	5.654	.136	5.382	5.925
Search Portals	5.931	.145	5.642	6.219
Social Media/Networking	6.182	.088	6.006	6.358
Video Conferencing	6.186	.135	5.918	6.454
Virtual Worlds	4.124	.123	3.878	4.370

2. Degree_of_Structuration

Estimates

Measure:MEASURE_1

Technology	Degree_of_Structuration	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Cloud Computing	1	3.240	.130	2.981	3.499
	2	5.093	.151	4.793	5.394
	3	6.667	.126	6.415	6.919
Mobile Internet Technologies	1	5.688	.204	5.283	6.094
	2	7.584	.124	7.336	7.832
	3	8.442	.077	8.288	8.596
P2P Music Sharing	1	5.351	.203	4.946	5.755
	2	5.987	.148	5.691	6.283
	3	5.623	.175	5.274	5.973
Search Portals	1	6.338	.186	5.967	6.709
	2	5.922	.175	5.573	6.271
	3	5.532	.196	5.142	5.923
Social Media/Networking	1	4.000	.173	3.655	4.345
	2	6.532	.135	6.263	6.802
	3	8.013	.086	7.842	8.184
Video Conferencing	1	4.935	.178	4.581	5.289
	2	6.468	.166	6.137	6.798
	3	7.156	.156	6.845	7.466
Virtual Worlds	1	3.347	.129	3.089	3.605
	2	4.507	.172	4.163	4.850
	3	4.520	.169	4.183	4.857

D.8 A Paired t-Test Analysis per Each Time frame Pairwise for Each Technology

T-Test

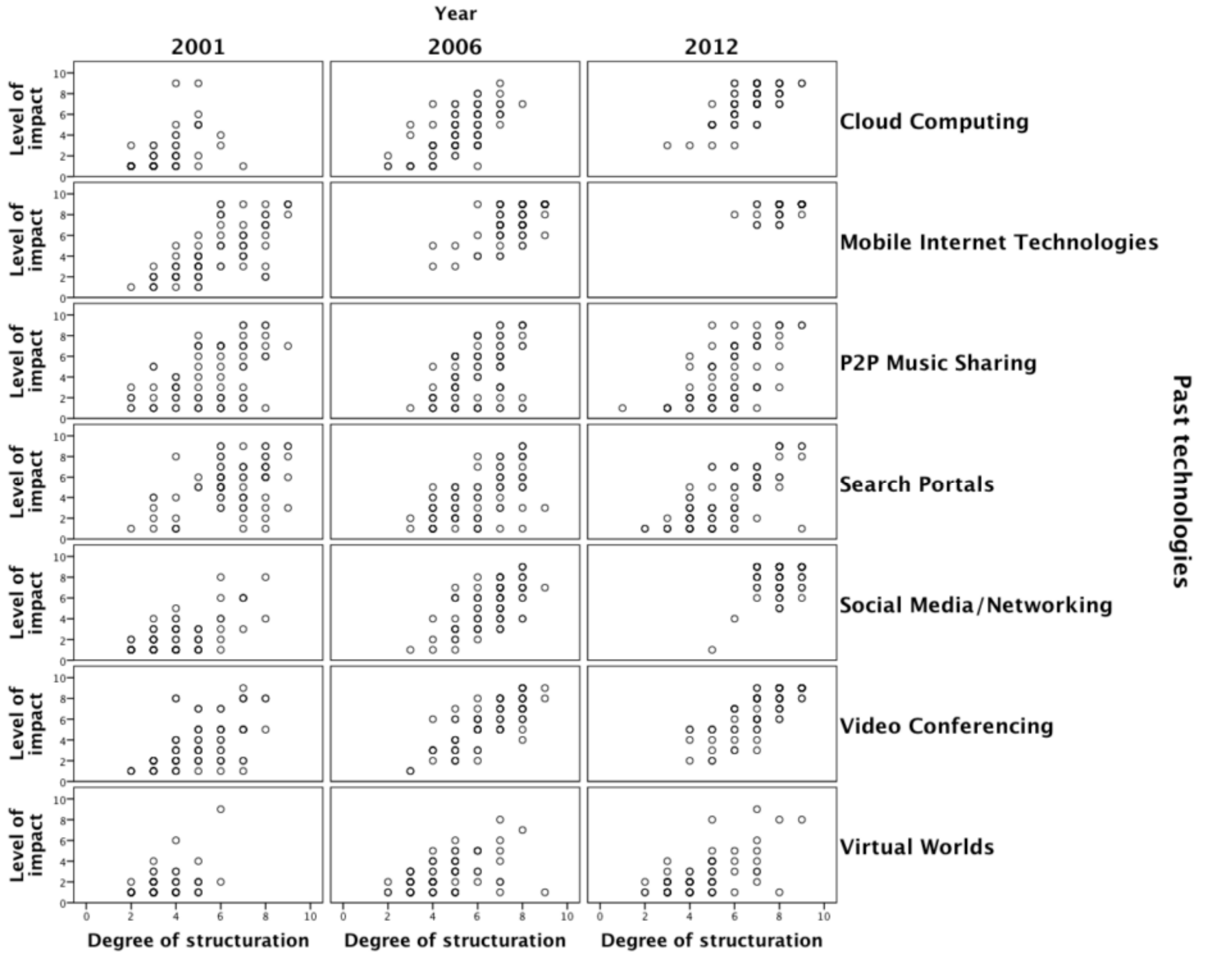
Paired Samples Statistics

Technology			Mean	N	Std. Deviation	Std. Error Mean
Cloud Computing	Pair 1	Degree_of_ structuration_2001	3.22	76	1.127	.129
		Degree_of_ structuration_2006	5.11	76	1.302	.149
	Pair 2	Degree_of_ structuration_2006	5.09	76	1.298	.149
		Degree_of_ structuration_2012	6.68	76	1.098	.126
	Pair 3	Degree_of_ structuration_2001	3.24	75	1.125	.130
		Degree_of_ structuration_2012	6.67	75	1.095	.126
Mobile Internet Technologies	Pair 1	Degree_of_ structuration_2001	5.69	77	1.786	.204
		Degree_of_ structuration_2006	7.58	77	1.092	.124
	Pair 2	Degree_of_ structuration_2006	7.58	77	1.092	.124
		Degree_of_ structuration_2012	8.44	77	.678	.077
	Pair 3	Degree_of_ structuration_2001	5.69	77	1.786	.204
		Degree_of_ structuration_2012	8.44	77	.678	.077
P2P Music Sharing	Pair 1	Degree_of_ structuration_2001	5.35	77	1.783	.203
		Degree_of_ structuration_2006	5.99	77	1.303	.148
	Pair 2	Degree_of_ structuration_2006	5.99	77	1.303	.148
		Degree_of_ structuration_2012	5.62	77	1.539	.175
	Pair 3	Degree_of_ structuration_2001	5.35	77	1.783	.203
		Degree_of_ structuration_2012	5.62	77	1.539	.175
Search Portals	Pair 1	Degree_of_ structuration_2001	6.34	77	1.635	.186
		Degree_of_ structuration_2006	5.92	77	1.537	.175
	Pair 2	Degree_of_ structuration_2006	5.92	77	1.537	.175
		Degree_of_ structuration_2012	5.53	77	1.721	.196
	Pair 3	Degree_of_ structuration_2001	6.34	77	1.635	.186
		Degree_of_ structuration_2012	5.53	77	1.721	.196
Social Media/Networking	Pair 1	Degree_of_ structuration_2001	4.00	77	1.522	.173
		Degree_of_ structuration_2006	6.53	77	1.187	.135
	Pair 2	Degree_of_ structuration_2006	6.53	77	1.187	.135
		Degree_of_ structuration_2012	8.01	77	.752	.086
	Pair 3	Degree_of_ structuration_2001	4.00	77	1.522	.173
		Degree_of_ structuration_2012	8.01	77	.752	.086
Video Conferencing	Pair 1	Degree_of_ structuration_2001	4.94	77	1.559	.178
		Degree_of_ structuration_2006	6.47	77	1.456	.166
	Pair 2	Degree_of_ structuration_2006	6.47	77	1.456	.166
		Degree_of_ structuration_2012	7.16	77	1.368	.156
	Pair 3	Degree_of_ structuration_2001	4.94	77	1.559	.178
		Degree_of_ structuration_2012	7.16	77	1.368	.156
Virtual Worlds	Pair 1	Degree_of_ structuration_2001	3.35	75	1.121	.129
		Degree_of_ structuration_2006	4.51	75	1.492	.172
	Pair 2	Degree_of_ structuration_2006	4.49	77	1.483	.169
		Degree_of_ structuration_2012	4.56	77	1.500	.171
	Pair 3	Degree_of_ structuration_2001	3.35	75	1.121	.129
		Degree_of_ structuration_2012	4.52	75	1.465	.169

Paired Samples Test

Technology			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
Cloud Computing	Pair 1	Degree_of_structuration_2001 - Degree_of_structuration_2006	-1.882	1.211	.139	-2.158	-1.605	-13.549	75	.000
	Pair 2	Degree_of_structuration_2006 - Degree_of_structuration_2012	-1.592	1.328	.152	-1.896	-1.289	-10.448	75	.000
	Pair 3	Degree_of_structuration_2001 - Degree_of_structuration_2012	-3.427	1.587	.183	-3.792	-3.062	-18.701	74	.000
Mobile Internet Technologies	Pair 1	Degree_of_structuration_2001 - Degree_of_structuration_2006	-1.896	1.401	.160	-2.214	-1.578	-11.876	76	.000
	Pair 2	Degree_of_structuration_2006 - Degree_of_structuration_2012	-.857	.914	.104	-1.064	-.650	-8.233	76	.000
	Pair 3	Degree_of_structuration_2001 - Degree_of_structuration_2012	-2.753	1.679	.191	-3.134	-2.372	-14.387	76	.000
P2P Music Sharing	Pair 1	Degree_of_structuration_2001 - Degree_of_structuration_2006	-.636	1.877	.214	-1.062	-.210	-2.975	76	.004
	Pair 2	Degree_of_structuration_2006 - Degree_of_structuration_2012	.364	1.157	.132	.101	.626	2.757	76	.007
	Pair 3	Degree_of_structuration_2001 - Degree_of_structuration_2012	-.273	2.004	.228	-.728	.182	-1.194	76	.236
Search Portals	Pair 1	Degree_of_structuration_2001 - Degree_of_structuration_2006	.416	1.866	.213	-.008	.839	1.954	76	.054
	Pair 2	Degree_of_structuration_2006 - Degree_of_structuration_2012	.390	1.237	.141	.109	.670	2.764	76	.007
	Pair 3	Degree_of_structuration_2001 - Degree_of_structuration_2012	.805	2.109	.240	.326	1.284	3.350	76	.001
Social Media/Networking	Pair 1	Degree_of_structuration_2001 - Degree_of_structuration_2006	-2.532	1.603	.183	-2.896	-2.169	-13.867	76	.000
	Pair 2	Degree_of_structuration_2006 - Degree_of_structuration_2012	-1.481	1.304	.149	-1.776	-1.185	-9.963	76	.000
	Pair 3	Degree_of_structuration_2001 - Degree_of_structuration_2012	-4.013	1.788	.204	-4.419	-3.607	-19.694	76	.000
Video Conferencing	Pair 1	Degree_of_structuration_2001 - Degree_of_structuration_2006	-1.532	1.501	.171	-1.873	-1.192	-8.960	76	.000
	Pair 2	Degree_of_structuration_2006 - Degree_of_structuration_2012	-.688	1.103	.126	-.939	-.438	-5.474	76	.000
	Pair 3	Degree_of_structuration_2001 - Degree_of_structuration_2012	-2.221	1.796	.205	-2.629	-1.813	-10.848	76	.000
Virtual Worlds	Pair 1	Degree_of_structuration_2001 - Degree_of_structuration_2006	-1.160	1.560	.180	-1.519	-.801	-6.440	74	.000
	Pair 2	Degree_of_structuration_2006 - Degree_of_structuration_2012	-.065	1.207	.138	-.339	.209	-.472	76	.638
	Pair 3	Degree_of_structuration_2001 - Degree_of_structuration_2012	-1.173	1.671	.193	-1.558	-.789	-6.079	74	.000

D.9 Scatter/Dot Graph Between Level of Impact and Degree of Structuration Grouping per Technology and Year



D.10 Descriptive Analyses of the Variance of Level of Impact and Degree of Structuration for "Mobile Internet Technologies" and "Social Media/Networking"

Descriptives

Descriptive Statistics

Past technologies	Year		N	Minimum	Maximum	Mean	Std. Deviation	Variance
Mobile Internet Technologies	2001	Level of impact	77	1	9	4.38	2.513	6.317
		Degree of structuration	77	2	9	5.69	1.786	3.191
		Valid N (listwise)	77					
	2006	Level of impact	77	3	9	7.32	1.642	2.696
		Degree of structuration	77	4	9	7.58	1.092	1.193
		Valid N (listwise)	77					
	2012	Level of impact	77	7	9	8.77	.560	.313
		Degree of structuration	77	6	9	8.44	.678	.460
		Valid N (listwise)	77					
Social Media/Networking	2001	Level of impact	77	1	8	2.29	1.661	2.759
		Degree of structuration	77	2	8	4.00	1.522	2.316
		Valid N (listwise)	77					
	2006	Level of impact	77	1	9	5.34	2.094	4.384
		Degree of structuration	77	3	9	6.53	1.187	1.410
		Valid N (listwise)	77					
	2012	Level of impact	77	1	9	7.97	1.469	2.157
		Degree of structuration	77	5	9	8.01	.752	.566
		Valid N (listwise)	77					

D.11 Test of Means of the Degree of Structuration Between Clusters of Individuals with High and Low Level of Awareness at the Technology Level

Technology		Test of means of the degree of structuration between clusters of individuals with high and low level of awareness		
		2001	2006	2012
Failed or dormant technologies	P2P Music Sharing	F = 48.340; df (75); p = 0.000	F = 7.368; df (75); p = 0.008	F = 12.453; df (75); p = 0.001
	Search Portals	F = 11.212; df (75); p = 0.001	F = 11.389; df (75); p = 0.001	F = 8.478; df (75); p = 0.005
	Virtual Worlds	F = 5.530; df (73); p = 0.021	F = 7.136; df (75); p = 0.009	F = 4.933; df (75); p = 0.029
Influential technologies	Cloud Computing	F = 16.106; df (73); p = 0.000	F = 38.321; df (75); p = 0.000	F = 12.107; df (74); p = 0.001
	Mobile Internet Technologies	F = 18.551; df (75); p = 0.000	F = 16.474; df (75); p = 0.000	Fewer than two groups
	Social Media/ Networking	F = 31.571; df (75); p = 0.000	F = 16.302; df (75); p = 0.000	F = 16.890; df (75); p = 0.000
	Video Conferencing	F = 18.117; df (75); p = 0.000	F = 19.378; df (75); p = 0.000	F = 6.645; df (75); p = 0.012

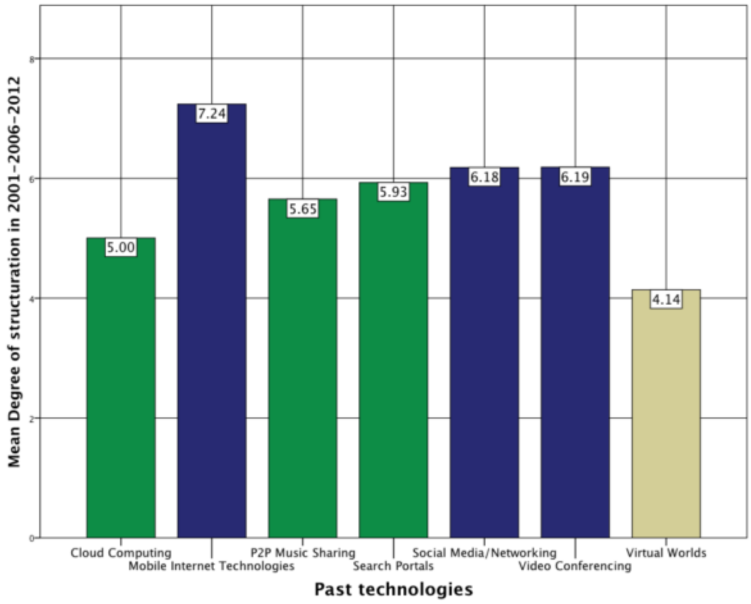
D.12 Correlations Between Degree of Structuration and Level of Engagement Comparing Different Time frames and Technologies

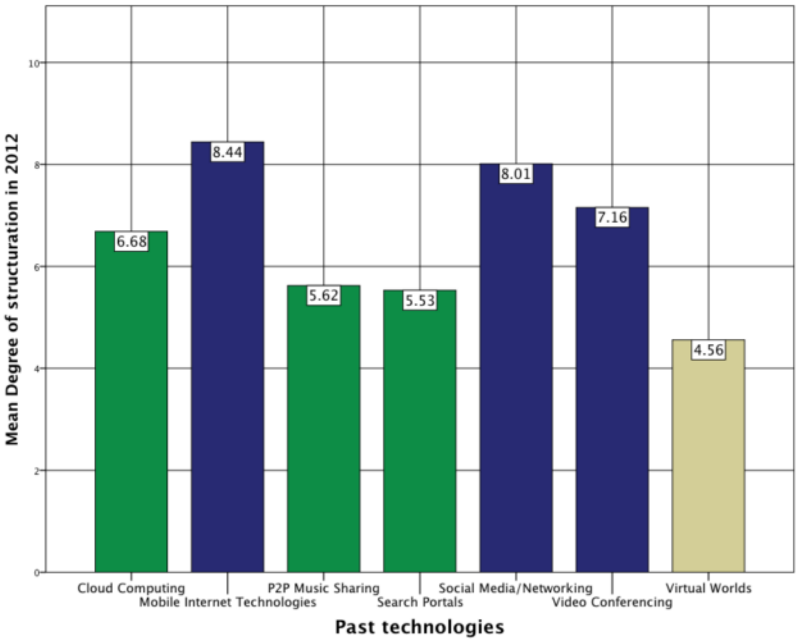
Technology	Time frame		
	2001	2006	2012
P2P Music Sharing	N=77 .310**	N=77 .239*	N=77 .267*
Search Portals	N=77 .094	N=77 .240*	N=77 .303**
Virtual Worlds	N=75 -.027	N=77 .062	N=77 -.026
Cloud Computing	N = 76 .330**	N=77 .426**	N=76 .294**
Mobile Internet Technologies	N=77 .267*	N=77 .165	N=77 .203
Social Media/ Networking	N=77 .062	N=77 -.165	N=77 .126
Video Conferencing	N=77 .120	N=77 .165	N=77 .132

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

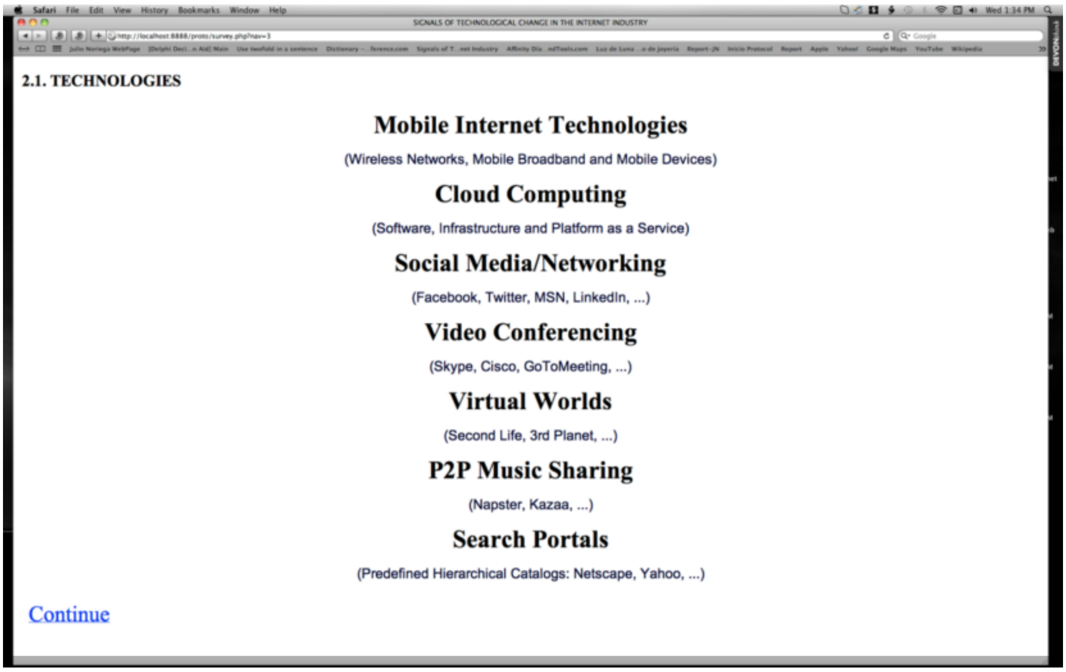
D.13 Bar Graph Describing Means of Degree of Structuration for Each Technology



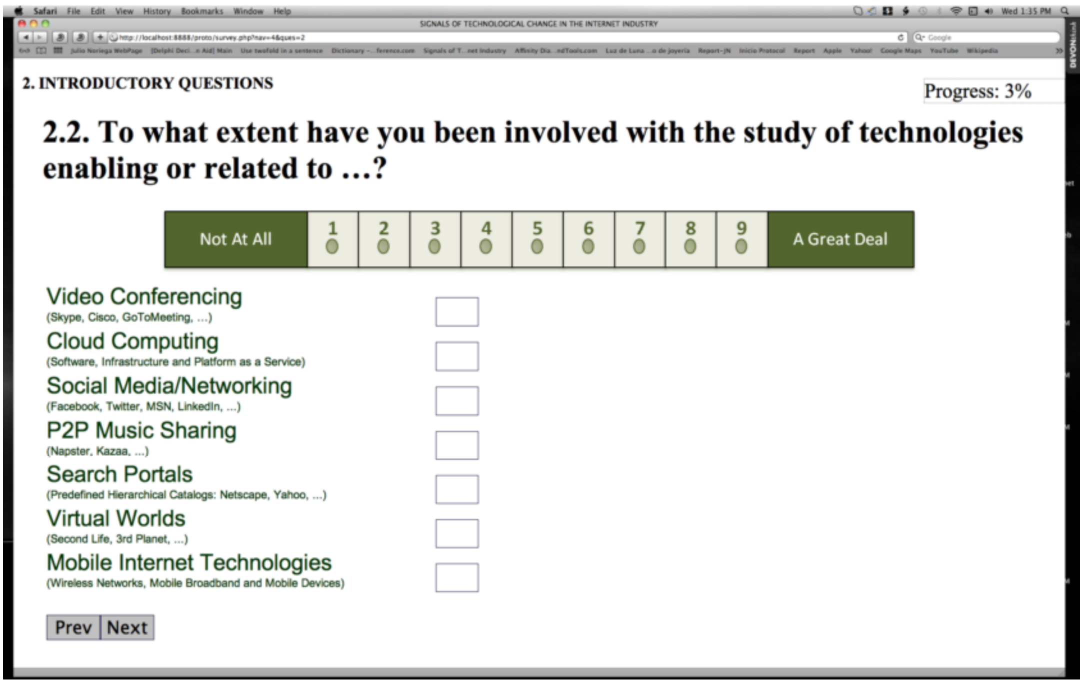


Appendix E Screen Captures from the Software Application

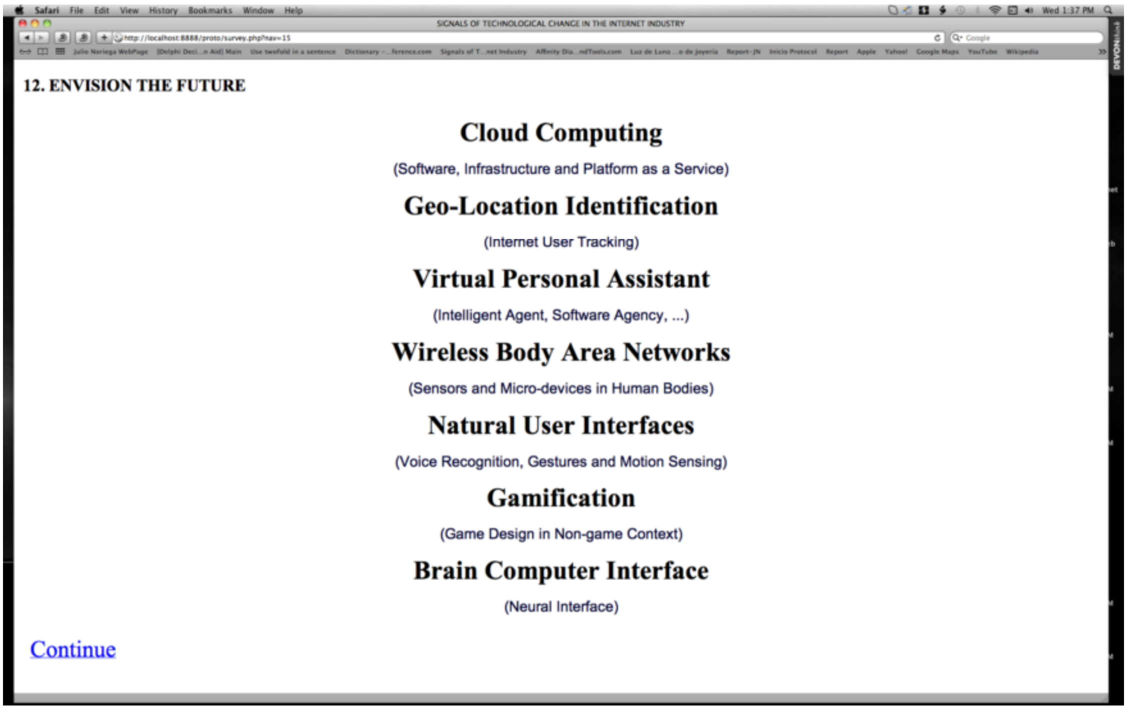
This screen capture from the software application shows the list of past Internet technologies that was used in the first section of the second-phase interview.



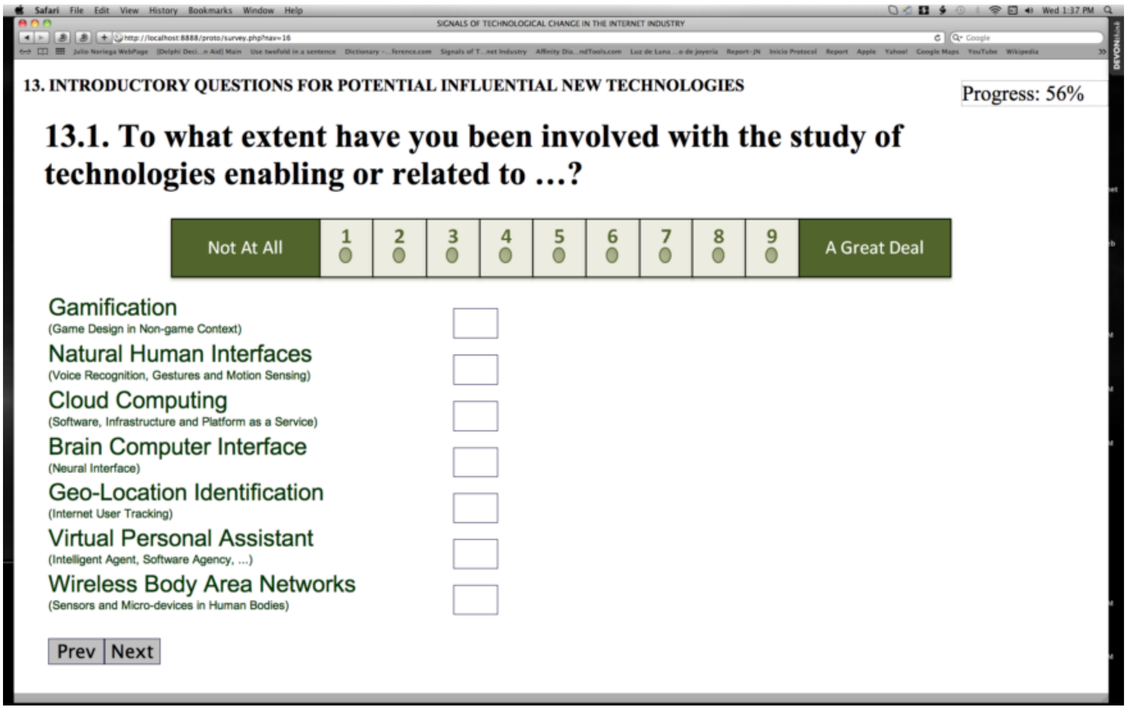
This screen capture from the software application shows an introductory question that was posted in the first section of the second-phase interview.



This screen capture from the software application shows the list of potential influential new Internet technologies that was used in the second section of the second-phase interview.



This screen capture from the software application shows an introductory question that was posted in the second section of the second-phase interview.



Appendix F Selected Potential Influential New Technologies

These definitions of potential influential new technologies in the next years emerge from participants' contributions in the first interview. This list is in alphabetical order and was used as part of the second interview protocol in order to establish the same level playing field for participants' responses.

Cloud Computing refers to using shared Internet-based computing resources, software and devices via web browsers operating on a range of terminals (desktops, laptops, tablets and smartphones).

Brain-computer or Neural Interface refers to a direct communication between user's brain and computing devices. Neural Interface uses electroencephalographic sensors analyzing neural patterns. Hence, it is a way to communicate with devices. Internal devices can be built into user's brain or external devices with electroencephalographic sensors can be worn.

Gamification refers to using game design techniques, game thinking and game mechanics in non-game contexts in order to increase the "fun" attribute in applications and to encourage users to engage, adopt and master websites and Internet infrastructures.

Geo-Location Identification refers to the set of technologies enabling the identification of who you are and where you are through your mobile device (e.g., Wi-Fi geo-location, geo-fencing and others). Effective geo-location identification technologies can enable highly personalized services and applications such as location-based searching, location-based retrieval, location-based personalized Internet marketing, as well as tracking Internet interactions, transactions and mobility of mobile Internet users.

Natural User Interfaces refer to technologies recognizing spoken commands, gestures, or facial cues in order to achieve experiences of easiness, speediness, naturalness and friendliness for users to control Internet-based systems.

Virtual Personal Assistant refers to a software system, an intelligent agent and information management tool that is able to conduct certain tasks on behalf of their users. It is largely self-directed and autonomous, and coordinates distributed resource anticipating user needs and wants. This software agency delivers information to a range of terminal devices (desktops, laptops, tablets and smartphones) via the Internet. Apple Siri and Watson IBM project are early initiatives of this future technology.

Wireless Body Area Networks **(Health Care Preventing Monitoring Technologies)** treat, monitor and prevent health-related problems by using wireless sensor technologies on human bodies. It enables real time analysis of biological signs such as heart rate pulse, blood oxygen levels and other health indicators.

Appendix G Emerging Forms and Tools for Identifying Future Technologies

The extant body of practitioner-oriented literature refers to six recent forms and tools that firms can use to identify technology-sensitive information related to their business. These tools claim to be systematic web-based initiatives able to provide information of upcoming trends and respond effectively to rapidly changing environments.

IBM's WebFountain

Menon and Tomkins (2004) and Gruhl, Chavet, Gibson, Meyer, Pattanayak, Tomkins and Zien (2004) describe an IBM project called "Web-Fountain" which is a powerful computational platform for very large-scale text analysis for structured and unstructured data. Web-Fountain depends on users' ability not only to formulate good questions but also to explore data interpretability. If users are able to articulate search queries using the right search terms and operating Web-Fountain wisely, the tools claims to help them to identify upcoming trends, business-related patterns, missing information in a given context, competitors' and users' expressions. According to Battelle (2004), Web-Fountain is not a consumer market application, and only large corporate clients connect, query, and develop applications. Thus, Web-Fountain functions as a middleware platform. Dow Jones Factiva, a provider of online business news and information, has used Web-Fountain among other technologies to provide evaluation of corporate reputation and other intelligence services.

SRI – Consulting Business Intelligence

Patton (Patton, 2005) describes an open intelligence system offered by SRI Consulting Business Intelligence (SRIC-BI). Monthly, and enabled by WEB, SRIC-BI employees from all levels and perspectives assemble more than 100 short abstracts describing signals of change, discontinuities, outliers, items defying conventional wisdom, inflection points, disruptive developments or technologies. Participants are researchers, analysts, technology intelligence experts, strategy consultants, marketing and sales staff from across the world. This paper by Patton describes two approaches from many by which SRIC-BI and organizations can gain understanding from this environmental scan: conceptual patterns within different abstracts and cross-category signs within groups of abstracts. SRIC-BI claims success as an early warning system, as a form of peripheral vision, as a process for increasing awareness, as an input to innovation process, and as a tool for strategic vision within organizations.

Tech Mining

Porter (2005) describes a quick technology intelligence process (QTIP) called "Tech Mining" by which managers in just minutes can powerfully improve the bases for MOT decisions. Tech Mining consists in applying text mining approaches to science and technology databases in order to draw out a set of predefined MOT indicators. The author proposes to develop standard output templates which show one-page visual information that profiles such key indicators for given emerging technologies (i.e. publications, patents, associated terms, creators, partners, competitors). Tech Mining is enabled by four factors: 1) instant access to science and technology databases (Science Citation Index, INSPEC, and Derwent World Patent Index); 2) use of analytical software (i.e. statistical analysis, trend analysis, and visual organization); 3) scripting routines of analytical process; and 4) the standardization of decision process (i.e. stage-gate tool).

Fountain Park

Ilmola and Kuusi (2006) propose a model which captures weak signals and challenges the structure of the organization as defined by influential mental models. Based on a web-tool facilitating signal collection, signal evaluation and signal analysis, organizational members anonymously provide their thoughts as narrative and situate others' contributions in a cognitive map. In this way, participants contrast collected signals with their existing mental models. Thus, organizations not only open their filters but also identify weak signals which are defined by contributions with high deviation and low average relevance. A final report shows the dominant perception of the surveyed group and the list of potential weak signals. Empirical evidence suggests that this process can enhance peripheral vision.

TechCast Method

Halal (2013; 2008; 2007) describes an online academic research tool called TechCast, and states that "TechCast is a learning system conducted by a community of practice to continually improve results and approach a scientific consensus". Enabled by the Web, a group of experts across the world assemble forecasts of breakthroughs in many fields of science and technology. These experts are taken through an online analysis and instructed to enter their estimations based on the best information available on each time. Forecasts are cyclically improved as new technologies arrive. Halal argues that TechCast approach is superior because, although it uses combined experts judgments through the Delphi method, experts' contributions are based on the best qualitative studies and solve the inherent uncertainty in such methods. TechCast has provided results over the last 15 years on multiple projects and its results have demonstrated forecast variations with an average error of +/- 3 years. TechCast subscriptions are offered to companies and include additional services (TechCast, 2009).

Coolhunting for Trends on the Web (TecFlow)

Gloor (2007) introduces a novel approach to search for trends and trendsetters on the Web. Arguing that the Web reveals a similar image to that of the real world, he describes how to apply two concepts of social network theory to find the most influential Web node in a particular subset of Web sites. The social network theory concepts are "betweenness centrality" and "degree of separation". Gloor's argument is based on the idea that "you are who links to you". So, using the "link" command from Google, trendhunters can build the linking structure of Web sites for a given topic with a given degrees of separations. Similarly, trendhunters can create additional linking structures for all their topics under evaluation. Thus, combining this multiple data set, the betweenness of each node can be calculated to find out which nodes are the most influential – the nodes with the highest betweenness centrality. Gloor provides empirical evidence of this approach and refers to TecFlow as a tool supporting this dynamic social network analysis.

Comparison Table

Tool and author(s)	Type of tool	Type of signal	Type of users	Level of interaction	Source of information	Searching perspective
Web Fountain IBM **(Menon & Tomkins, 2004)**	Platform	Specified by user	Large Corporations	Intensive	Users & The Internet	Inside-out & Outside-in
SRIC-BI **(Patton, 2005)**	Service	General Trends	Firms	Low	Experts	Outside-In
Tech Mining **(Porter A. L., 2005)**	Method	Emerging Technologies	Firms	Moderate	Firm User & Structured Databases	Inside-out & Outside-in
Fountain Park **(Ilmola & Kuusi, 2006)**	Method	General Trends	Firms	Moderate	Firm's Members	Inside-out
TechCast **(Halal, 2013; 2008; 2007)**	Service	Emerging Technologies	Firms and Industries	Low	Experts	Outside-in
Coolhunting **(Gloor, 2007)**	Method	Specified by user	Firms and Individuals	Intensive	Users & The Internet	Inside-out

Notes:

a) Type of tool refers to if the tool is a platform, a service or a method.
b) Type of signal refers to what pattern is going to be identified: specified by users, a general trend (social, political, economic, cultural, ecological and technological trend), and technology trend.
c) Level of interaction refers to the relationship between the user and the tool. Low implies an informative relationship. Moderate implies few encounters to guide the searching process. Intensive implies a high number of encounters to guide the searching process.
d) Source of information indicates from where the information is obtained.
e) Searching perspective indicates if the searching focuses on technological trends from company's existing areas (inside-out) or technological trends outside the company's existing areas (outside-in).

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