

Framing Strategic Decisions in the Digital World

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ABSTRACT

This paper develops a conceptual framework to analyze the impact of digitalization on firms. Algorithms release cognitive resources of decision-makers who can focus on low-frequency/high-impact strategic decisions, such as innovation decisions, M&As, capital structure, and the acquisition of talent. In a digital world, different ability to frame firm strategies represents a key source of competitive advantage: by adopting a scientific approach to decision-making firms can embrace rather than escape uncertainty and rely on owners as strategists. We show that the growth of knowledge (ΔK) becomes the ultimate purpose of the firm, from which other purposes descend. We analyze some applications of the framework and conclude by suggesting a research agenda.

Keywords: Strategic decision-making, theory-based strategies, digitalization, algorithms, uncertainty, scientific approach

Introduction

Why do superstar firms characterized by hyper-growth emerge in the digital era? Why are public, managerial corporations eclipsing in favor of concentrated ownership, agentic investors and high financial leverage? Why do owners/entrepreneurs remain at the helm of firms and keep running them even if they become complex and large? Why do firms increasingly rely on M&As and

external growth flexibly reconfiguring their knowledge base and assets? Why do firms become increasingly customer-centric and tend to experiment more?

These apparently unrelated, complex questions have fazed strategy scholars during the last decade generating a set of conspicuous streams of research that try to address them separately.

These questions are intimately related and their explanation is grounded on the effects of the digital revolution on the functioning of firms. Digitalization changes the nature of the firm, radically transforming strategic decision-making and strategic management.

This paper develops a conceptual framework to analyze the impact of digitalization on firms. It derives broad implications for strategic management, and particularly for ownership, governance, capital structure, innovation management and the staffing of top management teams. It also provides a rationale for a variety of interesting trends, including ownership concentration (Bebchuk and Hirst, 2019), ownership competence and agency (Foss *et al.*, 2021), the emergence of superstar firms (Autor *et al.*, 2020), hyperscaling (Adner *et al.*, 2019), business experimentation (Luca and Bazerman, 2021), acqui-hiring (Chatterji and Patro, 2014), strategic hiring (Elfenbein and Sterling, 2018), and diversified capital structures (Lemmon *et al.*, 2008). It suggests ways in which future strategy research might focus its efforts on investigating questions of interest to both academic research and practice.

The key tenet of this paper is that digitalization and algorithms affect profoundly the strategies of firms. The organizational impacts of digitalization and algorithms are more visible (Brynjolfsson and McElheran, 2016), and thus have been studied to a greater extent (Autor *et al.*, 2020, 2019). However, as data, algorithms, AI and machine learning allow to digitalize high-frequency/low-impact decisions, managers can dedicate their time and intelligence to strategic, low-frequency/high-impact decisions. More than in the past, this makes the ability to frame strategies a key enabler of firms' growth and a key source of cross-firm performance differences. We argue that as algorithms spread out in organizations, top managers are relieved from routine decisions and can focus on strategic decisions which are both characterized by fundamental uncertainty and conducive of higher value creation. This calls for a particular "decision-making technology", with managers adopting a scientific approach to strategic decisions. We also argue that this transforms the structure and governance of firms, with owners playing a key role in strategy making. The framework is applied to four typical strategic decisions firms make: innovation, key talent acquisition, capital structure and M&As.

Decisions in Algo Firms

Data and algorithms allow not only to automate most operational activities and decisions, but also to automate an increasingly larger fraction of managerial

decisions. Automation is a secular trend in organizations (Zuboff, 2019), a keystone of the information processing view pioneered by March and Simon (1958) and is consistent with the view of organizations as “artificial intelligences” (Csaszar and Steinberger, 2021).

While digital technologies drive increasing automation of high-frequency/low-uncertainty/low-impact decisions, there remains a set of decisions which are not amenable to automation. These low-frequency/high-impact decisions are non-recurrent and structurally different across firms and over time. They are characterized by fundamental uncertainty as they relate to what is unknown or hard to be known. Consequently, they require human discretion and judgment, as well as a decision-making “technology” that must rely on conceptual frameworks, beliefs and experiments since data might not be readily available.

These decisions will also increasingly benefit from digitalization (Agrawal *et al.*, 2017). For example, machine learning and artificial intelligence can enhance managers’ cognitive skills and creativity (Wilson and Daugherty, 2018) and experiments can be done more readily, effectively and efficiently (Ghosh *et al.*, 2020). Yet, these decisions cannot and will not be fully delegated to algorithms for two reasons. On the one hand, they are characterized by human purpose, intention and interactions (they are “strategic”). On the other hand, they are fundamentally uncertain because they are located at the frontiers of what firms know (and owners want) so that the underlying problems are ill-defined or “wicked” (Rittel and Webber, 1973). For them, data is scarce and past causal structures do not represent informative basis for predicting future events (“non-ergodic” decision contexts). Even owners’ goals, preferences and needs are ambiguous and variable (Rindova and Courtney, 2020).

Figure 1 graphically illustrates the structure of decisions in Algo firms. Of the myriad of decisions made by managers in a given organization, the vast majority are recurrent, can be foreseen and codified. Some of them are instead non-recurrent, “unique” and no or little past data are available to inform them.

Business decisions can be ordered/ranked according to their increasing degree of uncertainty and impact (x -axis of Figure 1). The point D marks the threshold between “automated” decisions (made by computers/algorithms) and human decisions.

The automation of high-frequency/low-impact/low-uncertainty decisions has two implications. First, other things equal, it frees-up managerial cognitive resources that can be dedicated to making low-frequency/high-uncertainty/high-impact decisions. Second, as firms need fewer traditional managers to make high-frequency/low-uncertainty decisions, it generates new managerial jobs needed to support the digitalization/automation process and to make low-frequency/high-impact/high-uncertainty decisions (“Quant-managers” and “Quant-owners”) (Pignataro, 2021).

The first implication is particularly important for our framework. Building on Penrose (1955), we maintain that the availability of managerial resources

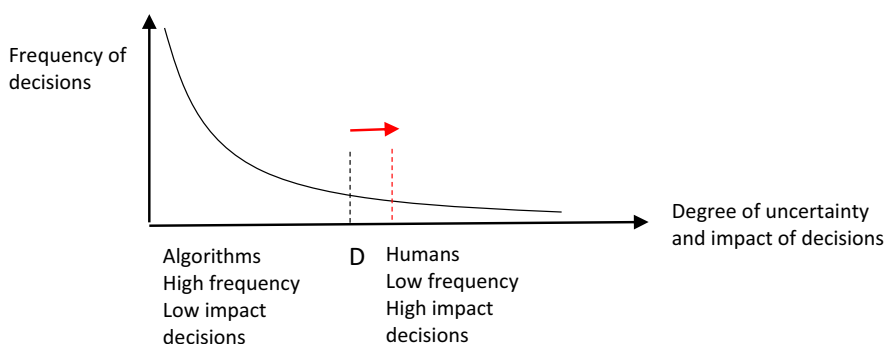


Figure 1: Managerial decisions contingent on degree of uncertainty and digitalization.

for strategic decisions represents a major constraint to firms' growth. The fewer the managerial resources dedicated to implementation and execution (what we call "high-frequency/low-impact decisions") the more the managerial resources that can be dedicated to "low-frequency-high impact decisions" (or, in the original Penrose's phrasing, to "research and planning" (1955, p. 533)).

Of course, managers will not necessarily deploy the freed-up cognitive resources to low-frequency/high-impact decisions unless the right incentives are in place. However, as again noted by Penrose (1955), there might be increasing returns to dedicating time and attention to low-frequency/high-impact decisions also for managers, since "expansion itself tends to create opportunities for further expansion opportunities that did not exist before the expansion was undertaken" (p. 532).

The number of type of managerial decisions that will be supported and/or made by algorithms will increase over time, as managers solve problems and mitigate uncertainty. This ensues managerial cognitive release so that more time and attention can be oriented to frame and make those decisions that remain characterized by fundamental uncertainty. However, as data, information and knowledge are accumulated, the threshold "D" in Figure 1 will keep moving to the right, thus allowing for further managerial cognitive resource release.

Strategic Decision-making in Algo Firms

Strategy Implementation, Formulation, and Ideation (Why, What, and How)

Digitalization and algorithms affect strategy implementation, formulation, and ideation: the *how*, *what*, and *why* of firms (Pignataro, 2021):

- with regard to *implementation*, they transform business processes and the associated capabilities, dramatically affecting *how* firms operate and perform,
- with regard to *formulation*, they affect *what* firms offer to their customers widening the scope of potentially viable business models and enhancing the possibility to flexibly reconfigure products and services,
- with regard to *ideation*, they liberate time that can be used to address questions about the causes of phenomena and actions — such as *why* the firm exists, *why* it should grow internally or externally, *why* it should target specific types of customers, *why* it should undertake specific innovations, pursue certain M&As rather than others, deploy a given capital structure, or *why it should* hire some people rather than others.

Better performance in “*how*” (implementation/capabilities dimension) is rooted in “operational attributes” that mostly reflect more efficient high-frequency/low-impact decision-making, such as better design and continuous improvement of workflows and algorithms, more distributed and effective information systems, flatter and more flexible organizational structures and management practices (Brynjolfsson and McAfee, 2011).

Better performance in “*what*” (strategy/business model choice) depends instead on the ability to translate customer needs into “design attributes”, offering superior products and services and “monetize” them through better business models (Zott and Amit, 2010).

Although often understood as the reason why digitalization drives better financial performance, the performance improvements along these two dimensions (“*how*” and “*what*”) are not decisive. The critical impact of digitalization occurs with regards to strategy ideation (*why*) — that is, understanding *why* the firm wants to focus on certain actions and the implications thereof. In turn, this requires that decision-makers understand logically the underlying phenomena and their causes. This helps to select the most valuable actions (value creation) and the ways to capture this value (monetization).

These three dimensions are complementary. Superior implementation/execution frees up cognitive resources so that top management teams can concentrate their attention on strategic decisions (Joseph and Wilson, 2018). This generates opportunities that can be exploited more effectively and timely, generating a virtuous circle. This virtuous circle characterizes superstar firms and explains their hyper-growth and abnormal returns (Tambe *et al.*, 2020).

This also magnifies differences in the ability to choose relevant domains and frame problems, and therefore to see more strategic alternatives and predict their outcomes. Digitalization and algorithms make it possible to focus on the creation of opportunities and the predictions of their implications (*why* and *what*). This complementarity and the underlying increasing returns imply

that small initial differences across firms are likely to magnify in the future. Therefore, in the digital world, firms that do not set the right conditions for taking advantage of these opportunities are far more likely to be penalized by competition than in the past (Davenport and Westerman, 2018).

To summarize, the novelty of the conjecture we articulate in this study is that superior operational performance (*how*) is the most apparent but not the most important consequence of digitalization. It becomes a major source of competitive advantage when complemented with the ability to better explore the market, profile customers, tap into their needs and design products and services accordingly (*why* and *what*).

Complementary Conditions in Algo Firms

We envisage three conditions that can produce superior performance out of cognitive time and effort spent on low-frequency/high-impact decisions:

1. *A “scientific approach” to decision-making under uncertainty* — high-performance low-frequency/high-impact decisions rest on an approach based on: (a) well-defined theories (Felin and Zenger, 2009, 2017) or mental representations (Csaszar, 2018; Csaszar and Levinthal, 2016) based on the search and use of “canonical” forms, “simple rules”, general categories, analogies and “first principles” thinking (Bingham and Eisenhardt, 2011); (b) appropriate evidence, data and experiments (Luca and Bazerman, 2021; McAfee et al., 2012; Thomke, 2020). We call this approach “scientific” because it resembles the approach used by scientists to develop and test their theories (Camuffo et al., 2020). This approach is geared towards knowledge growth (henceforth, for simplicity, ΔK) which, as illustrated below, represents the ultimate source of business growth and, hence, the purpose of the firm. The adoption of the “scientific approach” is then simply a better “technology” that decision makers (top managers) apply for ΔK .
2. *Embracing fundamental uncertainty as the ultimate source of economic growth* — opportunities for growth come from unbounded exploration of unknown problems (Nickerson and Zenger, 2004) and the discovery/creation of market imperfections (Alvarez and Barney, 2010). Uncertainty is not necessarily an aversive state that managers and organizations should avoid or mitigate. Rather, opportunities arise from uncertainty “creation” (Griffin and Grote, 2020), which allows to move the knowledge frontier (ΔK). We argue in particular that the ultimate source of business and economic growth remains on the “granular” and fundamentally uncertain nature of customers’ needs (Davenport et al., 2011). Top managers then need to allocate the time and attention freed-up

by digitalization to the acquisition of knowledge about uncertain, variable and increasingly differentiated customers' needs, matching them to appropriate solutions (Von Hippel and Von Krogh, 2016).

3. *Owners as strategists* — with fewer decisions to be made, the traditional role of managers loses importance, as well as the agency problems it implies. ΔK (the exploration of unknown) is hard to contract for, since professional managers might not have the skills or the incentives to embark in moving the knowledge frontier. Besides, the cost of aligning their interests and solve agency problems might be prohibitive. ΔK , therefore, becomes a task owners tend to take on directly, becoming the firm strategists. With appropriate governance, combining ownership and strategy-making (“owner-as-strategists”) can create strategic, incentive, and commitment benefits that facilitate value creation (Foss *et al.*, 2021; Schulze and Zellweger, 2020). Better making of low-frequency/high-uncertainty decisions requires that owners modify corporate governance (board of directors) and executive teams so that they become “clubs” of decision-makers who share similar values and purposes, have the general abilities to explore an uncertain world (Kaplan and Sorensen, 2021) and directly take on responsibility for strategic decision-making. Many superstar companies today (e.g., Amazon, Facebook, Google) are good examples of firms which have been sustainably and effectively managed by owners and their “top-management-team-as-a-club” members.

These three conditions are complementary. If companies adopt any subset of them, they will enjoy significantly lower performance than any company that adopts all three altogether. In the remainder of the paper, we explain why companies that abide by all three conditions can achieve high, possibly “superstar-firm-like” performance. We also show how and why this framework implies that the ultimate purpose of the firm is the growth of knowledge (ΔK), and that all the other purposes descend as implications of this primitive purpose. Finally, we offer plausible explanations for other puzzling phenomena including the apparent financial markets’ overvaluation of Algo firms, high variation in returns from (unrelated) M&As and the rise of private capital. Figure 2 provides a synthetic visualization of our framework.

Three Conditions for High-performing Low-frequency/High-impact Decisions

A Scientific Approach to Strategic Decision-making

Low-frequency/high-impact decisions under uncertainty call for effective models of decision-making. Unlike high-frequency decisions, in which decision-makers

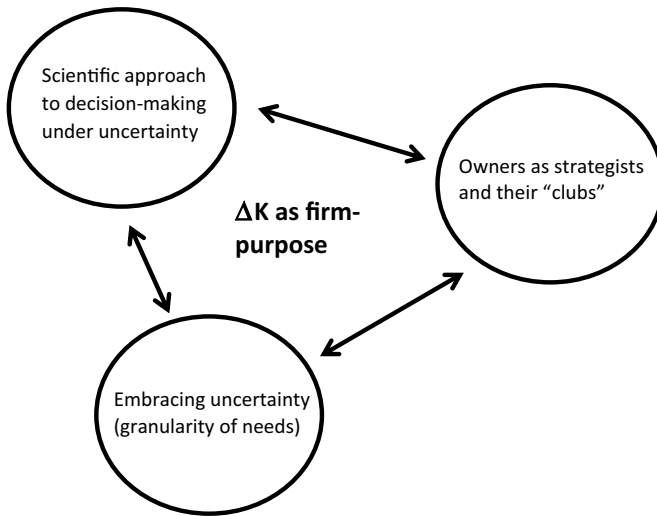


Figure 2: Complementary conditions in Algo firms.

have to find solutions to well-defined problems (e.g., a performance gap or target), in low-frequency/high-impact decisions managers first have to define the problem, and only then explore solutions. The thought process is typically synthetic (Nickerson *et al.*, 2007) and based on deductive, abductive and analogical reasoning. Since these decisions are characterized by Knightian uncertainty, decision-makers need to imagine and model the world, construct the possibilities that they have to decide upon, and more generally construct the decision problem conceptually (Arikan *et al.*, 2020). For these reasons, these decisions cannot be de-coupled from human judgement, and can hardly be automated (Alvarez and Porac, 2020).

Recent streams of strategy research have endorsed this view, emphasizing the role of mental representations (Csaszar, 2018; Csaszar and Levinthal, 2016), logical thinking (Sørensen and Carroll, 2021) and theory development (Felin and Zenger, 2009, 2017).

We move in this direction, and also try to better understand the nature of the exploration process (March, 1991). In particular, we envision two elements of the process: *investigation* and *problem definition*.

The *investigation* phase aims at learning about an unknown environment, and it does not commit to any definition of decision alternatives and scenarios. This phase is characterized by uncertainty “creation” (Griffin and Grote, 2020) and a “non-predictive” approach (Packard and Clark, 2020). It is an open path in which decision-makers pursue whatever they need in order to understand which opportunities they may pursue and their implications, and more generally

understand the environment in which they have to make the decision (Kaplan, 2008).

Of course, decision-makers have a sense of the path that they want to pursue. The investigation phase focuses on three elements: *choice of domain*, *map of domain*, and *initial framing*. The choice of domain is the decision to what to focus upon. The map lays out the domain's characteristics. It identifies the relevant variables of the problem, and the relations between them. The framing connects the domain and its map with some outcome of interest through a function that represents the way decision-makers envisage the links between domain and desired outcomes. Decision-makers rank questions and problems and decide which ones to focus upon or neglect. The framing also provides logical connections that suggest what else decision-makers need to learn and map to make a good decision. The choice of domain, its map and the initial framing are not decided once and for all at the outset of the process, but co-evolve continuously. They get defined and re-defined repeatedly during the investigation phase following feedback from the process (Ott and Eisenhardt, 2020).

At some point, decision-makers have to decide whether to pursue specific actions. This changes the nature of the exploration process from an open path aimed at understanding the environment (non-predictive approach) to a closed space aimed at assessing the consequences of a selected set of actions (predictive approach). The investigation phase has defined what is possible and has identified potential actions (decision alternatives). The *decision problem* is the commitment to assess a specific subset of these actions.

This is a critical juncture because decision-makers have to select the actions to assess, and then have to define alternative scenarios associated with different outcomes of these actions. These scenarios are alternative contingencies or states of nature. In so doing, not only do decision-makers commit to such specific states of nature, but they also commit to a prior probability distribution about their future occurrence. The decision problem then involves the definition of the *consequences of actions*, a *prior probability distribution* about the scenarios, and the *choice of an experiment* aimed at updating the probabilities to make a more informed decision.

This is a reduction of uncertainty because decision-makers know that, by defining the scenarios and their probabilities, they leave the world of unknown future contingencies and pretend not only that they can exhaustively list the relevant contingencies that will occur in the future, but also calculate the probabilities with which they will occur. The upside is that this is the way in which they can transform the problem from one that is not amenable to experimentation to one in which they can make experiments. Making experiments help decision-makers to learn about the decision problem they have defined by updating the probabilities of the contingent states of nature that they have defined fictitiously. In this way, they also learn about the

expected consequences of their actions (potential payoffs), assuming that the world that they have envisioned is “reasonable”.

We use the adjective “reasonable” in a precise way, which resonates the constructivist approach to fundamental uncertainty (Alvarez and Porac, 2020). A “reasonable” world abstracts away from many irrelevant contingencies for the consequences of the selected actions and takes into account many contingencies that make a difference for the consequences of these actions. The decision of what is relevant or not is based on theories and mental representations. Moreover, theories and mental representations attribute probabilities to these relevant contingencies and estimate consequences under the different contingencies. A “better framing” makes a better selection of the relevant vis-à-vis irrelevant contingencies, and estimates more precise probabilities and consequences of actions.

For example, decision-makers may explore the potential of acquiring target firms, and during investigation they learn about the environment and some potential target firms. At some point they have to decide whether to start a due diligence process about one or more of these target firms. This has a cost in that focusing due diligence on some firms means giving up, at least for the moment, alternative actions, such as conducting due diligence on other firms, or exploring internal growth. Therefore, the decision to run the due diligence for a specific group of target firms is, implicitly or explicitly, consciously or not, a statement that, with the information available at the moment, the probability distribution of the outcomes associated with testing these acquisition targets yields better expected outcomes than alternative actions.

To summarize, we have distinguished between investigation, in which decision-makers explore the unknown, and decision problem, that resembles more closely a standard (financial) decision in which decision-makers study the expected values of actions under a given probability distribution that they assume. However, we do not see investigation and decision problem as rigidly separated and strictly sequential steps. They can very well be intertwined, so that investigation leads to decision problems that then open up new investigations either to refine the definition of the decision problem or to investigate other decisions. Conceptualizing investigation and decision problem as separate, yet interdependent stages, makes our discussion fundamentally a discussion about the strategies of firms and not the mere assessment of alternative (financial) opportunities. In this respect our framework resonates the literature on strategic real options (Trigeorgis and Reuer, 2017).

Embracing Fundamental Uncertainty as the Ultimate Source of Business Growth

Thinking in terms of general frameworks is only a necessary condition, though. They have to be applied to the solution of uncertain problems that create

value (Alvarez and Barney, 2007). Granularity of market needs is the ultimate source of value and a fundamental source of uncertainty. Customer needs are “unknowable”, hard to know, unpredictable and “granular”. Understanding them means moving the knowledge frontier. They are a source of business growth because, ultimately, growth depends on the growth of demand, and while the quantitative growth of products eventually reaches diminishing returns, profiling of demand captures the differential value that customers place on different solutions. The ability to single out specific solutions has a considerable potential for growth in that it raises the utility of products or services of individual or small groups of customers. This raises the value they place on these products and services, and therefore their demand compared to standard solutions.

Understanding and profiling customers’ needs (“customer-centricity”) then becomes the “strategic core”. The automation of high-frequency/low-impact decisions complements this process. Not only do Algo firms design products and services and produce them more effectively (less variation and variability), but they can also more quickly reconfigure their processes (codification and digitalization allow to modularly recombine processes over time) as well as to gather more data about users. In the absence of frictions and other things equal, they have more incentives and resources available to explore markets, systematically profile customers and reconfigure and redeploy their capabilities accordingly (Teece *et al.*, 2016).

All this helps firms to profile customers, understand their differentiated and idiosyncratic needs and serve them with mass-customized solutions. This also helps to direct the general-purpose frameworks developed with the scientific approach from applications that are logically possible but not necessarily concrete to real applications. By digging into customer needs, decision-makers understand which logically possible applications are economically valuable and possibly envision new ones. To summarize, general frameworks provide broad options that become concrete when decision-makers understand the differentiated needs to which they can be deployed in practice. This dual process, developing general frameworks and understanding to what customers’ needs they can be applied, becomes the focus of attention of decision-makers in a world that has liberated cognitive time and effort for low-frequency/high-impact decisions.

This implies that Algo firms create value through knowledge accumulation: on the one hand, general frameworks enable to envision broader sets of opportunities and as they run experiments to assess these opportunities (whether small scale experiments or full-fledged large scale activities that represent experiments for other future initiatives), they learn, thanks to their broad frameworks, about new options. This process can scale with significant increasing returns; on the other hand, however, understanding the “granularity” of market needs represents both the opportunity for growth and the focus of a

process that could otherwise provide several opportunities with no clear logic about which ones to pursue.

Digitalization helps firms liberating time from high-frequency/low-impact decisions and also facilitates the process of knowledge accumulation for low-frequency/high-impact decisions. Algo firms progressively embody knowledge related to solved problems (including “known knowns”, “known unknowns”, and “unknown knowns”) so that the associated decisions are automated. This is what enables managers to explore, dynamically, new value creation spaces, dedicating time and attention to the solution of problems that are ill-defined, complex (“wicked”) or not thought of, yet.

The accumulation of validated knowledge then represents the ultimate goal that allow decision-makers to continuously map their goals onto alternatives and scenarios, thus navigating an evolving, rugged performance landscape (Grant, 1996). Broader and deeper knowledge stocks allow to more appropriately define exploration spaces (e.g., a new customer problem and segment) instead of optimizing locally the solution to an ill-defined, or irrelevant problem. What firms know constitute the foundation of how well they explore and how well they define and frame their set of strategic problems.

ΔK , Owners as Strategists, and their “Clubs”

The discussion so far implies that the growth of knowledge ΔK is the ultimate purpose of Algo firms: the pursuit of ΔK enables them to envision opportunities and deploying them in the appropriate markets to serve ever more granular customer needs (Nickerson and Zenger, 2004). ΔK is the ultimate purpose of the firm because all the other purposes descend from it.

As an example, suppose that firms have to make a decision on whether to undertake or not a costly sustainability ESG initiative (Flammer, 2015). One framing of the problem is that this decision is in conflict with the goal of financial performance, and the question is how to optimize the trade-off between the expected reduction in financial performance potentially deriving from the sustainability initiative versus the benefits (reputation, etc.) deriving from the initiative.

A different framing is to think about how to relax the trade-off and generate knowledge (ΔK) enabling the achievement of both financial performance and better ESG outcomes. Clearly, this requires tackling complex problems (“unknown-unknowns”) and investing in knowledge creation. More generally we can think of “ ΔK -as-purpose” as a general way to frame any problem in terms of value creation instead of value capture.

Digitalization offers a unique opportunity to dedicate more managerial time and attention to make low-frequency/high-impact decisions (as algorithms can take care of high-frequency/low-impact decisions). To the extent to which

decision-makers invest their time in general frameworks and the pursuit of relevant needs, this enables value creation as it moves the knowledge frontier.

The rise of ΔK as the ultimate purpose of firms has implications for their governance, too. The question is what governance modes enable firms to pursue their ultimate purpose (ΔK) and its deployment into its other purposes. The key issue is that ΔK is hard to define ex-ante, and thus contracts for knowledge are difficult to write (Teece, 1988). In the particular case of ΔK not only are inputs hard to define, but also outputs. Under these conditions, moral hazard and asymmetric information become critical impediments, engendering prohibitive agency costs when owners try to delegate firm activities to managers.

This is consistent with Nickerson and Zenger's (2004) position that, when problems are complex and interdependent and knowledge inextricably bundled (high uncertainty), authority and centralized decision-making works best because of "the capacity for one actor to identify the precise order of trials, thereby circumventing the need to contractually manage the order of trials or to spontaneously achieve some type of consensus through extensive knowledge sharing" (p. 624). Low-frequency/High-impact decisions imply fundamental tradeoffs only owners can ultimately solve.

So, as algorithms increasingly take care of high-frequency/low-impact/low-uncertainty decisions, the traditional role of professional managers in organizations gets thinner. Monitoring and coordinating Algo organizations is less demanding than the traditional coordinating and monitoring roles managers play in "Analog" organizations. Other things equal, this implies a more prominent and direct role of owners in strategy making.

This is also in line with Jensen's (1997) visionary prediction of "the eclipse of the public corporation" as well as with the rising literatures on owners as strategists and ownerships as competence (Foss *et al.*, 2021). As firms get digital, not only the need for a managerial technostructure (Galbraith, 1967) diminishes, but also the need for firms to converge to the model of the "public managerial firm" based on the separation between ownership and management (Berle and Means, 1932) fades.

Finally, financial markets' efficiency and diversification (decline of public equity markets, disintermediation of traditional financial institutions, etc.) also contribute to the rise of ownership-concentrated firms in which these fewer owners are more active/agentive. This implies tighter governance, with owners/investors directly able to define and monitor the corporate strategy. In such context, algorithms take care of executing the strategy which is defined by board of directors and top management teams based on what owners want. Cross-firm performance differentials will derive not only (and not so much) from cross-firm differences in capabilities but also from cross-firm differences in ownership competence (Foss *et al.*, 2021).

Owners' first best is then to retain a key role in making low-frequency/high-impact decisions that aim at defining ΔK . Owner-managers can run the companies through boards of directors and top management teams which function as "clubs" of selected members that share similar attributes, values and motivations and are not kept together by performance contracts and optimal incentives aimed at reducing agency costs. Owners staff their "clubs" by selecting members motivated by similar non-pecuniary incentives to raise ΔK . The owner then defines the "what", and together with the club defines the "why". The managers develop algorithms to take care of the execution "how".

To summarize, digitalization makes the structure of the managerial firm, with ownership separated from professional management developed and evolved in an Analog setting a "second best" vis-à-vis the entrepreneurial (Schumpeterian) model of the firm. Thanks to the automation of high-frequency/low-impact/low-uncertainty decisions, the entrepreneurial model becomes fully "affordable" and "scalable", with owners more capable to act as "strategists", concentrating on low-frequency/high-impact/high-uncertainty decisions. The owner/entrepreneur can build and scale up the business without having necessarily to switch (at given firm size thresholds) to the managerial model in which ownership and management are decoupled. This shorter decision chain significantly reduces agency problems and inefficiencies related to incentive and monitoring cost, further unleashing resources for exploration of the unknown, knowledge accumulation and business growth (Schulze and Zellweger, 2020).

At the same time, board of directors and top management teams can dedicate more cognitive resources to make better low-frequency/high-uncertainty/high-impact decisions. They can adopt a broader, more comprehensive view of how to create value through exploration, aligning and integrating low-frequency/high-uncertainty/high-impact decisions, facilitating the consistency among choices regarding ownership and capital structure, customer markets, M&As, and human capital. These choices can be considered "in parallel" and not as "standalone" decision problems which can be decided in isolation and optimized separately (Leiblein *et al.*, 2018).

The Relationship between Algo Firms and Scientific Approach

We argue that the independent adoption of digital technologies and the adoption of a scientific approach to strategic decision-making both result in better performance.

On the one hand, as demonstrated by a sizable body of empirical research, the adoption of complex sets of digital technologies (ML, AI, big data, etc.) has positive performance effects driven by higher productivity and operational efficiency (Brynjolfsson and McAfee, 2011; Brynjolfsson and McElheran, 2016).

On the other hand, as demonstrated by empirical studies about the application of the scientific method to entrepreneurial and managerial decision-making, entrepreneurs and managers that behave like scientists make better decisions (Camuffo *et al.*, 2020; Zellweger and Zenger, 2021).

However, while firms can benefit from the independent and separate adoption of digital technologies and the scientific approach to decision-making, we maintain there is complementarity in their joint adoption, so that Algo firms adopting the scientific approach to decision-making can hyperscale and outperform competition.

Similar to Milgrom and Roberts (1990) in relation to the emergence of modern manufacturing, we argue that digital technologies reduce information and decision costs for high-frequency/low-impact decisions. In addition to this direct effect on performance, there is also the indirect effect deriving from the managerial cognitive release. More managerial cognitive resources available make the returns on the adoption of a scientific approach to decision-making larger. This indirect effect reinforces the direct effects of adopting separately digital technologies and the scientific approach so that the joint adoption of digital technologies and the scientific approach to decision making have super-additive effects on performance.

Therefore, firms can do better by either adopting digital technologies (i.e., transforming themselves into Algo firms) or adopting the scientific approach to decision-making (i.e., remaining Analog firms). Yet, the complementarity between digitalization and scientific decision-making makes the returns deriving from their joint adoption larger.

“Better Framing” as a Key Source of Competitive Advantage

Algo Firms Choose Experiments

One implication of our framework is that *decision-makers do not choose among alternatives to which they attach different expected values, but among different experiments* (Camuffo *et al.*, 2021).

For instance, in the acquisition example discussed earlier, decision-makers choose to run the due diligence on some target firms and not others, or vis-à-vis internal development or other alternative actions; or they could run different experiments on the same target firms, such as a minority participation to assess the potential for future acquisition; or they could frame the experiment differently, for example if they think of the acquisition as the addition to the product portfolio of the acquirer or as a source of skills for a broader project; or they could simply design more informative experiments, such as a more informative procedure in the due diligence process in which they ask different questions or focus on different information. The key point is that, once the

choice of which experiment to run is made, the choice after the experiment is predetermined: the experiment establishes what to do under the different contingencies. The key strategic choice that makes a difference for performance is then which experiment to run rather than what to do given the experiment.

We interpret experiments broadly. Decision-makers run many conceptual experiments during the investigation phase. When they choose the variables to focus upon, or when they realize they should consider other variables, they are *de facto*, and often implicitly, making conceptual experiments. Moreover, we can think of their background knowledge, or their experience with the phenomenon, or anything else that make them believe that their conjectures are robust, as the extent to which they rely on “pseudo-observations” that make them confident about their conjectures. When they move to problem definition, they make a more explicit choice of an experiment. However, this experiment need not be physical. It could still be a conceptual experiment, such as an accurate thought of whether to invest in the due diligence for a particular set of firm targets rather than experimenting with alternative opportunities.

Of course, on many occasions the experiment is a tangible commitment, such as the decision-makers carry out the due diligence for a specific set of firm targets. In this respect, even the full-scale investment (e.g., the acquisition of the firm, or the market launch of an innovation) can be thought of as an experiment. While decisions may have different degree of reversibility, no decision is fully irreversible. It may be more costly to change it or it may require more time, but even a full-scale decision will produce information that may suggest future changes about what to do — from adjustments of the initial decision or investment, to radical changes such as a full redeployment of the resources (Folta *et al.*, 2016; Lieberman *et al.*, 2017; Santamaria, 2021).

Sources of Better Framing; Precision and Breadth

The complementarity among the three conditions discussed in the previous section, along with the choice of experiments, imply that different ability to frame strategies may yield radically different results, particularly if algorithms provide opportunities to focus attention on low-frequency/high-impact decisions. In a digital world, better framing becomes a central source of competitive advantage.

Better framing affects both the investigation and the problem-definition phase. We envision two sources of better framing.

The first one is precision. Precision is the ability to select scenarios in the problem-definition phase that overlap to a greater extent with payoff-relevant scenarios, and to exclude as much as possible irrelevant scenarios. In addition, decision-makers estimate more precisely the returns in each one of these different scenarios. During investigation this means that decision-makers have

a better ability to identify the relevant problems or questions, the relevant variables, the relations between them, and more generally they have a superior ability to develop and articulate conjectures. It also means that they generate a higher number and quality of experiments from which they select the experiments they run. They also design experiments better, in the sense that they run experiments that provide more information at the same cost (Camuffo *et al.*, 2021).

Precision stems from better theories that enable decision-makers to identify the right variables and scenarios, and to estimate payoffs with a lower margin of error. Theories and the pseudo-observations associated with their knowledge background and experience also make decision-makers more confident about what to do. For example, sometimes decision-makers do not know how to rank problems. This may paralyze decisions because decision-makers raise many problems, questions and variables, and do not know how to select the ones they should focus upon or tackle first.

The second source of better framing is the ability to work with general, canonical categories (Durand and Khaire, 2017). While precision has the ability to make better predictions through better acquisition and selection of information, the ability to frame problems more generally increase value. General categories enable decision-makers to see more options. This comes from more general theories and experiments, which are intertwined and they provide information about a broader set of implications and actions. This generates value in two ways. First, decision-makers can pursue several opportunities of growth. Second, if firms are resource-constrained and can only pursue a subset of options, they have more choices, and thus a higher expected value of the best options. This is the essence of “scientific” reasoning (Camuffo *et al.*, 2020) whereby decision-makers think in terms of canonical forms and general categories and conceptually link seemingly distant phenomena.

For example, consider a firm that targets the acquisition of a firm specialized in AI applications to the health industry, such as an automated diagnostic tool. The acquirer could think of the acquisition as an opportunity to expand its portfolio of products, or as an opportunity to acquire the AI skills of the target firm for a broader project with several applications. In the former case the focus is on the specific product. In the latter case it is on the general-purpose asset underlying the specific product (Conti *et al.*, 2019).

If we think of the due diligence on the target firm as an experiment (Puranam *et al.*, 2006), the acquirer will frame the problem and design the due diligence process — that is, the experiment — in different ways according to the narrower or more general goal (Reuer and Sakhartov, 2021). In the former case, it will focus on the value of the product and the relevant characteristics of the target firm in terms of their contribution to the portfolio of the acquirer; the due diligence will be narrower and informative about the potential market synergies deriving from the acquisition. In the latter case, it will focus on

the value of the technology and its potential applications. The results of this broader experiment will provide information about a larger set actions and opportunities. The different framing and the different due diligence in the two cases will lead to different evaluations of the target firm.

“Verticals”

Innovation (Market Strategy)

Innovation decisions are low-frequency/high-uncertainty/impact decisions as they try to address customers' needs which are characterized by fundamental uncertainty.

Any market innovation is rooted on deeply understanding customers' needs which derives from carefully mapping customers' goals/values/preferences onto such needs. The nature of such mapping is peculiar, though. Customers goals and preferences are unknown to firms and often unknown (not articulated) also to customers' themselves. This implies that it is often necessary to elicit them, and that customers' needs might not be simply discovered (they exist and need just to be surfaced) but somehow imagined/generated based on other knowledge (theory and data about customers). This implies that innovation opportunities are often created and not necessarily simply recognized/discovered. In this sense, innovation is firms' fundamental challenge (Knightian uncertainty) and the fundamental driver of value creation. Consequently, innovation decisions are the quintessential application of our framework.

The innovation process often starts from a domain identified by the decision-makers who explore it by creating maps of the relevant variables and phenomena, and then frame the links between environment and their potential actions. The investigation phase leaves the ground to a problem definition when the decision-makers want to test a particular innovation or design. In this case, they have to define scenarios, contingencies and probability distributions, and run their experiments to elicit signals about the viability of their innovations.

The definition of scenarios, probabilities, and actions is the outcome of the “fictitious” reduction of uncertainty that we discussed earlier. They rest on a commitment on the relevant scenarios for the consequences of the actions, and on assumptions about their probability distribution and the value of the actions under the different scenarios. In turn, better framing means greater ability to conduct this process in ways that will yield higher returns. This means ability to define more valuable actions, and then relevant scenarios, probabilities and consequences of actions, and design more informative experiments. The ability to define general-purpose innovations, or to embed the innovation in a broader framework and strategy of the firm, is likely to produce higher performance because it can give rise to more options to test. Of course, in a digital world,

an effective use of data can help both to develop better theories and mental models, and to run more informative tests.

Innovation decisions are also the critical realm where, by definition, the profiling of market needs and the ability to cover their granularity is crucial. As we said, the ability to tap into this differentiated demand creates value by offering mass-customized solutions which is the ultimate source of value creation. Predicting these needs involve fundamental uncertainty. A scientific approach to decision-making then provides a technology for uncovering these processes and making the underlying decisions.

Overall, we posit that Algo firms have more cognitive resources available to engage in the above described “investigation” phase. Because of that, they: (a) focus more on market needs exploration and in developing innovative monetization strategies; (b) conduct more and more effective experiments; (c) explore and test broader sets of alternative desirable/feasible/viable innovation opportunities; (d) develop, cumulate and validate more knowledge at a faster rate.

These conjectures are consistent with the burgeoning evidence and literature about business experimentation and emergence of business experimentation labs at Amazon, Facebook, Google, etc. as well as of business experimentation platforms (e.g., *optimizely*) (Thomke, 2020). They echo extant research suggesting that firms can increasingly test their market hypotheses effectively, rigorously and cheaply using analytics, artificial intelligence and machine learning (McAfee *et al.*, 2012) and that the availability of more data and more powerful methods exacerbates the need for interpretative frameworks and critical thinking (Brynjolfsson and McAfee, 2017). It is consistent with the theory-based approach to strategy (Felin and Zenger, 2009, 2017) according to which strategies cannot be mere trial-and-error search processes but require a conceptual framework that guides strategic action. It is compatible with the idea that managers and entrepreneurs should develop mental representations of their opportunities, that is, models of reality that can be used to generate predictions about it (Csaszar and Levinthal, 2016).

M&As

M&As are low-frequency/high-impact decisions with wide variability in performance (Haleblian *et al.*, 2009; King *et al.*, 2020).

The standard approach to M&As focuses on knowledge acquisitions to better serve a given business strategy. For example, a company buys a supplier to integrate the production of an input, or a buyer to minimize the impact of market uncertainty. These acquisitions typically focus on the capabilities of the target, as well as on the obtainable synergies. In this case, the source of uncertainty are the unknown attributes of the target and its actual market

value. These can be mitigated by acquisition of information, for instance via due diligence.

Alternatively, decision-makers can see acquisitions and mergers, as projects aimed at generating knowledge to run future projects, not yet well-specified. Clearly, these decisions imply greater uncertainty. In this case, M&A decisions are part of a broader theory devised by the firm about its future in which the acquisition of companies, or mergers, are options to carry out specific projects. While the details of the specific projects may not be laid down, there is a general theory behind the broader firm strategy. This will, in turn, inform the specific theory behind specific M&A operations.

In this respect, a theory or mental representation about M&As allows to frame the deal around dimensions such as:

1. *Relatedness* (categories, analogies). The scientific approach implies cross-acquirer heterogeneity in the definition of what is related and what is not. In particular, acquirers with broader frameworks may see relations that others, with narrower frameworks, do not see. This “theory-grounded” concept of relatedness has to do mostly with the choice and mapping of domain (Finkelstein and Halebian, 2002).
2. *Synergies* (market power vs cost reduction, complementarity and substitutability). The way acquirers define the potential outcome of the acquisition is a function of the domain choice and its mapping. This also defines the model of the potential benefits or gains expected from the M&As. Synergies have mostly to do with the framing of the problem (Rabier, 2017).
3. *Value creation vs value capture*. Acquirers could focus on what they contribute to the target (giving) or on what they get from the target (taking). For example, acquisitions to enter an attractive market are in the “take” mode. Under this condition, sellers can increase their price (especially if there are many potential buyers). But when the acquirer envisions projects that improves the value of the target or make the combined firm more valuable, the acquirer will face fewer competitive bidders and earn the rewards that flow from the value of the idea behind its project. Of course, the prospect of joining a more valuable project provides value to the target on top of other contributions of the acquirer, such as provision of growth capital, better managerial oversight, transfer of valuable skills, and sharing valuable capabilities (Capron and Pistre, 2002; Martin, 2016).
4. *Short- vs long-term visioning* (sequencing of operations, *ex ante* inclusion of *ex post* integration decisions). Time orientation is important in framing the acquisition decision-making process. First, it affects the domain’s

choice and mapping, as well as the problem framing. Second, it affects what states of the world are possible, and the probabilities and values associated to the contingencies. Third, time is associated to the cost of capital and the cost of foregone options, which further influences the acquirer's estimates. The longer the time horizon, the more complex the theory because of fundamental uncertainty (complex causal chains, nonlinearity, non-convexity). However, the theory is also potentially more promising. Fourth, time orientation determines what elements are relevant and might affect the outcomes of the operation (Renneboog and Vansteenkiste, 2019).

5. *Context.* M&As can be an episode of a strategy, such as in the case of a firm's theory that relies on organic/internal growth). In this case the theory underlying an M&A operation is narrow and ad hoc. Alternatively, M&As can become the strategy, such as when the firm's theory relies largely on M&As to dynamically configure a portfolio of customer needs and capabilities. In this case, the theory underlying an M&A operation is broad and general (Laamanen and Keil, 2008).
6. *Dynamic connection between acquisitions and divestitures, mergers, other investment.* Decision-makers, whether owners or board of directors, might have a theory for a single acquisition or for an acquisition program, or a theory for dynamic investment (series of M&As, divestitures, etc.). Again, this has implications for the breadth and depth of theory (Capron, 1999).

Acquirers can then use data either to calibrate or validate their theory, or to disprove and then possibly modify it, or to test the future outcomes of the decision given the underlying model or framework. Since M&A are low-frequency decisions, most often ideal data are not available. However, data may come from conjectures or from available information that, even if not perfectly suited for the goal, can be processed by theory to devise or support logically valuable implications. By definition low-frequency/high-impact decisions often lack robust past data and information. The data have to be created, and part of the task of theories and mental models is to design experiments that generate these data or information, or that fill, through logical frameworks, the gaps left by unavailable data.

Examples of data that can generate validated knowledge in M&A decisions are:

1. *Cross-sectional data on M&As.* Acquirers can use cross-sectional data (cross-firm, cross-industry) about other M&As as substitutes for longitudinal data on the M&A to be decided. The opportunity to learn from these different experiences depends on the ability to frame the

analogy and understand how and where decision-makers can use these cases to inform their own. Again, the theory, and the framing of the problem, is crucial to extract valuable information (Zollo, 2009). A scientific approach typically helps to design the experiment, through, for example, the specification of the error, the identification of counterfactuals, and then make the best use of available cross-sectional data for decision-making.

2. *Due diligence as an experiment.* Acquirers can collect meaningful data to both validate theory and refine estimates. The design of the experiment underlying due diligence is critical (nature and scope of due diligence). This implies that acquirers could use due diligence not only to check assumptions on estimates (confirmation biases) and mitigate, risks but to learn about unforeseen contingencies, question their theory and increase capabilities (Puranam *et al.*, 2006; Wangerin, 2019).

The process described so far is intertwined with the decision of the price of acquisition, via bidding and negotiation. Clearly, better framing also implies that companies will set the right price for the operations, with implied superior value creation, whether in the short-term (stock market reactions, and over/underpricing) or in the long term (financial performance of the combined firm).

CEO Succession

CEO succession (and more generally decisions about strategic human capital) are also typical low-frequency/high-impact/high-uncertainty decisions characterized by significance variation in terms of financial performance effects (Quigley *et al.*, 2019). Extant research shows that:

- (a) CEOs matter for the performance of companies (10–30% of variation in company financial performance) and their contribution has increased over time (Fitza, 2017; Hambrick and Quigley, 2014; Nguyen and Nielsen, 2014; Quigley *et al.*, 2017; Quigley and Graffin, 2017; Quigley and Hambrick, 2015). Yet, the distribution of CEOs' contribution to financial performance across firms follows a power curve, with a small number of CEOs generating most of the value within the top value generating companies in the US stock market (Aguinis *et al.*, 2018).
- (b) CEO compensation has grown over time with best firms sorting the best CEO in the market, and optimizing compensation cost conditional upon contribution (Falato *et al.*, 2015).
- (c) Firms focus on CEO compensation to induce optimal contribution given performance goals but underestimate the role of CEO selection as financial performance driver (Murphy and Zabochnik, 2004).

These trends are exacerbated in Algo firms because CEO succession decisions interacts with capital structure and M&A decisions. Besides, owners (or board of directors on their behalf) want to co-opt CEOs who can contribute to exploration, that is to the envisioning, design and implementation of multiple, novel and plausible market strategies (ultimately, ΔK).

As algorithms cover increasingly managerial tasks, the job of the CEO becomes less defined. CEO succession decisions can then be conceptualized as a process of “casting” for a project to be defined. Consequently, Algo firms will cast CEOs with more general human capital than Analog firms that will instead “hire CEOs for job” emphasizing managerial abilities.

Moreover, hiring CEOs for a project to be defined lowers the importance of contracts with optimal incentive structures vis-à-vis the processes of recruiting and selecting appropriate candidates. Algo firms can dedicate more time and effort to CEO succession decisions. Theory and data help them to better frame the CEO-succession problem and reduce uncertainty about the potential fit of the candidates with the company purpose and owner’s goals. Our prediction is that the adoption of a scientific approach will lead to consider broader sets of internal and external candidates, which will be thoroughly tested and scrutinized (potentially longer succession periods). Firms will incur in fewer false positives (more “no hire” decisions) and ultimately perform better. We also predict that more able CEOs will match with algo-firms because they can generate more knowledge (and value) in these companies (Elfenbein and Sterling, 2018).

Since digitalization also drives labor market transparency and efficiency, we predict that more able CEOs will obtain higher rewards. However, these higher rewards will not be necessarily monetary. Owners will select CEOs because they are intrinsically motivated to join and carry out the project of the firm. Because the project is not well defined, this motivation rests on the broader and basic principles of the project. We showed why the purpose of these companies is the growth of knowledge, ΔK . This suggests that selection will really be on the general motivation to pursue the growth of knowledge, as opposed to the details of the corporate or business project. We predict that Algo firms will feature “clubs” of top decision-makers composed of owners, CEOs and other high-level managers who share similar values and particularly the value that ΔK is the purpose of the firm. Monetary compensation will then be a “reverse membership fee” that CEOs and top managers will receive from the owner for being part of the club.

Scientific decision-making also implies that owners will first have theories and data to select and recruit CEOs or other members of the club, and since the recruiting and selection process will feature more prominently than contracts, they will then experiment, which means that members of the club will spend periods in the company before both parties will make long-term commitments. These experiments will enable both owners and potential

club-members to acquire information about the un-contractible unknown of the process. Compared to the traditional CEO “job-appointment” process, based on standard contracts, this CEO “casting” process makes appointments less likely at the beginning of the relation, but more likely to continue and become a solid long-term relation if it survives beyond the initial interim period. Since internal succession and succession planning might be cheaper and more effective experiments to conduct, other things equal we also predict that internal succession will also become more likely.

Ownership/Capital Structure

Capital structure decisions are probably the most important low-frequency/high-impact/high-uncertainty decision. They include the decision about ownership (why to own, whom should own, how and when) and access to capital.

In the past, this decision was simpler, as it was mainly a decision about how to optimize debt vs equity in order to satisfy the capital requirements associated to a given corporate strategy (Rajan, 2012). Today, the evolution of financial markets and instruments, as well as the rise of many and very heterogeneous potential investors makes it a far more complex decision. It is a decision filled with uncertainty about the best combination of co-ownership vs acquisition of financial capital, and the best parties with whom to partner (Dittmar and Thakor, 2007). Moreover, these decisions are, for the majority of firms, non-recurrent and difficult to reverse.

They are challenging decisions for business owners and require the application of the scientific approach as superior decision-making technology under condition of uncertainty. As Foss *et al.* (2021) suggest, competent owners make capital structure decisions about why to use or require capital, what to own and not to own, and about how to govern the relationships with the investors. Theories and mental representations then have to deal with dimensions such as:

1. number and type of owners (ownership structure and rights),
2. owners’ goals and time orientation (type and level of aspirations),
3. enacted financial markets (categories of financial intermediaries),
4. time horizon of capital structure decisions (sequencing of decisions, relationships among them, dynamic feasible set),
5. degree of reversibility of capital structure decisions and interdependencies with corporate/business strategy and human capital strategy,
6. cost of capital (WACC and opportunity cost),
7. earnings distribution policies.

Decision-makers can then use data either to validate their theory or to test the future outcomes of capital structure decisions given their theory. Data, conceptual experiments and other types of experiments can be used to validate the conceptual model of the hypothesized capital structures, thus allowing to check if they are sound and allow for fine-tuning, improvements, major changes or discarding. They can also be used to better predict the future outcomes of a capital structure, assuming a certain model, theory, or mechanism. In this case, the acquisition of data or conducting experiments improves the accuracy of the probability distributions of the decision alternatives allowing to learn about the viability (value) of a given theory.

Of course, because capital structure decisions are low-frequency decisions, and ideal data or experience to extrapolate from the past may not be available. However, as discussed earlier, the essence of our framework is not that decision-makers always run physical experiments with full-fledged physical data. As noted, data are created from available data and information, and it is the theory and the mental frameworks that help to interpret them in ways that enable decision-makers to validate theories or to devise new theories or solutions.

An important source of fundamental uncertainty is the association between capital structure and owners' general goals and needs. As discussed earlier, owners who bet on ΔK do not have well-defined projects. As a result, a theory about the best capital structure has to be combined with a theory about the project of the firm, as the two are interdependent. This makes the theory more complex, but also more solid since it does not ignore these interdependencies.

In addition, this means that different capital structure decisions have profound implications for firm performance not only because capital structure optimization reflects the capital requirements defined by the firm strategy, but also because capital structure decisions might shape and/or constrain the strategy of the firm. As we highlighted, the pursuit of ΔK , which is central for the performance of firms, requires a direct commitment of the owners in the strategy of the firm because of the inefficiencies associated with contracting uncertain and possibly intangible purposes (Schulze and Zellweger, 2020). The interdependence between firm strategy and capital structure decision implies that owners cannot delegate capital structure decisions either — for instance to specialist financial executives, instead owners need to collaborate with their “club” in making these decisions. However, the club has to be formed in the way we suggested earlier — that is, based on recruiting processes that select collaborators who share similar values. The point here is that these processes encompass decisions, such as capital structure and its management, that were largely delegated to specialist managers in Analog firms.

Variation in firm performance due to capital structure decisions (and related decisions regarding governance, ownership, etc.) has been widely investigated in finance and strategy but there is not an overarching theory able to explain and norm capital structure decisions from the standpoint

of business owners/entrepreneurs (Lemmon *et al.*, 2008; Myers, 2001). The standard approach in strategy is to conceptualize capital structure decisions as the solution to a corporate finance optimization problem, given the firm's purpose and strategy. The framework of this paper explains why capital structure decisions are fundamental strategic decisions, and not merely financial decisions. Not only do they contribute to the firm performance by enhancing real performance, and not just financial returns or lower cost of capital, but they also contribute to the ultimate purpose of the firm, ΔK .

Discussion, Research Agenda, and Conclusions

This paper argues that the digital revolution is not an organizational revolution, but primarily a revolution in the nature, implications and performance of firm strategies.

Our logic is simple. Algorithms help decision-makers to save time because they automatize high-frequency/low-impact decisions. This raises the opportunity to spend cognitive time and effort on low-frequency/high-impact strategic decisions. Since these decisions are highly uncertain, this opportunity requires a rigorous approach to make these decisions.

We highlight three pillars. First, uncertainty calls for a scientific approach based on theories that use general categories applied through deduction, abduction and analogy to alternative options. Second, this superior decision-making raises the value of strategies that embrace rather than escaping from fundamental uncertainty. Growth of knowledge, ΔK , then becomes the purpose of the firm because it helps to tap uncertain granular needs that are the main source of business growth. Third, the focus on ΔK implies that shared values and goals, particularly ΔK itself, become central to recruiting and partnering choices. A scientific approach then also becomes the way to make this selection into the club.

The importance of decision-making under uncertainty makes the ability to frame problems, and firm strategies more generally, a key source of competitive advantages. This is less central in Analog firms because they have less time for cognitive investments in low-frequency/high-impact decisions. Their competitive advantages rest on the ability to manage efficiently many high-frequency/low-impact decisions altogether. In Algo firms, instead, where these operations are taken care by algorithms, differences in the ability to frame low-frequency decisions can produce significant differences in performance. Moreover, we emphasize the complementarity between the three pillars. Better framing gives rise to superior performance if combined with a systematic attention to granularity of needs and ΔK , and a governance of firms in which owners play a direct role together with clubs recruited on the basis of shared values and a common motivation to pursue ΔK .

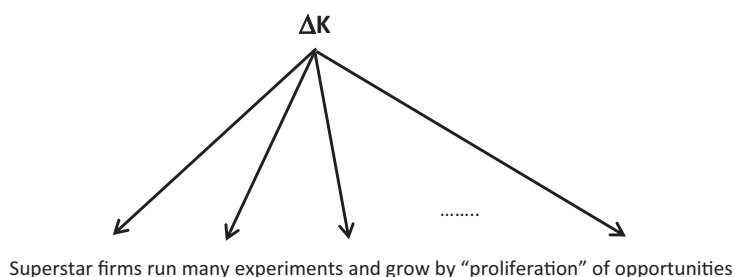


Figure 3: ΔK and superstar firms. Superstar firms run many experiments and grow by “proliferation” of opportunities.

We conjecture that these mechanisms explain the superior performance of superstar firms. As Figure 3 shows these firms lever the ability to exploit the general-purpose nature of ΔK to tap into multiple projects, typically different granular needs. The general-purpose nature of ΔK stems from the ability to think in terms of general categories that can be applied repeatedly to different contexts, an advantage that accrues particularly to Algo firms as many of these applications do not entail dramatic physical costs. Analog firms could exploit general-purpose categories only up to a point, first because they do not have time to generate the general frameworks, and then because the downstream costs of pursuing largely physical applications make it harder to exploit them. As discussed in the earlier sections, the potential to re-apply knowledge comes both from actual multiple applications and the opportunity to face more strategic options and bet on the most promising ones.

While superstar firms raise concerns about concentration, there are counter-veiling effects. As more firms learn to better frame problems and combine them with the other two pillars, we will witness more diffused opportunities of growth. Digging into the granularity of needs is largely non-rivalry because there are nearly untapped opportunities to differentiate solutions. The increasing returns associated with digitalization may then not only work at the level of the firm, but also of industries or economies as a whole. The ability to learn how to frame problems under uncertainty and to focus on ΔK , along with a governance based on ownership-related clubs, can then be crucial for both private and social returns.

This paper outlines a research program we intend to pursue: we want to understand better the nature of the three pillars and their mechanisms; we intend to collect evidence by conducting empirical analysis in different contexts and under different conditions; we want to study systematically the “verticals” only sketched in this paper to engage to a greater extent with existing literature and understand better the links with our framework. There are also more

verticals that we could suitably interpret with the lens of our model. Also, we want to understand better the investigation and problem-definition phases of the decision-making process (Camuffo *et al.*, 2021).

More specifically, we see three particularly promising investigation avenues. First, to engage the managers of Algo firms in experiments or other types of research activities so that we can understand *how their decisions are made when they are made*. Second, we would like to study innovation, capital structure, M&As and CEO succession decisions comparing and contrasting firms with different degrees of digitalization and performance. Third, we would like to understand how low-frequency/high-impact decisions themselves become more codified and possibly routinized and automated using “playbooks” and canonical forms.

Our framework raises a number of questions. An important low-frequency/high-impact decision is the very decision to digitalize the firm. One approach is to digitalize specific sections of the firm without an overarching theory of what to digitalize and why. These firms focus on the “how.” This will produce continuous checks and adjustments that demand systematic managerial attention that may reduce the advantage of liberating time for low-frequency/high-impact decisions. Simply put, the lack of a theory of how to digitalize the firm may undermine the potential of digitalization. A related question is about the choice of where firms will set point D in Figure 1 — that is, what is the share of decisions they choose to automatize vis-à-vis the decisions that they want to leave to the judgment of owners and decision-makers.

An open question in our analysis is whether decision-makers will actually re-deploy the cognitive resources freed-up by algorithms taking care of high-frequency decisions to low-frequency/high-impact decisions. This need not be. Decision-makers could re-allocate this time to leisure or more generally take it as a perk of their job. On the one hand, this will depend on preferences. On the other hand, it will depend on the recognition that the choice not to focus on ΔK will have implications for the competitive advantage of the firms. Our framework predicts that decision-makers who invest in ΔK will outcompete firms that do not do so. As a result of this selection process, firms that invest in ΔK are more likely to remain at the forefront of industries and economies. This is an area for research with far reaching implications for competitive strategy, market structure, and dynamic competitive processes.

A final relevant question has to do with the broader macro-implications of a world in which few decision-makers make key decisions inside the firms. Firms, or more generally societies, that embrace ΔK as purpose have the potential for high-growth in that it is hard to find boundaries to the growth of knowledge. This implies that, not only at the level of individual companies, but also at the level of industries or economies, the more individuals contribute to the growth of knowledge, the more we find opportunities for growth, whether

within the same firm or because of the growth of many firms working in many differentiated domains. However, this calls for heavy investments in education in that the main limitation will be the share of individuals in our societies who can contribute to ΔK . Another way to put it is that the potential for inequality created by digitalization may depend on the inability of societies to diffuse education and raise considerably the supply of contributors to ΔK .

In the transition, this may call for ex-post redistribution policies both within companies and societies at large. This issue is not central to our discussion which is focused on firm strategies, and a detailed discussion of this point is beyond the scope of this paper. But we cannot ignore this consequence of digitalization and the focus on ΔK as purpose. This recognition also helps to highlight that we need to understand how to cope with it and how to raise dramatically the supply of human capital in a digital world.

References

- Adner, R., P. Puranam, and F. Zhu. 2019. "What Is Different about Digital Strategy? From Quantitative to Qualitative Change". *Strategy Science* 4(4): 253–61.
- Agrawal, A., J. Gans, and A. Goldfarb. 2017. "How AI Will Change the Way We Make Decisions". *Harvard Business Review* 26.
- Aguinis, H., L. R. Gomez-Mejia, G. P. Martin, and H. Joo. 2018. "CEO Pay Is Indeed Decoupled from CEO Performance: Charting a Path for the Future". *Management Research: Journal of the Iberoamerican Academy of Management* 16(1): 3–30.
- Alvarez, S. A. and J. B. Barney. 2007. "Discovery and Creation: Alternative Theories of Entrepreneurial Action". *Strategic Entrepreneurship Journal* 1(1–2): 11–26.
- Alvarez, S. A. and J. B. Barney. 2010. "Entrepreneurship and Epistemology: The Philosophical Underpinnings of the Study of Entrepreneurial Opportunities". *Academy of Management Annals* 4(1): 557–83.
- Alvarez, S. A. and J. Porac. 2020. "Imagination, Indeterminacy, and Managerial Choice at the Limit of Knowledge". *Academy of Management Review* 45(4): 735–44.
- Arikan, A. M., I. Arikan, and I. Koparan. 2020. "Creation Opportunities: Entrepreneurial Curiosity, Generative Cognition, and Knightian Uncertainty". *Academy of Management Review* 45(4): 808–24.
- Autor, D., D. Dorn, L. F. Katz, C. Patterson, and J. Van Reenen. 2020. "The Fall of the Labor Share and the Rise of Superstar Firms". *The Quarterly Journal of Economics* 135(2): 645–709.

- Autor, D., D. Mindell, and E. B. Reynolds. 2019. *The Work of the Future: Shaping Technology and Institutions*. 58. Cambridge, MA: Massachusetts Institute of Technology.
- Bebchuk, L. A. and S. Hirst. 2019. *The Specter of the Giant Three* (No. w25914). National Bureau of Economic Research.
- Berle, A. A. and G. Means. 1932. *The Modern Corporation and Private Property*. New York, Harcourt: Brace and World.
- Bingham, C. B. and K. M. Eisenhardt. 2011. "Rational Heuristics: The 'Simple Rules' that Strategists Learn from Process Experience". *Strategic Management Journal* 32(13): 1437–64.
- Brynjolfsson, E. and A. McAfee. 2011. *Race Against the Machine: How the Digital Revolution Is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy*. Lexington, MA: Digital Frontier Press.
- Brynjolfsson, E. and A. McAfee. 2017. "The Business of Artificial Intelligence". *Harvard Business Review*: 1–20.
- Brynjolfsson, E. and K. McElheran. 2016. "The Rapid Adoption of Data-driven Decision-making". *American Economic Review* 106(5): 133–39.
- Camuffo, A., S. Cerreia-Vioglio, A. Gambardella, F. Maccheroni, M. Marinacci, D. Messinese, and A. Pignataro. 2021. *Modelling Low-frequency/High-impact Strategic Decisions Under Uncertainty*. Draft. Bocconi University.
- Camuffo, A., A. Cordova, A. Gambardella, and C. Spina. 2020. "A Scientific Approach to Entrepreneurial Decision Making: Evidence from a Randomized Control Trial". *Management Science* 66(2): 564–86.
- Capron, L. 1999. "The Long-term Performance of Horizontal Acquisitions". *Strategic Management Journal* 20(11): 987–1018.
- Capron, L. and N. Pistre. 2002. "When Do Acquirers Earn Abnormal Returns?". *Strategic Management Journal* 23(9): 781–94.
- Chatterji, A. and A. Patro. 2014. "Dynamic Capabilities and Managing Human Capital". *Academy of Management Perspectives* 28(4): 395–408.
- Conti, R., A. Gambardella, and E. Novelli. 2019. "Specializing in Generality: Firm Strategies When Intermediate Factor Markets Work". *Organization Science* 30(1): 126–50.
- Csaszar, F. A. 2018. "What Makes a Decision Strategic? Strategic Representations". *Strategy Science* 3(4): 606–19.
- Csaszar, F. A. and D. A. Levinthal. 2016. "Mental Representation and the Discovery of New Strategies". *Strategic Management Journal* 37(10): 2031–49.
- Davenport, T. H., L. D. D'Ignazio, and D. J. Patil. 2011. "Know What Your Customers Want Before They Do". *Harvard Business Review* 89(12): 84–92.
- Davenport, T. H. and D. J. Patil. 2018. "Why So Many High-profile Digital Transformations Fail". *Harvard Business Review* 96(10): 10–15.

- Dittmar, A. and A. Thakor. 2007. "Why Do Firms Issue Equity?". *The Journal of Finance* 62(1): 1–54.
- Durand, R. and M. Khaire. 2017. "Where Do Market Categories Come from and How? Distinguishing Category Creation from Category Emergence". *Journal of Management* 43(1): 87–110.
- Elfenbein, D. W. and A. D. Sterling. 2018. "(When) Is Hiring Strategic? Human Capital Acquisition in the Age of Algorithms". *Strategy Science* 3(4): 668–82.
- Falato, A., D. Li, and T. Milbourn. 2015. "Which Skills Matter in the Market for CEOs? Evidence from Pay for CEO Credentials". *Management Science* 61(12): 2845–69.
- Felin, T. and T. R. Zenger. 2009. "Entrepreneurs as Theorists: On the Origins of Collective Beliefs and Novel Strategies". *Strategic Entrepreneurship Journal* 3(2): 127–46.
- Felin, T. and T. R. Zenger. 2017. "The Theory-based View: Economic Actors as Theorists". *Strategy Science* 2(4): 258–71.
- Finkelstein, S. and J. Haleblan. 2002. "Understanding Acquisition Performance: The Role of Transfer Effects". *Organization Science* 13(1): 36–47.
- Fitza, M. A. 2017. "How Much Do CEOs Really Matter? Reaffirming that the CEO Effect is Mostly Due to Chance". *Strategic Management Journal* 38(3): 802–11.
- Flammer, C. 2015. "Does Corporate Social Responsibility Lead to Superior Financial Performance? A Regression Discontinuity Approach". *Management Science* 61(11): 2549–68.
- Folta, T. B., C. E. Helfat, and S. Karim. 2016. "Resource Redeployment and Corporate Strategy". *Advances in Strategic Management* 35.
- Foss, N. J., P. G. Klein, L. B. Lien, T. Zellweger, and T. Zenger. 2021. "Ownership Competence". *Strategic Management Journal* 42(2): 302–28.
- Galbraith, J. K. 1967. *The New Industrial State*. Princeton: Princeton University Press.
- Ghosh, S., S. Thomke, and H. Pourkhalkhali. 2020. "The Effects of Hierarchy on Learning and Performance in Business Experimentation". In: *Academy of Management Proceedings*. Vol. 2020. Briarcliff Manor, NY: Academy of Management, 20500.
- Grant, R. M. 1996. "Toward a Knowledge-based Theory of the Firm". *Strategic Management Journal* 17(S2): 109–22.
- Griffin, M. A. and G. Grote. 2020. "When Is More Uncertainty Better? A Model of Uncertainty Regulation and Effectiveness". *Academy of Management Review* 45(4): 745–65.
- Haleblan, J., C. E. Devers, G. McNamara, M. A. Carpenter, and R. B. Davison. 2009. "Taking Stock of What We Know about Mergers and Acquisitions: A Review and Research Agenda". *Journal of Management* 35(3): 469–502.

- Hambrick, D. C. and T. J. Quigley. 2014. "Toward More Accurate Contextualization of the CEO Effect on Firm Performance". *Strategic Management Journal* 35(4): 473–91.
- Jensen, M. C. 1997. "Eclipse of the Public Corporation". *Harvard Business Review* (Sept.-Oct. 1989), revised.
- Joseph, J. and A. J. Wilson. 2018. "The Growth of the Firm: An Attention-based View". *Strategic Management Journal* 39(6): 1779–800.
- Kaplan, S. 2008. "Framing Contests: Strategy Making under Uncertainty". *Organization Science* 19(5): 729–52.
- Kaplan, S. N. and M. Sorensen. 2021. "Are CEOs Different?". *The Journal of Finance*.
- King, D. R., G. Wang, M. Samimi, and A. F. Cortes. 2020. "A Meta-Analytic Integration of Acquisition Performance Prediction". *Journal of Management Studies*.
- Laamanen, T. and T. Keil. 2008. "Performance of Serial Acquirers: Toward an Acquisition Program Perspective". *Strategic Management Journal* 29(6): 663–72.
- Leiblein, M. J., J. J. Reuer, and T. Zenger. 2018. "What Makes a Decision Strategic?". *Strategy Science* 3(4): 558–73.
- Lemmon, M. L., M. R. Roberts, and J. F. Zender. 2008. "Back to the Beginning: Persistence and the Cross-Section of Corporate Capital Structure". *The Journal of Finance* 63(4): 1575–608.
- Lieberman, M., L. K. Lee, and T. B. Folta. 2017. "Entry, Exit, and the Potential for Resource Redeployment". *Strategic Management Journal* 38: 526–44.
- Luca, M. and M. H. Bazerman. 2021. *The Power of Experiments: Decision Making in a Data-Driven World*. MIT Press.
- March, J. G. 1991. "Exploration and Exploitation in Organizational Learning". *Organization Science* 2(1): 71–87.
- March, J. G. and H. A. Simon. 1958. *Organizations*. New York: John Wiley & Sons.
- Martin, R. L. 2016. "M&A: The One Thing You Need to Get Right". *Harvard Business Review* 94(6): 12.
- McAfee, A., E. Brynjolfsson, T. H. Davenport, D. J. Patil, and D. Barton. 2012. "Big Data: The Management Revolution". *Harvard Business Review* 90(10): 60–8.
- Milgrom, P. and J. Roberts. 1990. "The Economics of Modern Manufacturing: Technology, Strategy, and Organization". *The American Economic Review*: 511–28.
- Murphy, K. J. and J. Zbojnik. 2004. "CEO Pay and Appointments: A Market-Based Explanation for Recent Trends". *American Economic Review* 94(2): 192–6.
- Myers, S. C. 2001. "Capital Structure". *Journal of Economic Perspectives* 15(2): 81–102.

- Nguyen, B. D. and K. M. Nielsen. 2014. "What Death Can Tell: Are Executives Paid for Their Contributions to Firm Value?". *Management Science* 60(12): 2994–3010.
- Nickerson, J. A., B. S. Silverman, and T. R. Zenger. 2007. "The Problem of Creating and Capturing Value". *Strategic Organization* 5(3): 211–25.
- Nickerson, J. A. and T. R. Zenger. 2004. "A Knowledge-based Theory of the Firm — The Problem-Solving Perspective". *Organization Science* 15(6): 617–32.
- Ott, T. E. and K. M. Eisenhardt. 2020. "Decision Weaving: Forming Novel, Complex Strategy in Entrepreneurial Settings". *Strategic Management Journal* 41(12): 2275–314.
- Packard, M. D. and B. B. Clark. 2020. "On the Mitigability of Uncertainty and the Choice between Predictive and Nonpredictive Strategy". *Academy of Management Review* 45(4): 766–86.
- Penrose, E. 1955. "Limits to the Growth and Size of Firms". *The American Economic Review* 45(2): 531–43.
- Pignataro, A. 2021. *The Rise of Algo Firms*. Draft. Bocconi University.
- Puranam, P., B. C. Powell, and H. Singh. 2006. "Due Diligence Failure as a Signal Detection Problem". *Strategic Organization* 4(4): 319–48.
- Quigley, T. J., C. Crossland, and R. J. Campbell. 2017. "Shareholder Perceptions of the Changing Impact of CEOs: Market Reactions to Unexpected CEO Deaths, 1950–2009". *Strategic Management Journal* 38(4): 939–49.
- Quigley, T. J. and S. D. Graffin. 2017. "Reaffirming the CEO Effect is Significant and Much Larger than Chance: A Comment on Fitza (2014)". *Strategic Management Journal* 38(3): 793–801.
- Quigley, T. J. and D. C. Hambrick. 2015. "Has the "CEO Effect" Increased in Recent Decades? A New Explanation for the Great Rise in America's Attention to Corporate Leaders". *Strategic Management Journal* 36(6): 821–30.
- Quigley, T. J., D. C. Hambrick, V. F. Misangyi, and G. A. Rizzi. 2019. "CEO Selection as Risk-taking: A New Vantage on the Debate about the Consequences of Insiders versus Outsiders". *Strategic Management Journal* 40(9): 1453–70.
- Rabier, M. R. 2017. "Acquisition Motives and the Distribution of Acquisition Performance". *Strategic Management Journal* 38(13): 2666–81.
- Rajan, R. G. 2012. "Presidential Address: The Corporation in Finance". *Journal of Finance* 67(4): 1173–217.
- Renneboog, L. and C. Vansteenkiste. 2019. "Failure and Success in Mergers and Acquisitions". *Journal of Corporate Finance* 58: 650–99.
- Reuer, J. J. and A. V. Sakhartov. 2021. "Economies of Scope and Optimal Due Diligence in Corporate Acquisitions". *Organization Science*.

- Rindova, V. and H. Courtney. 2020. "To Shape or Adapt: Knowledge Problems, Epistemologies, and Strategic Postures under Knightian Uncertainty". *Academy of Management Review* 45(4): 787–807.
- Rittel, H. W. and M. M. Webber. 1973. "Dilemmas in a General Theory of Planning". *Policy Sciences* 4(2): 155–69.
- Santamaria, S. 2021. "Portfolio Entrepreneurs' Behavior and Performance: A Resource Redeployment Perspective". *Management Science*. forthcoming.
- Schulze, W. and T. M. Zellweger. 2020. "Property Rights, Owner-management, and Value Creation". *Academy of Management Review*.
- Sørensen, J. B. and G. R. Carroll. 2021. *Making Great Strategy: Arguing for Organizational Advantage*. New York: Columbia University Press.
- Tambe, P., L. Hitt, D. Rock, and E. Brynjolfsson. 2020. *Digital Capital and Superstar Firms* (No. w28285). National Bureau of Economic Research.
- Teece, D. J. 1988. "Technological Change and the Nature of the Firm". In: *Technical Change and Economic Theory*. Ed. G. Dosi et al. London: Pinter.
- Teece, D., M. Peteraf, and S. Leih. 2016. "Dynamic Capabilities and Organizational Agility: Risk, Uncertainty, and Strategy in the Innovation Economy". *California Management Review* 58(4): 13–35.
- Thomke, S. H. 2020. *Experimentation Works: The Surprising Power of Business Experiments*. Harvard Business School Press.
- Trigeorgis, L. and J. J. Reuer. 2017. "Real Options Theory in Strategic Management". *Strategic Management Journal* 38(1): 42–63.
- Von Hippel, E. and G. Von Krogh. 2016. "Crossroads — Identifying Viable "Need–Solution Pairs": Problem Solving without Problem Formulation". *Organization Science* 27(1): 207–21.
- Wangerin, D. 2019. "M&A Due Diligence, Post-acquisition Performance, and Financial Reporting for Business Combinations". *Contemporary Accounting Research* 36(4): 2344–78.
- Wilson, H. J. and P. R. Daugherty. 2018. "Collaborative Intelligence: Humans and AI are Joining Forces". *Harvard Business Review* 96(4): 114–23.
- Zellweger, T. M. and T. R. Zenger. 2021. "Entrepreneurs as Scientists: A Pragmatist Approach to Producing Value Out of Uncertainty". *Academy of Management Review*.
- Zollo, M. 2009. "Superstitious Learning with Rare Strategic Decisions: Theory and Evidence from Corporate Acquisitions". *Organization Science* 20(5): 894–908.
- Zott, C. and R. Amit. 2010. "Business Model Design: An Activity System Perspective". *Long Range Planning* 43(2–3): 216–26.
- Zuboff, S. 2019. *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power: Barack Obama's books of 2019*. Profile books.