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Managing Strategic Flexibility in Industry 5.0 Transition: An Integrated Real Options and Strategic Foresight Approach

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5.1 Introduction

After a decade-long interest in the concepts of Industry 4.0 among both academics and policy stakeholders, contours now emerge of an Industry 5.0 (I5.0) society shaped by digitalization and novel applications of artificial intelligence (AI). In this chapter, we look at corporate investment strategies through the lenses of Strategic Foresight (SF) and Real Options (RO) theory with a specific focus on Industry 5.0 and system-level Digital Twinning. The chapter is written out on the authors' beliefs that an important part of theorizing about AI and Industry 5.0 relates to theorizing about investments on them: when should companies engage

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in transitional investments and how could they approach them systematically. Integrating Strategic Foresight and Real Options Analysis could be one such way to attain strategic flexibility under such rapidly evolving conditions.

Strategic foresight as a tool involves a set of practices that help organizations choose an optimal path forward by understanding the potential consequences of their decisions and, subsequently, attain a superior position in future markets (Metz and Hartley 2020; Rohrbeck and Kum 2018). The Real Options theory introduced by Myers (1977, 1984) suggests that companies should assign value to their potential investment opportunities like investing in publicly traded options of financial assets. Following this logic, the value of an investment can be calculated using the analytical option valuation formula developed by (Black and Scholes 1973), which takes into consideration asset volatility, time until expiration, and the possibility of alternative risk-free investment.

This chapter considers the requirements of Industry 5.0 in the capital budgeting decisions of companies. The central question is how one can grasp the emerging opportunities of technological change while avoiding sunk-cost investments in, possibly, soon-to-be-obsolete technology applications. Misinformed or ill-timed strategic bets on losing technologies might result in significant company write-offs and, in the worst-case scenario, even jeopardize the company's existence. On the other hand, a simple wait-and-see strategy that postpones major investments "until the future becomes clear" (Courtney et al. 1997) can create windows of opportunity for new competitors. This managerial myopia may lead to situations that neither defend the company against new threats nor take sufficient advantage of new opportunities. It is not an optimal way to approach fast technological transitions.

As for the definition of Industry 5.0, we acknowledge it to be a contested concept in the sense that there is no clear and accepted definition, and the common conceptualization has drawn "mixed reactions" (cf. Lu et al. 2022). There is already an extensive stream of research aimed at investigating challenges and enabling technologies (Huang et al. 2022), but summarily, we see the extant vision of I5.0 as human-centric and recognizes the role of industry in achieving societal goals beyond jobs and growth. It remains unknown what the new technological

and societal landscape will look like, how the pace of the technological transformation will unfold, and how companies should prepare themselves. In this vein, the key question that this chapter strives to answer is how market incumbents, with technologically mature product/service portfolios, should attain strategic flexibility considering the I5.0 transition.

The novelty of the contribution rests on the attempt to produce a meaningful combination of two theoretical schools of real options and strategic foresight, which both can help strategy-making under uncertainty, but which have hitherto been siloed from each other. That is, this chapter discovers, surprisingly, that very few previous academic works have sought to integrate the two fields of ROs and SF. It is suggested here that ROs could be utilized for exploiting opportunities when the uncertainty is mainly of parametric (numerical) type whereas SF could serve as a more qualitative vehicle of opportunity exploration under structural and/or radical uncertainty. This is followed by an introduction of a sketch of a high-level decision-making framework applied to an emerging technology of system-level digital twinning referring to virtual models of the whole (industrial) systems, identified as one of the Industry 5.0 technologies.

This chapter continues with a literature survey which is followed by a more general introduction to the two schools of thought. Thereafter, we present an integrated framework of SF and ROs derived from the exploration versus exploitation dilemma. The primary contribution of this text follows as the applicability of the integrated framework is evaluated for I5.0. Since the integration of strategic foresight and real options is at such an early stage, this is presented as an explorative and conceptual model. Finally, the chapter closes with conclusions and discussion.

5.2 Earlier Works

The original idea of this paper was to draw insights from the previous literature that had already considered the integration of the two theoretical streams of Strategic Foresight and Real Options. To do this, the Scopus citation database was queried using the keywords “Real Option”,

"Real Options", and "foresight". A total of fifteen works were identified of which only three studies were selected after reading the abstracts. One of the main reasons for heavy filtering was that even though several RO papers did use term the "perfect foresight", they did it in a narrow sense to depict a situation where the pre-set numerical uncertainties would be known before something happens. Such studies did not fit into the scope of our inquiry, as we are specifically interested in circumstances without access to such information.

The first research effort found in this area was made by Collan and Liu (2003), who propose a partially automated decision support system that would collect and analyze information related to ongoing projects and employ a real options framework as a means of facilitating ongoing dialogue with decision-makers about alternative future courses of action. By assigning a value to each alternative, the proposed system helps decision-makers make informed choices.

Eriksson and Weber (2008) examined the role of real options in adaptive foresight and aimed to establish a tangible connection between foresight that generally promotes open participation of all interested parties in society, and decision-making that focuses on implementing targeted strategy development on an organizational level. The authors suggest that adaptive planning highlights the importance of keeping options open and postponing decisions to adapt to changing circumstances. As uncertainties become resolved, gradual increases in bets for different technologies should be made (ibid.). While the paper of Eriksson and Weber (2008) purportedly limits itself to public policymaking, the insights are applicable also on a corporate-organization level.

The last paper is a recent literature review on radical innovation by Tiberius et al. (2021). They imply that incorporating strategic foresight can boost creativity, while the use of real options can provide valuable insights for financial evaluations. However, Tiberius et al. (2021) note that the financial aspects of radical innovations remain a relatively unexplored area of research and suggest that further investigation, perhaps within the framework of a real options strategy, is needed to shed light on this topic.

As a conclusion of the few results of the literature survey, the intersection of real options and foresight has been acknowledged by a few authors so far. The possibilities of integrating the fields remain mostly unexplored. Probably, multiple reasons can help explain this conundrum. A simple explanation could be that, traditionally, the discipline of capital budgeting, and more importantly real options framework, has looked at investment with a limited timeframe and constrained uncertainty whereas strategic foresight takes a long-term perspective. Even though investments in capital budgeting are planned for 20–30 years, the practice of heavily discounting distant returns tends to result in decisions with short-term value maximization. On the other hand, the lack of interest in the topic in the literature may indicate that the idea has been considered too far-fetched to address previously.

As a conclusion, it is highlighted that this work is not a review of the literature but rather a literature-based attempt to synthesize accumulated knowledge of Strategic Foresight and Real Options. Hence next, we cover the foundations of SF and RO individually and then discuss the points of connection between these two schools that both deal with decision-making under uncertainty.

5.3 Theory

5.3.1 Foresight

The term foresight has been applied since the 1980s to describe an inherently human activity aimed at increasing organizational future preparedness (Schwarz et al. 2020). Foresight is *"the discipline of exploring, anticipating and shaping the future to help building and using collective intelligence in a structured, and systemic way to anticipate developments"* (Commission 2020). Strategic foresight practices in profit-oriented organizations seek to enable flexibility and responsiveness to counter potential disruptions (Marinković et al. 2022). Corporate strategic foresight is applied to build and support competitive advantages by interpreting changes in the business environment (ibid.). In contrast, corporate

strategy refers to the process of making choices about resource deployment within an organization (see Bowman and Hurry 1993).

The well-known dynamic capabilities theory (see, e.g., Teece et al. 1997) revolves around the reconfiguration of firms' resources to remain competitive in the current market environment. Strategic foresight in companies links to these ideas as it is considered as a series of micro activities aimed at negotiating an organizational path toward the future (Fergnani 2022; Marinković et al. 2022). Here we use the terms *strategic foresight*, *organizational foresight*, *and corporate foresight* interchangeably, as is often the case in foresight literature (Schwarz et al. 2020). Interest in these activities is fueled by the expectations that these practices will help companies with high future preparedness attain a superior position in future markets (Rohrbeck and Kum 2018). Longitudinal analysis (ibid.) does suggest the hypothesis is true: firms with higher levels of corporate foresight practices seem to overperform the average on growth and profitability.

Strategic foresight in business literature is often manifested through scenario planning, although it is an umbrella term for a range of methodological approaches. SF encompasses agile focus groups, such as panels and workshops, narrative techniques such as storytelling or world-building, and more complex techniques such as road mapping, horizon scanning, or, indeed, scenario planning (Sakellariou and Vecchiato 2022). A unifying component is that the primary value of the mostly qualitative approaches stems from high uncertainty situations that render traditional (quantitative) forecasts less applicable (Metz and Hartley 2020; Wack 1985). If companies are looking at a "clear-enough future" (Courtney et al. 1997), there is little need for introducing alternative methods for exploring the future.

A risk of being too preoccupied with foresight has also been identified: when firms' peripheral vision capabilities exceed their needs, they are said to be "neurotic" (Rohrbeck and Kum 2018). Too much emphasis on managing distant futures, while failing to provide sufficient attention to short-term matters has been coined "managerial hyperopia" (ibid.). Therefore, good corporate foresight practices should trigger *appropriate* organizational responses instead of lethargy (Rohrbeck et al. 2015).

5.3.2 Real Options

The Real Options theory builds on the neoclassical assumption of a rational decision-maker who is interested in maximizing her current wealth by making informed decisions under uncertainty by balancing between the risk and return. It has been implied (e.g., Adner 2007; Trigeorgis and Reuer 2017) that ROs could serve as a framework for guiding investment allocation decisions under uncertainty. Anand et al. (2007) distinct two foundational strategic option types as *growth* to add commitment and *switch* to embrace flexibility. In the context of forecasting, Eriksson and Weber (2008) distinct between *robustness* to describe fixed/passive uncertainty mit igation measures and *flexibility* that require active monitoring and decision-making. The "success indicator" of Real Option Analysis (ROA) is the perceived economic value of the decision and the extant literature has found numerous use cases for ROA including Research and Development (R&D) (Rogers et al. 2002), closing industrial operations temporarily during market downturns (Brennan and Schwartz 1985), or managing construction projects (Guma and de Neufville 2008), among others. For an in-depth review of the most common uses of ROs, we recommend referring to Trigeorgis and Tsekrekos (2018) and Bengtsson (2001) which gives a more comprehensive account of how to apply real options analysis at the manufacturing system level. In the big picture, most corporate strategy-related decisions are optional and can be theorized in terms of ROA of alternative actions. Lee et al. (2018) write that essentially *"real option theory helps isolate optimal choices"*. Research has shown that real-world managers tend to follow *real options reasoning*, i.e., they implicitly or explicitly respond to the value of preserving future investment decision rights (Gunther McGrath and Nerkar 2004).

In this chapter, we are interested in the strategic-level problem setting with more than one real option at the management's disposal. Within this RO-portfolio context, qualitative considerations include, for instance, the fact identified by Barnett (2008) that ROs noticed and selected by the company are shaped by the contextual and concrete channels of information filters where the managerial attention for sales pitches is dependent on the decision environment. Ghemawat and Ricart i Costa

(1993) define two types of organizational entities: first, *control-driven* steered by a top-down decision-making institution to pursue static efficiency and, second, a *knowledge-driven*, bottom-up one with an emphasis to resort to new opportunities that foster dynamic efficiency. The extant RO literature seems to be focusing on the former, which can be considered as exploitative-type, whereas more scholarly efforts to operationalize ROs for explorative capability building would be required. And, to do this, strategic foresight is considered here.

5.4 Toward an Integrated Framework of Strategic Foresight and Real Options

5.4.1 Dilemma of Control

By definition, the term exploitation, following March (1991), is characterized by refining, being efficient, and implementing existing knowledge to produce positive short-term returns whereas exploration, as its opposite, involves the acquisition of information through innovation, discovery, and experimentation with uncertain and distant returns. Already Bowman and Hurry (1993) proposed that, in general, organizations are more toward exploitation activity until a major change in the environment forces them to initiate exploration activities. The contradiction between exploration versus exploitation in the face of Industry 5.0 is at the core of our interest.

The problem of optimal balance between exploration and exploitation investments in dynamic markets can be viewed from several perspectives. First, the risk of obsolete exploration investments is evident that can constrain the exploitation of future opportunities [see, discussion, e.g., in (Uotila et al. 2009)]. On the other hand, the Collingridge Dilemma highlights the role of control—"*When change is easy, the need for it cannot be foreseen; when the need for change is apparent, change has become expensive, difficult and time-consuming*" (Collingridge 1980). A similar view on the assessment of new technologies being adopted is summed up by the maxim of Buxton's law, which states that rigorous assessment is always too early, until, unfortunately, it's suddenly too late (Barkun et al. 2009).

The dilemmas show the inherent challenges of acting optimally today to prepare for the future which is the shared foundational concern of both Strategic Foresight and Real Options. Over time, these two schools seem to have arrived at different conclusions on how. As the key difference, SF mostly builds on qualitative expert knowledge, while ROs build on the existence of traceable numerical uncertainties that are utilized to evaluate asset values. As observed by (Marinković et al. 2022), it is notable that (corporate) foresight methods lack profitability indicators as analysis outputs which is a gap in research that this chapter touches upon.

The requirement of traceable numerical uncertainties (or uncertainty proxies) practically limits the scope of ROs as documented, e.g., in Adner and Levinthal (2004) who write that ROs should be utilized in projects with specific technical implementations and whose value depends on quantifiable uncertainties. This observation is supported by Eriksson and Weber (2008) who note that the real options literature has primarily focused on simple exploitation problems in corporate finance, overlooking the existence of structural uncertainties. Barnett (2008) deducts that externally oriented organizational attention structures support exploratory, large innovative portfolios whereas the opposite favors small portfolios of incremental, "close-to-marker" options. It is not surprising that the bulk of existing literature on ROs to date has primarily focused on discrete, one-off investment projects treated as numerical exercises aimed at selecting optimal actions while at the same time, it is acknowledged (see, e.g., Bowman and Hurry 1993; Myers and Read 2022) that the long-term success of companies depends on the ability to strategically manage their portfolio of real options. We argue that the portfolio effects of having multiple ongoing projects in parallel are seldom addressed quantitatively as they bring several additional complexities and qualitative factors into the mathematical formulations taking the edge off the available RO methods. With regard to complexity, referring to Anand et al. (2007), the value of an option portfolio is dependent not only on the volatility and the number of individual opportunities but also on the correlation between the returns of underlying assets and the number of how many options can be exercised (resource constraints)—since new real options decrease the probability

of exercising the existing options in the portfolio. Furthermore, having an organizational resources aspect in the RO context brings it close to dynamic capabilities theory (Teece et al. 1997).

5.4.2 From Sensemaking to Strategy

To bridge the gap between Strategic Foresight and Real Options, the role of strategy should be considered. Bowman and Hurry (1993) write that opportunities for strategies emerge only once they are recognized and require "making sense" of organizational resources that serve as access to them. Strategic foresight offers one possible primer for such sensemaking activities (Sakellariou and Vecchiato 2022). Foresight activities do not seek to predict the future but rather support organizations in *sensing* (Teece 2007) or *perceiving* (Højland and Rohrbeck 2018) different possible futures, opportunities, and challenges. Hence, we suggest that the nature of SF, as an act, locates itself closer to exploration than exploitation.

Others have pointed out that incumbent companies may have challenges in digital transformation, as managers often rely on prior experience and prefer familiar strategic choices (see, e.g., (Warner and Wäger 2019) for a discussion on the digital transformation of incumbent firms). Creating systematic sensing and foresight capabilities in an organization can help overcome this potential legacy bias.

Literature on SF highlights its participatory nature (Dufva and Ahlqvist 2015). Stakeholder involvement can help produce better SF results by reducing potential biases and blind spots, and, simultaneously, SF processes can be a vehicle for aligning organizational visions and strategies across involved participants. Consensus may not be a target, however, as dissent among stakeholders in itself can be built into scenario development as an important component (Metz and Hartley 2020). One possible benefit of strategic foresight capabilities for companies is to limit exploration costs by ensuring a truly future-oriented strategic basis of investment activities by narrowing down the initial scope of opportunities for *value creation*. Therefore, at best SF could function as an open discussion tool to focus information-gathering efforts before the

capital budgeting processes are initiated (with ROs) that are confidential and aimed at *value capture*. In this two-stage process, feasible investments would most likely emerge once the high-value-creation capability implied by SF can be topped with a doable blueprint of value capture devised by the RO framework. For a detailed discussion about the value creation and value capture, we advise the reader to refer to Baden-Fuller and Haefliger (2013).

While strategic foresight might be useful as an input for one-off projects and investments, the conceptualization of foresight as a set of future-oriented capability-creating activities underscores the necessity of *continuous* foresight. Foreseeing and hitting a home run on one set of market trends—like Blockbuster anticipating the market for home video rentals or Nokia the explosion of mobile telecommunications—does not guarantee long-term success, if companies fail to foresee and adapt to market disruptions.

Eastman Kodak Company, one of the market leaders in analog photographing products, is often regarded as a "classic example" of strategic failure as it filed for bankruptcy protection in 2012. A less-known fact is that already in 1997 a seminal paper by Courtney et al. (1997) commended Kodak's strategic bet on digital photography products. The aspect that remains missing is that for decades the value capture element existed only in analog photography while digital photography was at an exploratory stage with value promise that was not realized until technological leaps were made in other sections of computing. From the management perspective driven by maximal monetary returns, it probably did make sense for Kodak to exploit its leading position to the maximum while keeping the, yet uncertain, digitalization as an R&D-based real option until the expiration date. When looked at this way, the case of Kodak's failure could be seen as a failure of strategic foresight on a large scale and, subsequently, the inability to exercise its existing call option(s) for digital photography timely enough to keep up with the competitors.

Summarily, strategic foresight *in itself* is hardly valuable in a company; the value rests almost entirely in the interpretation and uptake of its contributions, and, first and foremost, in the actions to which a company's SF might lead. Successful implementation relies on obtaining

organizational buy-in across multiple levels, while also emphasizing the importance of consistent updates to ensure its ongoing value. It is essential to recognize that this tool serves as a decision support system rather than providing explicit paths to the future.

5.4.3 Narrowing Down the Strategy to Actionable Options

In contrast to SF, Real Options theory starts from an assumption that explicit, alternative futures are described, and the decision-maker is in a position to bet on them based on probabilities of resolving uncertainties. As such, RO theory provides two key insights for companies struggling to make choices of emerging technology. The first is the importance of keeping options open in uncertain markets to see how uncertainties unfold, while the second is the advantage of reducing the uncertainty with one's actions. To implement these guidelines effectively, it is often necessary to establish "toehold" positions in projects and monitor their value, allowing these real options to be exercised promptly when the time is right to capture the value held by the RO.

The above guidance is much easier said than done: in reality, first, many of the investments are large, lump-sum projects that do not allow for gradual betting, and second, it is hard or even impossible to devise exact rules for the right timing that would trigger the pre-structured organizational actions. To complicate the situation further, a concept of "shadow options" has also been identified (Barnett 2008), referring to opportunities that exist but are not currently being systematically managed or pursued. At the same time, these shadow options might be the most valuable, for instance, in cases where structural or radical uncertainty unfolds in unpredictable directions that result in futures not included in the initially drafted RO analysis.

The discussion of Strategic Foresight and Real Options theory is summarized in Table 5.1 for comparison. It can be stated that the SF in the general business context is a qualitative tool aimed at identifying scenarios and their future value-creation opportunities that one should explore to maintain long-term competitiveness. The difference in the RO

Table 5.1 Comparison of problem formulation of corporate foresight and real options

Problem characteristic	Strategic foresight	Real options theory
Business orientation	Exploration	Exploration and exploitation
Business value focus	Value creation	Value capture
Main type of analysis	Qualitative	Quantitative
Wealth maximization	Long-term	Current
Organization	Open and participatory, broad stakeholder involvement	Closed and confidential; specialist committee/manager
Renew unsuccessful projects	Not stated	No
Uncertainty type in projects	Qualitative (narrative)	Mathematical (parametric)
Development of uncertainties	Yes/continuous	No/static probabilities
Portfolio effects of technology	Sometimes/context dependent	No/restricted to single investment

theory should not be overstated, but Real Options are more restricted to the current state of affairs highlighting the exploitation of opportunities with given uncertainties to produce numerically proven wealth as of today. Due to market competition, the nature of the Real Options Analysis process is expert-driven and confidential. It strives to excel others by implementing specific projects while SF is kept open and produces holistic insights that as such may not contain a tangible business value.

5.4.4 Budgeting Toward Industry 5.0

It is posed here that the frameworks of SF and RO could complement each other. We expand on this proposition with two main objectives: firstly, to explore the potential of a combined strategic foresight and real options approach for identifying promising exploratory opportunities on a theoretical level; secondly, to evaluate the suitability of this framework for analyzing Industry 5.0 opportunities. According to Eriksson and Weber (2008), the role of strategic foresight is to first look across the identified scenarios and then select the technology options and policies with the maximum robustness and adaptivity. The primary task for

the decision-maker is to assess the problem complexity for the task/organization and use strategic foresight to scope the landscape, relevant challenges, opportunities, changes, and options for value creation.

Strategic foresight is best suitable for situations that involve system-level changes and non-quantifiable uncertainties. It should be utilized to narrow down the feasible scenarios of interest. Then, *Strategic Flexibility*, discussed in recent research (see e.g. Brozovic 2018; Chanphati and Thosuwanchot 2023), can be drafted in broad terms starting with the aim of value creation. This can mean a long-term plan involving such elements as capability development through education to acquire a new skill base. In a landscape of rapidly evolving technologies, this type of broad flexibility fostering "shadow options" has value (Mankins and Gottfredson 2022) as it is still unclear what the right bet on the "winning" assemblage of technologies will be. Only after finite and discrete scenarios are possible to formalize explicitly, real options can serve as a vehicle for taking strategic actions aimed at value capture.

Capital-intensive industries typically make investments with a long-term horizon of 10–20 years or longer, which can limit their flexibility to change course in the rapidly evolving technological landscape, even when new, more efficient ways of doing business become available. While real options theory recognizes the option to abandon unprofitable ventures, often induced by technology changes, it's not a decision to be taken lightly due to the possibility of positive developments that could make the business profitable again. In other words, despite the "theory-level" valueadding flexibility of ROs, a company with limited resources is tied down with the investment decisions taken previously.

Therefore, the importance of being able to write down a discrete presentation of the problem in a manner that is compatible with the limits of RO methodology is underscored. This requires the uncertainties to be mainly of *parametric* type [see discussion (Langlois 1984)] and be able to represent them numerically. If the problem does not meet the requirements of quantitative RO formulas, also the benefit is likely to be negligible.

5.4.5 Managing Portfolios

The importance of investment decision formalization calls for more elaboration as it omits some of the flexibility aspects identified in the current real options literature on strategy. We suggest that from the point of view of a decision-maker, the ability to invest resources into multiple uncertain projects can be viewed as a "problem of multi-armed bandits" to a player at an imaginary casino who can choose between several slot machines and each time a machine is played it produces information on its return distribution. An extension to this problem is called "restless bandits" where the probability distributions change dynamically. As it is not known which of the slot machines bet at a certain point in time, one should conduct exploration by dividing bets before the exploitation phase—in this case, the investment decision.

As a well-known solution to this general problem, Gittins (1979) suggests that a rational decision-maker should utilize the best opportunity to the maximum before moving on to the next one which we see is the common case with capital budgeting aimed at producing maximum returns. That is, in terms of risk, rational businesses, like in the Kodak example, should prioritize the lowest risk—highest return activities when choosing between alternatives with different expected rates of return, and often there are no natural incentives for exploratory activities (= changing slot machine to another) over the exploitation. Therefore, system-level changes in the industrial landscape, driven by high-level legislation and top-down initiatives like Industry 5.0, are crucial in providing companies with guidelines for navigating their future economic risks when the actual business value remains distant.

Real Options Analysis falls short of identifying these faraway, yet possible, system-level changes in the business environment. Here, strategic foresight could help firms "build specialized sensors that reduce blind spots in their peripheral vision" (Højland and Rohrbeck 2018). This, for example, enables firms to identify relevant technological developments that are not yet directly affecting their operational environment today, being excluded from the capital budgeting analyses, but which *could* profoundly alter their industry in the mid or long term. The potential emergence of novel Industry 5.0 and AI solutions are one such

example that are widely known but as abstract concepts, rarely convert directly into value capture propositions formalized as actionable real options.

With the help of strategic foresight, mature companies are, ideally, better primed to anticipate relevant change drivers in their given market space, which would make them gain lead-time advantages against competitors (Højland and Rohrbeck 2018) and limit their risk of legacy bias associated with relying on past experiences (Warner and Wäger 2019). However, since SF analyses are subject to inherent structural uncertainties, it is borderline impossible to assign precise economic values to the various opportunities identified.

5.4.6 Evaluation Framework Proposition

Based on the discussion provided so far, a sketch of an integrated framework is visualized in Fig. 5.1.

Reiterating some of the previous points, the integrative framework suggests the following stepwise actions: (i) *Assess the level and type of uncertainty* The first step for companies seeking to take strategic actions with technology investments is to assess the level of uncertainty surrounding their concerns. Different levels of uncertainty call for different approaches to devising a path to the future (Courtney et al. 1997). This step effectively precedes the visualized model, and given the assessment of the level of uncertainty may render the rest of the steps

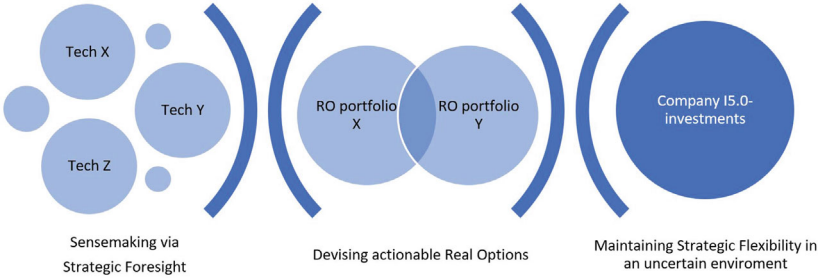

Fig. 5.1 Toward an integrative framework of strategic foresight and real options

unnecessary. After all, there is little need to maintain strategic flexibility if there is sufficient certainty about the right course of action.

(ii) *Sensemaking via Strategic Foresight* In investment cases surrounded by structural uncertainty, as the case is for mature companies pondering the transition to Industry 5.0, strategic foresight can help in sensemaking. When several simultaneous developments, some mature and some early stage, are happening in the technological and operational landscape, strategic foresight enables a better understanding of technological trajectories and potential consequences thus helping to provide insights into possible futures relevant to the given company. This narrows down the range of relevant courses of action.

(iii) *Devising Actionable Real Options* Once explicit, alternative futures are described, and the decision-maker is in a position to bet on them based on, at least subjective, probabilities of resolving uncertainties, real options theory can help isolate and highlight optimal choices. Real options thereby provide decision support for companies looking to put their money where their mouth is by investing in small "toehold" positions in emerging technologies.

(iv) *Maintaining Strategic Flexibility in an Uncertain Environment* The targeted outcome of the process is for the company to obtain strategic flexibility in uncertain and fast-changing conditions. It is important to note that to maintain strategic flexibility in this environment, the process has to be continuous and iterated.

5.4.7 Illustrative Application

To give an idea of how this framework could be used for budgeting in the Industry 5.0 context, we focus on real-time digital twinning (DT) of entire systems (system-level Digital Twins) which has been identified as one of the five critical technology areas of I5.0 by the European Commission et al. (2020). Instead of an off-the-shelf product, digital twinning is essentially a technology bundle consisting of several system components making the investment decision setting inherently complex

for capital budgeting. While the system-level DT remains at rather a conceptual level at the time of writing [see discussion, e.g., in Savolainen and Knudsen (2021)], an evident potential exists to generate significant, positive impacts in many foreseeable future scenarios, which makes the technology relevant for detailed analysis.

In the scale of exploratory versus exploitative investments, the real-time, system-level DT falls in the former category: for mature manufacturing companies, it represents a potential disruptive shift in the organizational set-up and its manufacturing processes as well as in the ways how the end-products are being used. Therefore, the uncertainty is structural at the uncertainty assessment phase (i). However, at the same time, partial investments in individual parts of the manufacturing systems to enable digital twinning in the future might be considered more of an incremental technological adaptation linked with the current business model exploitation. In this regard, value capture potential exists, but sensemaking of the future (ii) could be further exercised to focus constrained resources toward the most potential directions of development.

Suppose a company arrives at a realistic plan during the initial phases of analysis to build a customized, real-time, system-level DT for its key product that is, say, some type of moving equipment. In that case, it would be necessary to position itself in the market to understand the most likely scenarios and, subsequently, identify relevant, traceable indicators that can trigger RO positions [phase (iii)] from the current set of options aimed for DT-product launch. Since the technology remains in the development stage standards are in constant flux, one has to resort to strategic foresight to formulate these underlying scenarios and then build capabilities that align with most of them.

The prospect of having to switch the entire Real Option (RO) portfolio has to be kept in mind in case of scenario breakdown which calls for constant revision of the selected course of action as suggested by the framework phase (iv). In the case of digital twinning, one could imagine some type of standard DT model that works irrespective of the underlying application and its embedded ICT technology which at this moment seems impossible. However, keeping the scenario breakdown

in mind would enable the company to respond proactively and effectively to changes in the market and capitalize on new opportunities as they arise. This is in line with strategic RO literature, where Anand et al. (2007) states that a large portfolio of independent growth options should be preferred in high-volatility environments.

Due to the impossibility of predicting the future, it would be desirable for real option portfolios to have overlapping investments that are relevant irrespective of the scenario. We can think of these as "no-regret investments"; investments that would serve their purpose in any of the most plausible futures. It is worthwhile to consider whether some of the portfolio investments are "platform" projects that serve multiple purposes. For example, cloud computing capabilities can be used for both digital twinning projects (exploration) and advanced data analytics for refining existing business processes (exploitation). From the corporate perspective, developing such platforms may be more easily justified regardless of the scenario, as they are ambidextrous with regard to exploration and exploitation (see also, e.g., Sinha 2015) providing several opportunities for return on investment.

Summarily, putting the above example in context, companies can employ foresight to assess and contextualize potential disruptions (to their operations, organizational set-up, supply-chain relations, markets, etc.) entailed by leaps in digital twin capabilities. Foresight may also help illuminate possible implications caused by developments in peripheral fields, e.g., advancements in artificial intelligence. A viable guess is that foresight would also underline the possible future benefits of having access to greater amounts of data with higher levels of granularity, suggesting an incentive for initiating increased generation and collection today (Savolainen and Knudsen 2021). *Exaptation* (the utilization of existing knowledge or technologies, hitherto unutilized, for novel purposes) is a well-recognized source of innovation and expected future AI and digital twin capabilities make incumbents' large amounts of data make a promising exaptive pool (Garud et al. 2016) for potential future exploitation. Even if derived investments would not be economically feasible at present, this effectively represents a shadow option (Andriani and Cattani 2016) for future exaptation. Once the potential and plausible scenarios are laid out, companies can use real options tools to align

their investment strategy for digital twins, taking into consideration also the value of shadow options. An investment portfolio that supports both exploration and exploitation activities is possible but calls for rigorous allocation of limited resources. If successful, the company can flourish across a wide range of possible technological trajectories of system-level digital twinning.

5.5 Conclusions and Discussion

This chapter focused on the strategic allocation of corporate resources in the transition process to Industry 5.0 (I5.0). It explored on a conceptual level how organizations could combine the theories of Strategic (or corporate) Foresight and Real Options as a practical tool to make better-informed decisions about resource allocation and position themselves viably in the rapidly evolving I5.0 landscape. The interest in the integration of SF and ROs lies in the authors' shared aspiration of finding more valuable, yet workable, means to navigate in uncertain technological transitions that would circumvent the method-specific problems of SF and ROs once utilized individually in the investment decision-making process. The key takeaway of this chapter is that SF could serve as a tool of organizational sensemaking and value creation that can be utilized to formulate more rigorous real options problems, while RO-framework should be seen as a tool that improves the value capture.

Technological advancements, not least in the realm of artificial intelligence, leave mature, incumbent organizations faced with radical uncertainty about the near-future operating environment. Investment choices about whether and how to commit to Industry 5.0 technology investments—exemplified in this chapter with system-level digital twins—are inherently difficult under these conditions. We believe that the suggested integrative framework could provide valuable decision support for organizations seeking to navigate through uncertain waters. Each of the two theories seeks to increase the number of areas that organizations can explore while decreasing the cost of each exploratory foray (Gunther McGrath and Nerkar 2004)—when applied together, we believe this is even more true.

As shown in the literature study, the idea of using strategic foresight and real option methodologies in concert has remained largely unstudied until now. Therefore, several future research directions exist out of which some of the most fruitful areas could include example case studies where the proposed integrated framework has been adopted and documenting its applicability. Secondly, a more rigorous, theoretical development of the integrated framework would be valuable as well that could meaningfully bring together the qualitative insights of strategic foresight with the numerical analysis of real options in the context of several uncertainties.

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