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# Environmental uncertainty, foresight and strategic decision making: An integrated study

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ABSTRACT

This paper explores how the foresight practices and techniques that might be used for coping with environmental uncertainty are coordinated throughout large corporations and how their results are used for supporting strategic decision making. Based on an in-depth and multiple study of several companies, we analyse the main characteristics of environmental uncertainty - complexity and dynamism - that shape companies' approaches to strategic foresight and uncertainty management. We explore the impact of growing complexity and dynamism on these approaches and the role of prediction and control in their design and implementation. We outline a conceptual framework for strategic foresight activities - and their relationships with decision making under uncertainty - as a planned learning process about the future which enables managers not to know opportunities and threats in advance, but to detect them more promptly and to react more effectively as soon as they start emerging.



## 1. Introduction

Uncertainty is a key issue for strategic decision makers in charge of sustaining the advantage of the firm over time [1]. Since the early 1970s the investigation of the likely evolution of the business environment has been regarded as a relevant area of management research. A survey of US companies revealed that in the late 1970s and the early 1980s almost half the US Fortune 1000 industrial companies were using techniques like scenario planning in their decision-making processes; European firms followed a similar pattern [2,3]. The wide interest in future studies seems to be confirmed by their growing number in both the private and the public sectors [4,5]. Today the terms "Foresight" and "Strategic Foresight" have become commonly used to encompass the wide range of approaches and activities which underlie future studies and aim at supporting long range planning [6,7].

Despite the intense interest and debate over uncertainty and foresight, we know little about the formal systems (i.e., the overall methodological and organizational frameworks) through which companies coordinate their foresight efforts and activities [8,9].[1] We can define such systems as "Foresight Systems". The goal of this paper is twofold: first, to investigate foresight systems in corporate organizations; second, to examine how the results are concretely used in strategic decision making.

Our research is based on a multiple-case study of major companies that operate in different industries and thus have to face different environmental conditions. These firms are Royal Dutch Shell (Shell in the paper) in the oil industry, Nokia in mobile communication, BASF in chemicals, Philips in consumer electronics. These firms provide compelling examples since they have been engaged in foresight activities over many years and thus have progressively designed and refined their foresight systems.

This paper contributes to literature on foresight and strategic management in three ways. First, it provides descriptive data and empirical evidence about the foresight systems that were used by some of the world's largest and most influential companies

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[1] A remarkable exception are contributions on Shell by previous scholars: see Cornelius, Van de Putte and Romani [8], and Davis [9]. We build upon this work by investigating further the case of Shell and by comparing it with other relevant firms. Most of all, we deepen the investigation of how the results of foresight practices and techniques are concretely used in strategic decision making and thus affect the long term performance of the organization.

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throughout the 2000s for coping with increasing uncertainty. Second, it sheds light on the role of foresight practices and techniques in strategic decision making. Third, it addresses the long-running debate between the *planning* and *adaptive schools* of strategic management, and the roles of *prediction* and *control* in strategy formulation.

## 2. Environmental uncertainty and strategic decision making: theory and practice

The concept of 'uncertainty' has been central in the literature on strategy and organization. Early conceptualizations go back to fundamental management scholars like Knight, Barnard, and March and Simon, who argued that firms' business environments are inherently unstable [10–12]. This instability creates uncertainty for rationally bounded managers, since information about external changes is intrinsically difficult to collect, process and comprehend fully. More specifically, uncertainty arises when managers do not feel confident that they understand what the major events or changes in their business are and when they feel unable to predict something accurately [13–15].

Strategic management literature defines the micro environment and the macro environment, by distinguishing sectors with which the firm has direct contacts and which directly affect its business strategy from sectors that affect the firm indirectly [16]. The micro environment is made up of competitors, customers, suppliers, potential incomers, substitute products and providers of complementary products [17]. The macro environment is made up of the political, economic, ecological, societal and technological landscapes (PEEST) which surround the business micro environment.

### 2.1. Strategic management theories: the roles of prediction and control

Studies in the strategic management of environmental uncertainty have developed around two fundamental theoretical frameworks. On one hand, the *planning school* argues that, as uncertainty increases, organizations that work more diligently to predict changes in their environments accurately will outperform those that do not. Relevant empirical studies support this notion [18,19]. This approach therefore emphasizes the importance of systematic analysis and integrative planning, and discipline in the scanning of trends, the generation of alternatives and forecasts, the rational evaluation of information and its integration into the firm's existing operations: these are the hallmarks of the planning school [20,21]. According to this approach, scholars recognize that predictions might not be perfect because they are obviously difficult; however, predictions represent the best way of remaining aligned with a changing environment. In contrast, the *adaptive school* prescribes avoiding prediction as much as possible, but focussing rather on responding to change events as they emerge, and so emphasizes continuous experimentation and fast adaptation to changing environments. This strand suggests firms learn what to do next by minimizing the use of predictive rationality, and by experimenting instead so as to be able to move quickly to capture emerging opportunities. It advocates using purely adaptive approaches which avoid trying to define future changes and events, and seek instead to position the firm to make timely responses to *actual* events and changes [22,23].

Both planning and adaptive strategies basically assume that the key elements of the business environment are exogenous to the organization's own efforts. Under this assumption, positioning resulting either from prediction or from quick adaptation turns out to be the only viable ways for organizations to optimise their performances. However, influential scholars have more recently relaxed the assumption of exogeneity, emphasizing the organizations' ability to be active in shaping the development of some of their environmental elements (e.g., technological standards, customer preferences). Under this (endogeneity) assumption, the firm may do something other - something more -than simply positioning itself in its environment: it may actually try to push its evolution toward a more favourable structure. Some scholars therefore argue that a new dimension – beyond mere prediction - has to be considered to fully understand an organization's viable responses to environmental uncertainty: the dimension of *control* [24]. Control measures the level of *influence* an organization can have on the components of its environment, and thus the degree to which they can be endogenous to its own efforts.[2]

Thus, two further approaches to the strategic management of environmental uncertainty were identified: the *visionary* and the *transformative*. The visionary approach embodies the notion of 'heroic' insightful and entrepreneurial actions. This type of approach has strong connections with the planning school, and envisages the organization as building its environment by imagining future possibilities and working proactively to bring them to fruition. The essence of the vision is to set inspiring goals so as to create and to colonize new spaces in the environment [25,26]. Prominent scholars like Hamel and Prahalad (1994) emphasize the ability of the (major) companies to play an active role in influencing the development of their business. In contrast, the transformative approach has strong connections with the adaptive school, suggesting that firms should not focus their efforts into prediction, but rather on co-creating goals with other business ecosystem players in mutually supportive processes where action often precedes clear and predictable outcomes [27,28].

On the basis of the higher or lower levels of these dimensions – prediction and control - it is possible to derive the taxonomy represented in Fig. 1, which summarizes the main strategic management approaches to dealing with uncertainty [24].

### 2.2. Management practices and techniques

In the vein of the planning school, specific foresight tools and practices have been developed for improving predictions and informing major investments decisions under uncertainty. Overall, these tools and practices encompass two main tasks. The first

[2] It is worth stressing that the notion of "control" – which emphasizes the capability of the organization to influence, to a certain extent, the evolution of drivers of change - relates only to large companies, but not to public institutions.

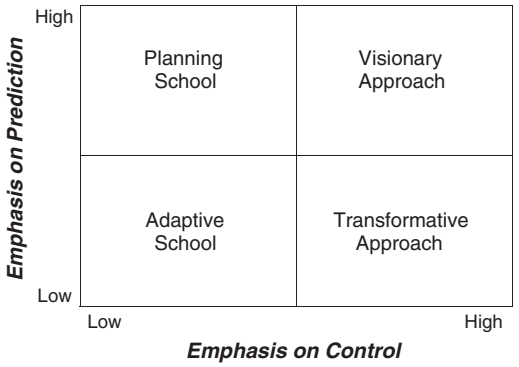


**Fig. 1.** Strategic management of environmental uncertainty: Framework of prediction and control.

concerns 'environmental scanning' and the detection of new events and drivers of change [29–31]. The second one concerns the investigation of divers of change in relation to their likely evolution, their consequences on the organization, and the most suitable responses. The most popular techniques for performing such investigation are roadmaps, scenarios, and real options. Roadmaps consist of representations as interconnected nodes of major changes and events in some selected fields of the external environment, like science, technology, and markets. The links connecting the nodes are the roadmaps themselves, illustrating the temporal and causal relationships between nodes [32–34]. Scenarios are focused descriptions of fundamentally different futures presented in a coherent script-like or narrative fashion: they represent credible and coherent stories that describe different paths leading to alternative futures [35–39]. Real options correspond to the application of financial options theory to investment decisions on real assets. The real options approach emphasizes that many initial investments (for example market tests, joint ventures, or operating licenses) create relevant follow-on opportunities which give the firm the right, but not the obligation, to make further investments [40,41]. Other common techniques are Delphi, simulation modeling and systems dynamics, and game theory [42–44].

However, foresight practices and tools for coping with uncertainty had uneven success [45]. In the vein of the learning school, criticisms have addressed the theoretical foundations themselves of strategic foresight, by pointing to the impossibility of making reliable predictions. While relatively accurate in the short term, in the medium and long term forecasting accuracy begins to diminish as political, economic, social and technological drivers of change interact in novel ways and environmental uncertainty increases [46]. Prominent scholars supported the idea that "*prediction is not a worthwhile managerial activity*" [47] and emphasized strategic agility and flexibility [48,49].

Our multiple-case study research aims at contributing to debate over the merits of the foresight practices and techniques that might be used for coping with uncertainty, thus helping managers decide if and how they should invest their time and efforts in such practices and tools. First of all, we illustrate the formal systems – 'foresight systems' - through which some of the world's largest and most influential companies coordinated foresight efforts and activities (practices and techniques) throughout their organization during the 2000s. Second, we explore how business executives concretely used the results of foresight in decision making processes, and how (and to what extent) such use was consistent either with the principles of the planning school or the adaptive school, or either with the visionary approach or the transformative approach. As we position foresight systems in Fig. 1, we try to shed light on their role and contribution to the performance of the organization.

## 3. Research method

We based our research on a set of explorative case studies of major firms that have engaged in foresight activities over considerable periods. We adopted the case study methodology for two reasons: first, the lack of theory in literature relating to the design and functions of foresight systems, and second because our goal was to gather descriptive data on foresight practices and their adaptation to growing uncertainty. Given the gap in the extant literature and the open-ended nature of our questions, we felt this would be the most useful methodological approach [50,51]. The firms we investigated are Shell, Nokia, Philips, BASF (see Table 1), all of whom had carefully designed and gradually improved their foresight systems in order to handle increased uncertainty in their business environment, while seeking ways to best match them with their strategy formulation processes. In particular, we focused on the 2000s decade as the main time horizon of our study.

**Table 1**
Overview of Case Studies.

| Firm | Business | Foresight system started |
|---|---|---|
| BASF | Chemicals | Mid 1990s |
| Nokia | Mobile Communication | Early 2000s |
| Philips | Consumer Electronics (Healthcare, Lighting) | Early 1990s |
| Shell | Oil (Energy) | Late 1960s |

Despite major drivers of change in their environments, all these firms were able to sustain their performance. (Nokia in particular achieved remarkable results throughout the 2000s. However, in 2010 the company suffered a decrease in market share and profits – notwithstanding it remained the market leader. This was basically due to the rise of new competitors like Apple and Google, that entered from the PC industry in order to exploit the boom of Internet services and applications on mobile –smartphone- devices.[3] The boom of mobile Internet represented a major shift in the mobile communication industry and a major discontinuity for traditional mobile phone manufacturers, in terms of resources and competences – first of all in software. For this reason in 2011 Nokia partnered with Microsoft in order to build a mobile ecosystem able to compete with the Apple's and Google's ones.)

We adopted a twofold unit of analysis. We examined the historical evolution of each firm's industry over in the last two decades, and the nature of the main drivers of change that have affected its business micro and macro environments. Contextually, we also analysed each individual firm's foresight system, focusing on the specific characteristics of the business environment and environmental uncertainty that had shaped those systems, and their appropriateness.

Data were collected from a combination of different sources through an iterative process, beginning with publicly available data on the selected firms and their industries, including historical annual reports, financial analyst reports, conference presentations by top managers, articles and prior studies in the business press and scientific journals. Company archives (internal memos and technical papers, etc.) supplemented this publicly available data, and (in the case of Shell in particular) we were greatly aided by the work of other scholars and practitioners [52–56]. Finally, we interviewed a sample of senior and mid-level managers - specifically, the heads of the case-firms' foresight units, but also external consultants and managers (from academia or from partnering organizations) - involved in their foresight processes. Data collection and analysis used traditional inductive research approaches, and were highly iterative [50,51]. Analysis began with detailed written accounts and schematic representations of the evolution of each industry and the development of the firms' foresight systems. After building the case histories our early constructs were developed based on within-case analyses, after which cross-case analysis and theory triangulation with different bodies of strategic management literature on environmental uncertainty, foresight and strategy formulation contributed to our final conceptual framework.

## 4. Structural dimensions of environmental uncertainty

The different nature of drivers of change in their business environments had led our sample companies to develop very different foresight systems. Thus, we can group the firms into two clusters on the basis of the *main determinant* of their uncertainty: complexity, in the cases of Shell and BASF (oil and chemicals); or dynamism, in the cases of Nokia and Philips (mobile communication and consumer electronics). The identification and analysis of dynamism and complexity as the main determinants of uncertainty draws on previous scholars in literature on strategy and organization [13–15]. Of course, we do not mean that Shell's and BASF's industries are not dynamic industries at all, nor that Nokia's and Philip's industries are not complex as well. We mean instead that, throughout the 2000s, either complexity or dynamism was the prevalent issue of concern for the strategic decision makers of each firm, which drove the development of its foresight system.

Complexity in the oil industry and chemical industry results from: i) heterogeneity of drivers of change and new events in the business environment; ii) the relationships and mutual influences among drivers of change, and the relationships of each driver with a large number of components of the micro and macro environments; iii) the low rate of evolution of drivers of change. More generally, the more heterogeneous the drivers of change are, the longer their development time and the more tightly they are linked (that is, the more they influence each other reciprocally), the higher the complexity of the business environment will be.

In contrast, dynamism in the mobile communication industry and the consumer electronics industry is the result of: i) the frequency of the rise of new and disruptive drivers of change; ii) the speed of the evolution of these drivers. More generally, the more frequently disruptive drivers of change emerge, and the faster their development, the higher the dynamism of the business environment will be.

In particular, the most significant difference in the kinds of environmental uncertainty faced by our case companies concerned the disruptive power of drivers of change. On the one hand, the oil and chemical industries featured a large number of drivers of change that led to incremental (rather than disruptive) developments in the value chain and the business models of incumbent firms, and thus in their main kinds of activities and products[4] [57,58]. On the other hand, the mobile communication and the consumer electronics industries featured key drivers of change that were relatively low in number but which caused deep discontinuities. These drivers had disruptive effects on the business models of incumbent firms and led to completely new kinds of products, players and activities in the value chain. The boundaries themselves of the industry underwent significant shifts. Table 2 compares the structural dimensions of complexity and dynamism in our sample industries.

### *4.1. High complexity in the business environment: the cases of Oil and chemicals*

Complexity is typical of mature global industries where trajectories of technologies and customer needs are well-established and companies compete for market share at the international level: the situation of the oil and chemical industries (and thus of

[3] The term "Smartphone" is today commonly used to refer to mobile phones that offer advanced computing ability and connectivity, allowing users to install and run more advanced applications. Smartphones thus run complete operating system software providing a platform for application developers: the broad set of software companies creating programs for a given operating system makes up its "ecosystem".

[4] The business model of the firm defines the manner by which it creates and delivers value to customers, entices customers to pay for value, and converts those payments to profit.

**Table 2**
Defining complexity and dynamism: main dimensions and comparative analysis of sample industries.

| | Heterogeneity of drivers of change | No. of relevant drivers | Disruptive power of drivers | Relationships between drivers | Frequency of rise of new drivers | Pace of evolution of drivers |
|---|---|---|---|---|---|---|
| Oil and chemicals: *prevalence* of complexity | High | High | Low | High | Low | Low |
| Mobile communication and consumer electronics: *prevalence* of dynamism | Low | Low | High | Low | High | High |

Shell and BASF). The boundaries between the micro and macro environments are blurred in these industries; the huge number of drivers of change in their PEEST landscapes, their strong mutual influences and the slow overall pace of evolution have contributed to markedly increased complexity.

In the oil industry, the main drivers of change over the last three decades have been: the growing coordination between the supplier countries (OPEC - the Organization of Petroleum Exporting Countries); the rise of state-owned companies (such as Saudi Aramco, Kuwait Oil, Petroleos de Venezuela); the collapse of the Soviet Union; the two Iraqi wars; nationalism in Russia and Venezuela; economic growth in emerging countries (Brazil, Russia, India, and China - BRIC); ecological concerns; the economic recessions of the 1980s and the recent financial crisis. As a result, new sources of competition came to fore. The power of suppliers (OPEC) increased and the dominance of the oligopoly of the original international majors (the 'Seven Sisters') was broken. By the 1990s the list of the top 20 global oil and gas producers was dominated by state-owned companies. Market transactions for crude oil and refinery products became increasingly important, while macro economic and political cycles made prices much more volatile. BRIC countries led the growth of global demand for energy, but renewable sources (solar, wind, geothermal, etc.) gradually increased their share in global consumption, due also to the evolution of government legislation (e.g. in US and EU). However, the boundaries of the industry were relatively stable: the main kinds of products and activities in the value chain did not go through deep discontinuities, and the kinds of suppliers (e.g., oil producing countries), customers (e.g., car users), and substitute products (e.g., renewable sources) were basically the same.

The case of the chemical industry is very similar. Its structure derives from an as yet uncompleted consolidation process, with the rise of new competitors in Asia, Middle East and Eastern Europe that entered the market in the last decade producing reliable, good-quality commodities at low cost. Since the 1990s the demand in chemicals has been characterized by low growth and considerable cyclicality (which is likely to increase in the near future). Capacity cannot be adjusted easily, so there is a constant danger of over capacity. The industry has also been exposed to rising raw material prices, steep rises in energy costs, growing ecological concerns and stricter environmental rules – while, at the same time, the rapid development of ICT tools has made the market far more transparent, increasing the pressure to optimise commodity production.

### *4.2. High dynamism in the business environment: the cases of mobile communication and consumer electronics*

Dynamism is typical of emerging industries and more generally of industries where technology is the main driving force and new customer needs rise to the fore. This is the case of mobile communication and consumer electronics, the contexts of Nokia and Philips.

Let's consider the mobile communication industry. In the early 2000s, the establishment of 2.5 G and 3 G technologies and technological advances in hardware and software prompted the convergence of some traditional mobile voice communication, Internet, information technology, media, entertainment, music and consumer electronics sectors into one, broader industry. This led to the creation of new devices, features and services, and to different concepts of mobile phone use, resulting in completely new market segments and market players. In particular, digital imaging, music, game, and micropayment technologies have turned mobile phones into a combination of a camera, an iPod, a PlayStation and even a credit card, while high speed Internet access is enabling more and more varied services in terms of content and performance, such as watching football matches team or finding your way via satellite navigation mapping. Thus, not only new sources of competition came to the fore, but the key activities of the value chain and components of the industry radically changed. That's the case in particular of direct competitors (e.g., PC makers like Apple and Acer, providers of operation systems like Microsoft and Google) and suppliers (e.g., providers of software applications, providers of multimedia contents and services).

The consumer electronics case is very similar. Let's consider display and large-screen TV segment: the last decade has seen major market launches of such new technologies as Liquid Cristal Display (LCD), Plasma Display Panel (PDP), Surface Induction Electron display (SED), Organic Electroluminescent (EL) and Liquid-Crystal-on-silicon (LCOS). New applications and consumption opportunities have become ever-more widespread – digital pictures and videos, Internet, pay-TV, sport events, home cinema and movie on-demand, game consoles and 3D and interactive games, each requiring specific product features in terms of resolution graphics, colours brightness and image definition.

## 5. Complexity, dynamism, and foresight systems

The prevalence of either complexity or dynamism as the main determinant of environmental uncertainty has strong implications. In order to face growing complexity, Shell and BASF developed and refined scenario-based management systems

which provided all the organizational units with an organic background of knowledge and helped integrate the strategy formulation process at corporate, business and operational levels. Efforts for coping with uncertainty are framed around a "horizontal dimension" of analysis, which encompasses all the main drivers of change and explores their mutual connections and influences. These efforts consist in a long and complex process, reflecting the complexity of the business environment: time horizons are usually 15–20 years or even longer, according to the payback period of these firms' substantial capital investments.

On the other hand, in order to keep the pace with growing dynamism, Nokia and Philips developed completely different foresight systems which basically aim at: i) identifying trends and disruptive drivers of change to strategy formulation; ii) acting as a tool for identifying new business opportunities and driving organizational renewal. The overall methodological and organizational framework is framed around a "vertical dimension", which focuses on the impact of some selected drivers and aims at exploiting the new market opportunities they might open up. In these companies, the foresight system is quick and flexible, in order to match the pace of change of the environment and to act on these changes in a timely manner: time horizons are typically no longer than 5–10 years. Table 3 summarizes our main findings on the relationships between complexity, dynamism and the foresight systems of large corporate organizations.

### *5.1. Coping with business environment complexity*

#### *5.1.1. Practices, techniques, and foresight systems*

Again starting with the oil industry we consider the case of Shell. The company first began making significant use of scenarios in 1972: of the six scenarios built then, one suggested that disruptions of oil supply could result in a sharp rise in prices, thus anticipating the oil crisis that took place only a year later. Scenarios were adopted widely throughout the company shortly afterwards, and have gradually evolved (over almost four decades) in terms both of their scope and how they are used. The initial focus in the 1970s - on the key variables relevant to the business, namely energy demand and oil prices - has widened to include the effects of economic and political events and trends. In the 1980s deeper analysis of social and environmental (ecological) changes was added, so that by 1987 Shell's scenarios filled three separate volumes on oil, energy and the macro trends in the PEEST landscapes.

The core elements of Shell's foresight system today are its 'global scenarios', which address the energy industry as a whole and holistically encompass international level changes in politics, economy, society, ecology, technology and demographics. The Shell global scenarios to 2050 (released in 2008) described two possible worlds, where the political and social choices made by governmental authorities interact strongly to shape energy demand and supply and the effects on the physical environment (Shell International BV, 2008). Thus, the 'Scramble' scenario saw national governments struggle to secure their own energy supplies, while the 'Blueprints' scenario foresaw new action plans emerging from coalitions between various layers of societies and governments (ranging from local to international) to respond to the challenges of economic development, energy security and environmental pollution in the perspective of sustainable growth. The previous Shell global scenarios (to 2025), considered the legal environment, the market culture and the forces of integration and fragmentation as key drivers of change, and described how these factors could stimulate national societies and the global community to strive towards the objectives of efficiency, social justice and security. Shell's global scenarios not only provide qualitative descriptions of the major macro environmental forces likely to affect the energy industry, but also aim at quantifying the impact of these forces on economic growth and the demand for energy, by outlining different GDP rates and different mixes of energy sources in each global scenario. A wide range of more detailed 'focused scenarios' (derived from global scenarios) are then built for each energy industry business area and each geographic area where Shell operates. Here, the macro drivers of change in the PEEST landscapes are combined with more specific market issues regarding the strategic behaviour of Shell's competitors, suppliers and customers, so that implications can be drawn from the global scenarios at business and country levels. Finally, the likely impact of global and focused scenarios on specific investment projects is figured out in 'project scenarios', which gather and process more detailed information on competitors, price, profitability, technical and managerial risks. Global scenarios are built every three or two years and have 20–30 year time

**Table 3**
Foresight systems in corporate organizations: the impact of complexity and dynamism.

| | Complexity | Dynamism |
|---|---|---|
| Organizational process/methodological framework | Focus on the PEEST landscapes (macro environment); Complex and hierarchical scenario-based framework; Real options; 'Complex' (articulated) output; Long duration of the overall process; Horizontal dimension of analysis (focus on relationships between drivers); 20-30 year time horizon | Focus on technology and customer needs (micro-environment); Flexible framework (selection of a low number of most relevant drivers, Roadmaps); 'Simple' (synthetic) output; Short duration of the overall process; Vertical dimension of analysis (focus on in-depth investigation of selected drivers); 5-10 year time horizon |
| Integration of results in strategic decision making | Strategic options; Exploration of drivers of change; Preparing for alternative paths of evolution of drivers of change | Venture activities/strategic initiatives; Exploitation of drivers of change; Fostering early action/commitment on drivers of change |

horizons: focused and project scenarios have shorter time horizons, to match the schedule of strategic planning at business and project levels.

BASF's efforts for coping with uncertainty are also framed around scenarios, which are built via a top-down process that starts at corporate level, first taking into account the global economy and the overall chemical industry, and subsequently elaborating regional and business scenarios in relation to each specific geographic and business area of the firm and its investment projects. Systemic use of scenarios at BASF began in the mid 1990s, when the company realized that the chemical industry was facing major structural changes which made accurate and reliable predictions impossible. It therefore decided to use scenarios as its basic methodology for tackling the challenge of investigating the major driving forces and how they might affect the chemical industry. Macro forces and their likely evolution are described in BASF's 'Global Economy Scenarios', where econometric models elaborate basic data in both qualitative and quantitative terms, and likely GDP growth rates are depicted. All the company main customer industries – the manufacturing, agriculture and construction industries - are included, so that conclusions can be drawn about the resulting demand for chemical products and about the overall industry's internal adaptation, in terms of consolidation, mergers and acquisitions, divestments etc. Subsequent efforts address specific regions (EU, US, Asia) and countries, by breaking down global scenarios into the firm's main sectors and business areas, i.e. chemicals, plastics, performance products, functional solutions, agricultural solutions, oil and gas. These country and business scenarios derive from a more focused analysis, which considers a larger set of framework variables, such as national regulations or exchange rates, and market issues, such as actions by suppliers and established competitors. The time frame is usually 10–15 years for global scenarios, but much shorter for sector and business scenarios.

*5.1.2. Use of results in strategic decision making*

Shell global scenarios are designed for supporting corporate level strategic decision makers, by anticipating shifts in the global energy mix and thereby informing the company's upstream and downstream investment decisions. The Executive Committee of the company outlined several key decisions regarding its activity portfolio based on these scenarios: for instance, more capital spending on exploration and production of oil and gas, a rising share of natural gas and of non-conventional oil. At the business level, the strategic funnel is narrowed in order to define the competitive advantages to be pursued in each market segment, while (at the lowest level) project scenarios support specific investment decisions. Over time scenarios have been combined with other tools such as real options, to become an integral part of strategic planning at all decision-making levels. Scenarios contribute to real options in three fundamental ways: they help identify real options; they provide a framework for evaluating real options; and they help time the decision to exercise real options. In particular, every organizational unit has to demonstrate the robustness of a proposed investment not only against the project scenarios, but also the global and focused ones, so that investment projects proposals are taken up again at corporate level and evaluated against each other from the portfolio viewpoint.

An example that illustrates this use of scenarios and real options clearly concerns the decision about an investment project in an oil and gas field in Sakhalin (Far East Russia) begun by Shell in the mid 1990s. Some of the most relevant global scenarios indications highlighted the rise of the overall worldwide demand for energy – especially in Asia, and the deepening concerns about ecological sustainability, which implied that the demand for natural gas was expected to grow quickly, leading to the search for new sources. Country focused scenarios were developed, taking into account both long term trends and changes in the political situation of different producing countries (as potential suppliers), and in economic growth in neighbouring countries (as potential customers). Finally different investment project options were selected and assessed against local regulations, ecological concerns, financial and technical constraints (e.g., difficulties of building a pipeline, of liquefying and shipping natural gas due to the seismic activity and morphological conditions of the natural environment) as well as through the lenses of both the underlying global and focused scenarios. At the end of this process Sakhalin was chosen. The project, named 'Sakhalin II', involved the development of two oil and gas fields: the Piltun-Astokhskoe and Lunskoe. Shell established the Sakhalin Energy Investment Company (SEIC), gaining a stake of 55%. In June 1994 SEIC signed with the Russian Government the commercial contract (production-sharing agreement, PSA) which governed Sakhalin II and soon started the first phase, concerning the Piltun-Astokhskoe field. The development of the Lunskoe field, that was the major one and represented the very reason for the existence of the SEIC, started in 2003, involving investments for an expected worth of $10 billion. Sakhalin II thus represented the single largest investment decision in Shell's history. However, at that time the company had gained new information regarding the technical issues of the project and had already signed commercial contracts for a significant share of the expected output with target customers in Far East Asia.

In the same way scenarios are seamlessly embedded in the strategy formulation process at BASF, as they are seen as providing information inputs essential for assessing the profitability of current and emerging business areas, and for assessing investment (and divestment) decisions for expanding (or downsizing) operations in the firm's main business and geographic areas. Scenarios are usually combined with the real options. A notable recent corporate-level example has been the decision to withdraw from the pharmaceutical industry. Notwithstanding the positive outlook of both demography and demand growth, the analysis of the future evolution of the business highlighted increasing operating costs due to social and political concerns, as well as the likelihood of strong pressure to reduce prices to consumers, undermining general profitability levels. Future pharmaceutical R&D activities also promised to require huge investments, meaning resources had to be shifted from other, more attractive, business areas.

At business and operational levels, scenarios support the definition of target features for enhancing products and services, as macro trends in the global environment are translated down into priorities for action in specific innovation fields. For instance, in the performance products and construction sectors, macro trends of increasing pressure on cost saving, environmental concerns and growing urbanisation has led the firm to boost product development in the thermal insulation, glazing and heat storage fields.

### 5.2. Coping with business environment dynamism

#### 5.2.1. Practices, techniques, and foresight systems

Nokia has started adopting in the early 2000s a foresight system that is very flexible and aims at enhancing the speed of its reaction to drivers of change. The first task of this system consists basically in scanning and evaluating emerging changes in technology and customer needs: the focus of investigation is the whole ICT industry, rather than just mobile communication. Scanning activities involve researchers and experts from all corporate, business and functional divisions, together with external partners like suppliers, customers, consultants and public research and academic centres. The investigation is then extended to the macro forces in the PEEST landscapes and how they may affect the business micro environment in relation to new technology adoption, the spread of new consumption patterns and acceptance of new product and services.

The resulting list of emerging drivers of change is evaluated to select those that are most relevant, a process that focuses on each driver to determine its likely evolution and, most important, its likely impact on the firm's value chain, so as to derive implications for the firm's business model. The initial list of drivers is reduced to a short list of (about ten) key topics, which is disseminated quickly to all corporate, business and operational units within the organization via a communication process that involves books, exhibitions and presentations - as well as an on-line interactive version. The target audience ranges from Nokia's top decision makers and strategic planners downwards to its employees and outwards to its key customers and industrial partners. The list of emerging drivers is updated annually, and covers a time horizon of 5–7 years, according to the strategic planning time-frame. Some examples of relevant topics considered since the early 2000s were social networks and media-blogging, as customers were starting to use their mobile phones to capture and share a wide range of media contents like photos, videos, and texts.

As with Nokia, the foresight system of Philips aims essentially at identifying new trends in society, technologies and customer needs in a timely manner. A corporate unit (Philips Design) established in the 1990s, delivers innovative design concepts and services for the company's main businesses. Within Philips Design, the 'Trends and Strategy' team is devoted to the investigation of three axes - 'Society', 'Culture' and 'People', with a focus on upcoming changes in social values and the expressions of these values as they emerge in customers' attitudes towards the technologies and products they use in their everyday live. A new initiative - the 'Probes Program' - has been established more recently as a long run (10 year time horizon) research initiative intended to present 'provocations' about new lifestyle patterns, which are published or exhibited to stimulate debate and criticism within the organization (a recent example concerned clothing and electronic tattoos that reveal the emotional state of their wearers).

Philips' efforts for coping with uncertainty also include Philips Research - the group's corporate R&D unit - which regularly develops technology roadmaps concerning the group's main business sectors. These different sorts of insights are finally matched through an interactive process that brings the social researchers from Philips Design and the technologists from Philips Research together with the business managers from all Philips' product divisions. Insights about socio-cultural trends are exchanged and made to cohere with those about technologies and markets, to provide a comprehensive vision of the future evolution of the firm's business environment. Such future vision usually covers a 10-year time horizon, while investigation processes of emerging trends and changes are scheduled yearly to fit in with the annual strategy calendar.

#### 5.2.2. Use of results in strategic decision making

Most efforts for handling uncertainty at Nokia go beyond environmental scanning and the identification of drivers of change. The team of corporate managers in charge of coordinating scanning activities has the mandatory task as well of: i) identifying the most appropriate strategic initiatives for responding to the selected drivers of change; ii) determining which of the group's units would be most suited to be the 'owners' of each initiative, so as to promote their commitment. Strategic initiatives encompass the design of new product and service concepts, the development of prototypes, their launch in target market niches, the promotion of internal forum for fostering dialogue among executives, and the launch of new venture projects and start-ups. As a result, since the early 2000s Nokia experimented with a large array of new services and products, product features, and software applications. Some examples include: new systems and applications for worldwide electronic payments by radio frequency enabled credit cards; web based applications for uploading photos, audio, and videos on weblogs; applications for grouping and retrieving messages and multimedia contents according to conversational threads.

In particular, Nokia makes an extensive use of roadmaps for planning the development of its product portfolio and defining its competitive position in emerging markets. The roadmap building process integrates and aligns insights from researchers, designers, marketers, and executives of different functions and business areas. The main aims are: to identify the paths of evolution of technologies, markets, products and product features; to select the time to launch of new products and services; to identify the emerging value chain and the rising players (first of all, new entrants) in the converging digital industries. Relevant examples of new products (and product families) lunched since the early 2000s are the Nokia N-Gage (a mobile phone that could use a handheld game system), Communicator devices (advanced phones that could be used as small notebooks), the Nseries, and more recently, the Xseries (advanced, integrated multimedia smartphones).

The main goal of foresight efforts at Philips is similar - to drive the renewal of the organization by figuring out how to exploit the new market opportunities enabled by new technologies or shifts in customer needs. Since the late 1990s, future studies have played a key role in re-defining the company's mission, as it focused its value proposition on the 'Sense and Simplicity' concept. In this context, Philips Design and Philips Research have jointly developed the 'Ambient Intelligence' vision, which means an 'intelligent home environment' that utilises a wide range of interconnected and embedded digital devices to make the environment sensitive, adaptive and responsive to the presence of people. Following this vision, Philips has built its core

technological competencies around displays, connectivity and storage, and started to develop and experiment with innovative product concepts in all divisions. A notable example is the Ambilight concept (Ambient Lighting Technology), which aims at enhancing the home cinema experience by generating lighting effects around the TV set that match the video content, enabling customers to enjoy a 'larger' virtual screen and thus a more immersive viewing experience.

## 6. Uncertainty, foresight, and strategic decision making under uncertainty: foresight as 'planned learning'

This section aims to shed light on the role of foresight practices and techniques in strategic decision-making. In particular, we assess the attitude of corporate and business executives (and thus position foresight systems) with regard to the fundamental dimensions established in the literature: *prediction* and *control* (see Fig. 1). We contrast the objectives and theoretical premises of foresight systems with the main approaches advanced in strategic literature and point out their consistency with either the *planning* or *adaptive* schools, and either with the *visionary* or *transformative* approaches.

Drawing on all the companies we studied, we found empirical evidence that the kind of uncertainty faced in the business environment is relevant in positioning foresight systems with respect to control, but not with respect to prediction. Whether the main determinant of uncertainty is complexity or dynamism, the emphasis on (and degree of confidence in) prediction is basically the same. Of course, management practices and techniques for coping with uncertainty entails taking a pro-active attitude towards the future, in order to anticipate changes in the environment and thus be able to gain first mover advantages over rising sources of competition (which is consistent with the planning school). At the same time, whether they face complex or dynamic environments managers are fully aware that is not actually possible to anticipate every future change and event (an understanding that is consistent with the adaptive school). With this in mind, they conceive their foresight efforts (and use their outputs) to set the ground for a 'planned learning process', the main goal of which is not to know the future in advance, but to get ready to detect environmental changes more promptly and react more effectively to them as soon as they start appearing.

However, the emphasis on control is strictly dependent on the main determinant of environmental uncertainty. In the case of high complexity (and where the drivers of change are exogenous), foresight systems basically consist in *explorative* approaches that aim to position the firm so as to take maximum benefit from changes in the business environment. In the case of high dynamism (and endogenous drivers of change), foresight systems basically consist in *normative* approaches aimed at shaping the evolution of drivers of change and thus of the business environment.[5] Fig. 2 summarizes our framework of foresight systems, prediction and control.

### 6.1. Foresight systems and prediction

According to the planning (and the visionary) school, foresight practices and techniques in the firms we studied stress the importance of the systematic analysis of emerging changes and events in the environment, based on the assumption that organizations that work more diligently to predict these changes will outperform their rivals. As uncertainty increases, foresight practices and techniques are essential for enhancing - even for enabling - strategic planning. At Nokia and Philips, environmental scanning, timely exploration of changes in technologies and customer needs and roadmaps are meant to identify the nascent industry value chain and the role of new entrants. At Shell and BASF scenarios set the ground for analysing the industry structure (Porter's Five Forces [17]) that would prevail in each one, and the rise of new sources of competition. These practices and techniques entail a pro-active attitude to changes and future events: by anticipating them - and therefore the sources of competition that are likely to come to the forefront - the organization gives itself a better opportunity of responding to these sources in a timely manner and thus of achieving a first mover advantage [59]. Shell's response to the oil crisis in 1973 still offers a remarkable example: the price shock turned into the most acute discontinuity the industry had ever faced. But Shell was prepared: its scenarios had allowed the company to revise its investment policies in refining and production capacity at the right time. When the refining capacity in the industry quickly ran into considerable oversupply, Shell suffered much less, and so outperformed the industry by a significant margin.

In mature global industries, the competitive advantage an organization may attain lies in the pre-emption of scarce resources, primarily physical assets and input factors (e.g. oil/gas fields and pipelines in the energy industry). In the case of technology driven industries, the scarce resources to be gained are more often customers' perceptual and product characteristic spaces, i.e. niches for product differentiation. More generally, a sound competitive advantage may be gained through the timely development of the new and different organizational capabilities (e.g., R&D, product design, brand management) that are crucial for addressing new technological or market opportunities.

On the other hand, in line with the adaptive (and transformative) schools, in all the firms we studied managers are fully aware that no methodological framework or approach can be developed that will really predict the future accurately: inevitably some changes and events that can not be foreseen (or simply are not foreseen) will take place. For that reason, all our sample firms are continuously scanning and monitoring their environments in the search of weak signals and new events that may allow them not

[5] According to mainstream scholars in foresight literature, *exploratory* approaches (and techniques) generally deal with questions regarding what might possibly happen on the basis of the forces at play. Such approaches begin with the past and the present as a starting point and move toward the future in a heuristic manner, looking at all available possibilities. *Normative* approaches (and techniques) are, instead, goal-oriented as they tend to take into account the purpose of the organization, its mission, and, most of all, its expected achievements and outcomes. Then normative techniques move backward to see if these objectives can actually be pursued given the capabilities available or achievable by the organization.

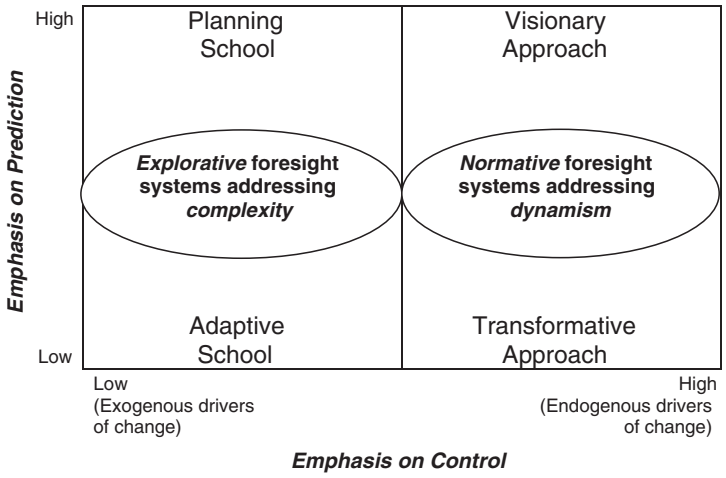


**Fig. 2.** Framework for uncertainty, prediction and control: positioning foresight systems.

just to figure out which of their alternative hypotheses for the future is becoming real, but actually to continuously question and re-conceive these hypotheses. In this way, they avoid to fall into the trap of locking in their predicted future, blinding themselves to events and changes other than those they have previously imagined. In particular, Shell and BASF combine scenarios with real option analysis, in order to position the firm for quick responses to unpredictable events as they emerge. In technology driven industries, real options usually take the shape of new prototypes, market tests, (a large set of) new products and services, and venture activities. The latter ones, in particular, provide useful information and insights at a relatively low cost and, most of all, the opportunity to play a role in the game later on when uncertainty has been reduced. Nokia has built its Venture Partners and Growth Partners for just this purpose. In this context, foresight practices and techniques are not an alternative, but rather an essential element of the strategic agility and adaptive capability which prominent scholars and practitioners urged for profiting from emerging opportunities and threats [48,49].

Summing up, the emphasis on prediction is neither high or low; managers in our sample firms neither claim to predict what their future environment will be (as in the planning and visionary approaches) nor avoid making predictions at all (as in the adaptive and visionary approaches). Simply, they seek to *predict* future changes in order to be able to better *adapt* to them. The core benefits of strategic foresight lie in establishing a process of '*planned learning*' about the future, which enhances the organization's capabilities to re-act more *quickly* and more *effectively* to external opportunities and threats as they arise.

This learning process about the future is something that goes beyond the formal output of foresight practices and techniques (i.e., roadmaps or scenarios) and may take place notwithstanding inaccuracies in this output. The case of Sakhalin II may be helpful to clarify this point. Shell's country and project scenarios did not predict the allegations for huge ecological damages which led to Gazprom (the Russian state-owned gas giant) gaining control of the project consortium in 2007. However, even in the case of this pitfall, scenarios still helped decision makers at Shell prepare for such changes. Country and project scenarios had considered strong insistence on a larger share of the profits and the likely leverage of legislation, licenses, and technical approvals for achieving this goal. At the same time, they highlighted the role of the Russian government as a powerful partner for the commercial success of Sakhalin II by backing up the construction of pipelines and the access (distribution) to target customers. With these scenarios as a backdrop, when it underwent first allegations for ecological damages, Shell was quick to fully sense the size of the threat underpinning this move (and likely future moves) by the Russian government, and thus to finalize the entrance of Gazprom in the Sakhalin II consortium. In the end, Shell kept the ownership of a relevant stake in one of the world's largest integrated oil and gas fields and granted itself the endorsement of the Russian government against rivals who are running other energy fields in the country and are targeting the same markets in the Asia Pacific region (first of all, the ExxonMobil-led Sakhalin I). Today, the Sakhalin II project is a major engineering and commercial success for Shell.

Similarly, BASF did not forecast accurately the size of the global financial crisis and economic recession in 2008. Nor Nokia and Philips were able to anticipate accurately every major shift in customers' preferences, and thus to know the future of their business in advance. For instance, the Nokia N-Gage cell phone and gaming device was a big disappointment and achieved lower than expected performance. However, efforts for coping with uncertainty allowed the managers of BASF, Nokia, and Philips, to know what kind of changes they could face (e.g., slowdown in the economy and low GDP growth in the case of BASF, demand for digital contents ad multimedia files in the case of Nokia), and what kind of response they should adopt. The success of the Nokia Nseries in the mid 2000s built also on the previous experience with N-Gage. It is exactly this capability - of preparing managers for next changes and events – what the *planned learning process* about the future consists of, and where its real value and contribution to strategic decision making lies.

### *6.2. Foresight systems and control*

While the nature of the uncertainty being faced - i.e. whether complexity or dynamism is its predominant component – does not affect the emphasis of foresight practices and techniques with respect to *prediction*, it has a strong influence on the emphasis

on *control*. In very complex contexts like mature global industries, drivers of change generally lie in the macro environment, and their large-scale nature, their huge numbers and their tight mutual relationships, mean that these macro forces are fundamentally beyond the control of – or even any influence from - any major industry player. Such firms therefore face great complexity by adopting an *explorative* approach which, according to the *planning* and *adaptive* schools, aims at positioning the firm in an environment that is basically exogenous to its efforts. Since Shell and BASF cannot act directly on the drivers of change in their PEEST landscapes, they must instead engage pro-actively in preparing for the likely evolutionary paths of these drivers and seek to identify the most suitable responses to these paths. Scenarios and real options are very valuable tools for systematically collecting, processing and organizing knowledge about future events and likely changes in the macro environment, allowing executives to get ready for action as soon as uncertainty starts to be resolved.

On the other hand, in highly dynamic industries the key (disruptive) drivers of change are relatively few and tend to be (at least partly) endogenous, as they basically lie in technologies and customer needs, the development of both of which firms can try to influence. In such contexts, leading firms may do something more than simply position themselves to optimize their performance in the face of the likely outcomes and evolutions of drivers of change. According to the *visionary* and *transformative* approach, leading firms may decide instead to 'move' pre-emptively and seek to *control* the evolution of drivers of change to a certain extent, by playing an active role in establishing and shaping these drivers. Of course, as we already noted, these companies do not claim to be able to build the future exactly as they want it to be (any more than to predict it exactly as it will be). However, as they push the diffusion and rate of development of new technologies and move quickly into the emerging markets these new technologies open up, Nokia and Philips can *try* to affect the evolution of customer needs in ways that favour themselves, and most of all they can *prepare* more effectively to benefit from these needs. Indeed, this was exactly the attitude of Nokia towards the rise of digital technologies (images, music, games, and so on) in mobile communication, or Philips in large screen TV (Ambilight).

Fig. 2 sums up our conceptual framework of the relationships between foresight systems and prediction and control. In particular, we position foresight systems in the middle of the vertical axis, emphasizing their mediating approach towards *prediction* (i.e., foresight systems as 'planned learning processes'). At the same time, we position *explorative* systems (e.g., Shell and BASF) in complex environments on the left side, between the *planning* and *adaptive* schools - so emphasizing a low degree of *control* over (exogenous) drivers of change - and *normative* systems (e.g., Nokia and Philips) on the right, between the *visionary* and *transformative* approaches, emphasizing their higher degree of *control* over (endogenous) drivers of change.

## 7. Conclusions

This paper describes the (integrated systems of) foresight practices and techniques that major global firms used during the last decade for handling increasing complexity and dynamism in their business environments. We argue that whatever the kinds of uncertainty, the main contribution that foresight efforts bring to strategy formulation lies not in *predicting* the future (i.e., in the predictions themselves that represent the outputs of foresight), but in *preparing* the managers of the organization to handle the future (i.e. in the learning process about the future enabled by these predictions).

Overall, our findings are consistent with some recent streams of strategic management research that have pointed to 'planned emergence' and 'strategy as simple rules' as concepts that bridge the gap between the planning and adaptive approaches [1,60,61]. These research streams encourage firms to plan in order to enhance their capabilities to adapt. In particular, we refer to the dynamic capabilities framework in showing that the main benefits of the practices and techniques that might be used for coping with uncertainty consist in enhancing the organization's capacity to: i) sense changes in the environment; ii) seize these changes; iii) re-configure its tangible and intangible assets to keep them aligned effectively with its external environment [58].

Much additional research must be done to improve the conceptual framework outlined in this paper. Efforts are required to explore the cases of other industries and firms. In particular, Shell and BASF on one hand, and Nokia and Philips on the other, represent polar cases, where uncertainty and related management systems are strongly driven by either complexity or dynamism as their main determinant. However, we believe our work makes a significant contribution in clarifying the real value of foresight practices and techniques, and in helping business managers (and scholars) decide whether and how they should invest their time and efforts in such practices and techniques. Future research may build on our work to address other types of industries, and thus other types of uncertainty, combining more balanced levels of complexity and dynamism. In this regard, it is worth noting that Philips and Nokia recently started to expand their analyses of macro drivers in politics and economics, as a result of increased linkages between their macro and micro environments and thus of increased complexity of their businesses. Finally, we hope that the joint efforts of scholars and practitioners can improve foresight practices and techniques in ways that are consistent with the principles of the dynamic capabilities framework, by backing up the concept of a *planned learning process* about the future that help managers sense, seize and respond to emerging opportunities and threats.

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