# Guest Editorial Resource, Routine, Reputation, or Regulation Shortages: Can Data- and Analytics-Driven Capabilities Inform Tech Entrepreneur Decisions

## I. Introduction

ENTREPRENEURIAL ingenuity plays a crucial role in building new business enterprises, especially when resources are lacking, routines are nonexistent, a firm's (or its owner's) reputation is not established, and/or regulations (business, labor, legal, environmental, etc.) are inadequate. Resources in the form of human capital (e.g., talented engineers or scientists) or financial capital (e.g., in-kind, government grants, private financiers, or financing institutions) are often the foundation of independent startups or new corporate business ventures [1], [2]. Routines in the form of organizational and technical processes are often key in building these new ventures [3]. Reputation in terms of an entrepreneur's accomplishments or network is essential for acquiring needed resources and developing fundamental routines to initiate, commit to, organize, and grow the startup [4]. And regulations including public policies and laws (e.g., trademarks, copyright, and patent law) and corporate incentive structures (e.g., share of equity) are often essential in spurring entrepreneurial startups or corporate ventures [5].

But even with shortages of resources, routines, reputation, or regulations (the 4Rs), technology entrepreneurs' ingenuity can transform many threats associated with these shortages into opportunities. Not only can this transformation take place when the shortages are internal to the fledging business enterprise, but also when the shortages are triggered by events external to the entrepreneur and the business venture. The shortage of oil, for instance, served as an opportunity for technology entrepreneurs to develop bolt-on features to 18-wheel trailer trucks and road trains to reduce wind resistance and increase gas mileage. Similarly, a crisis like 9/11 created a need for routines to effectively process people through more rigorous (and time consuming) security checkpoints at airports, which created an opportunity for technology entrepreneurs to find new ingenious ways to screen passengers and freight.

In some countries, public policies have addressed such technology shortages by offering early-stage funding for basic sciences and technology commercialization efforts. For instance, the U.S. Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E), funded Foro Energy to develop laser-powered drilling technology that can weaken and break up ultrahard crystalline rock for efficient oil and thermal energy recovery that may increase drilling rates up to 10-fold [6]. In another example, with the rising interest in reducing healthcare costs and complexity, federal institutions and venture capital firms have allocated funds to store, access, and share biomedical data in the cloud [7]. However, it is unclear whether such support policies create more impactful technology entrepreneurship than in settings without such polices. We can debate whether these shortages are detrimental because, for instance, they affect how difficult it is to start a business and thus impede economic prosperity, or if they are beneficial because they require more socially responsible actors who are forced to use their ingenuity to start up with leaner resources.

To further explore the impacts of shortages of resources, routines, reputation, and/or regulations, and how these shortages create threats or opportunities for independent startups and new business ventures spun off from established firms, we compiled (through a call-for-papers) five scholarly, interdisciplinary articles that address multiple aspects of technology and engineering management from a diverse set of methodologies. These five articles went through the rigorous peer-reviewed process at IEEE Transactions on Engineering Management. We use this editorial perspective to first describe these studies that contribute to theory and create practical insights for managers in the technology arena, noting the dominance of either time or timing as a crucial concept in technology entrepreneurship.

## II. Overview of the Five Compiled Articles

Each of the five articles considers at least three of the four R's as elements of interest: 1) resources; 2) routines; 3) reputation; and 4) regulations. However, a specific R can be considered *explicitly*, meaning that the particular R (e.g., amount of resources allocated to a startup's facilities and equipment) is tracked, analyzed, and discussed in detail. Alternatively, a specific R can be considered implicitly, meaning that the particular R (e.g., self-leadership routines such as training or communication) is not tracked, but its aggregate effect is either observed through a proxy questionnaire or discussed anecdotally. Table I classifies the five articles in terms of what information is available with respect to the 4R coverage, using *E* to signify that a particular

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TABLE I
CLASSIFICATION OF THE FIVE COMPILED ARTICLES

| Authors | Theme | Resources | Routines | Reputation | Regulations |
|---|---|---|---|---|---|
| Marvel & Patel | Self-leadership and time allocation | E | E | n/a | E |
| Bailey & Tatikonda | Accelerating venture milestone achievement | E | I | I | I |
| Luo & Yin | Business startup selection of accelerators | E | E | E | I |
| Huang, Yoo & Gokpinar | Impact of consumer peer learning and incumbent reaction | E | I | E | n/a |
| Canakoglu, Erzurumlu & Erzurumlu | Business opportunity evaluation with imperfect information | E | E | E | E |

Legend: E = explicitly covered; I = implicitly covered; n/a = not applicable

R is explicitly addressed and *I* to signify that a particular R is implicitly addressed.

In the first article, Matthew Marvel and Pankaj Patel set up a regression model to examine the influence of self-leadership, defined as self-direction or self-motivation routines, to manage oneself in overcoming a crucial resource constraint–time scarcity. By analyzing a dataset involving 97 incubators listed in the National Business Incubation Association's (NBIA) online database, the authors show that self-leadership increases innovation speed. While controlling for regulation factors (i.e., trademarks, copyrights, and patents), this article also suggests that the value of self-leadership decreases with increasingly radical innovations. By extending the self-leadership theory into the entrepreneurship realm, this work also informs decision-making since the findings can assist product development efforts in identifying cognitive and personality aspects of entrepreneurs that are important for entrepreneurial team formation or coaching activities among others.

In the second article that we compiled, Jennifer Bailey and Mohan Tatikonda draw upon a dataset of a longitudinal survey of nascent entrepreneurs collected by the Panel Study of Entrepreneurial Dynamics across five cohorts: Australia, China, Sweden, and two U.S. panel datasets (one in 1999 and the other in 2005). During the initial start-up stage, they examine the impact of resource-acquisition timing on time-to-first-sale. Then, during the scale-up stage, they examine the impact of both resource-acquisition timing and time-to-first-sale on time-to-positive-cash-flow. This study explores several resource-acquisition decisions, including employee hiring, materials purchasing, and facilities and equipment investment, while considering the technology novelty level as a key variable. The findings suggest that decisions concerning resource-acquisition timing can have contradictory effects on shortening the time-to-first-sale versus shortening the time-to-positive-cash-flow. The findings further highlight the difficult tradeoffs that entrepreneurs must decide upon when making resource-acquisition decisions, which affect multiple milestones across a venture's lifecycle. Constructs such as routines to build human resource capabilities and sales department's reputation are handled implicitly.

For the third article, Jianxi Luo and Bangqi Yin unpack funding decisions for new business ventures. They identify a number of critical 4R-related criteria specific to two decision stages in the selection process of a highly competitive business accelerator. In the selection process' first (screening) stage, the authors draw from a dataset of 200 startup profiles, with half being randomly selected from a 'filtered' group of 841 Singaporean startups and the other half from an 'interviewed' group of 162 Singaporean startups. In the second (selection) stage, the authors rely on 40 randomly selected startup profiles from the 122 ones in the 'interviewed but unsuccessful' subgroup to compare with the 40 in the 'interviewed and successful' subgroup. The authors use a scoreboard of 30 criteria based on the real-win-worth framework (by asking: Is it real? Can it win? Is it worth doing?) to compare the profiles of the selected versus rejected startups. This work suggests that accelerator managers' implicit decision criteria tend to shift from the 'real' or 'win' category in the screening stage to the 'win' or 'worth' category in the selection stage. The authors argue that understanding the 'shifting' decision criteria can inform accelerator managers of their own preferences so as to improve their decision processes (i.e., screening and selection), and as a result also increase entrepreneurs' empathy toward these managers to sharpen their applications.

Yufei Huang, Onesun (Steve) Yoo, and Bilal Gokpinar develop a game theoretic model endowed with evolving information across two stages of a growing business venture. In particular, this two-stage model addresses information updates on both 'peer-learning' (i.e., peer consumer influence that alters consumers' purchase behavior) and an incumbent firm's reaction to the new venture's sales effort. This setup enables the authors to investigate how technology entrepreneurs can best allocate their limited time during their startups' product sales process. This work reveals twin dynamics prevalent in the marketing of new technology products: consumers seek feedback from other consumers in order to inform their own purchase decisions and incumbent firms react in order to deter new market entry by competing entrepreneurs. This work thus offers guidance for 4R management in terms of the best time-allocation strategy during the selling process, depending on the target market's levels of peer consumer influence, incumbent firm's reaction, and market segmentation.

Ethem Canakoglu, Sinan Erzurumlu, and Yaman Erzurumlu consider the phenomenon of recognizing business opportunities,

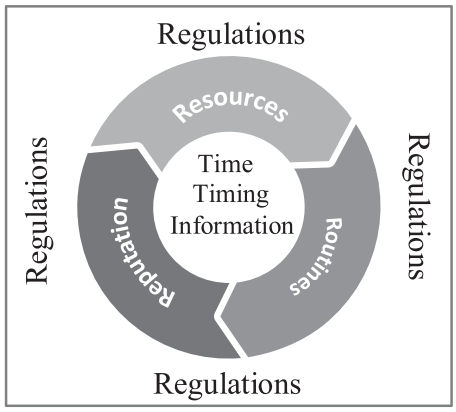


Fig. 1. Time, timing, and information-driven view of the 4Rs interactions.

and the resulting variations in resource allocations in a context without perfect data on the market's reaction to a recognized business opportunity. They develop a formal (Markovian) decision model that analyzes a variety of imperfect market-related data (e.g., financial, social, regulatory), while factoring in the entrepreneur's risk preference and potential shortages of the 4Rs. Numerical findings show that rather than pursuing the highest expected returns strategy or using resources to gather as much information as possible, entrepreneurs allocate resources to favor investments that could enable them to adapt to market needs based on their cash levels and risk preferences. In terms of decision making, in order to overcome uncertainties, entrepreneurs are advised to periodically update investment strategies based on analysis of market-related data. Simulation studies illustrate that even myopic (i.e., short time horizon) resource allocation policies, when updated frequently in the presence of resource shortages, provide useful insights for recognizing business opportunities during a finite time horizon.

In reviewing the findings from these five articles, we notice that these authors all highlighted the role of information and also time and timing (e.g., by considering stages in the decision process). We locate these three elements at the center of Fig. 1 because they are crucial for capturing potential interactions among the 4Rs and for entrepreneurs who wish to capitalize on the tradeoffs associated with shortages of one or more of the 4Rs in their decision-making. In highlighting the dominance of time or timing as a crucial concept in technology entrepreneurship, this set of studies underscores the importance of information available to early-stage firms and, importantly, when and how much information is available. We next consider the emergence of the timely availability of information, both in terms of quantity and fidelity, in the academic- and practice-driven technology entrepreneurship literatures.

## III. Information Availability and Usage in Technology Entrepreneurship

The importance of information availability in these studies directs our attention to the availability and usage of data, as well as the development of a variety of computational technologies that have been coevolving over the past decade. This coevolution has seen many digital technology milestones, such as the diffusion of personal computing and mobile devices [8] and access to data and application programs through cloud computing [9]. The resulting reduction in development costs and ease of access to information have also spurred novel modes of entrepreneurship worldwide such as crowdfunding and its ability to rapidly test new product ideas through platforms such as Kickstarter [10]. Therefore, inspired by the above-mentioned studies that accompany this editorial perspective, we focus our discussion on two related and significant phenomena: The prevalence of data and analytics in tech startups and the need for knowledge workers with data and analytics capabilities.

At the macrolevel, a review of recent startups that received funding shows a prevalence of data and analytics technologies. Summary statistics for the past eight fiscal quarters (2016 and 2017) of global funding for startups, including venture capital from angel investors and venture capitalists, corporate venture capital investments, and private equity investment, show that 88 percent of funds went to technology sectors [11]. A closer scrutiny within each of these technology sectors shows the prevalence of data and analytics. For instance, the largest number of deals in the largest sector–Internet-based startups–were for accounting and finance, video processing and business intelligence, and analytics and performance management. Another way to view the trends underlying this dataset is to examine firms that are using data and analytics capabilities such as artificial intelligence (AI) technology. According to a CB Insights' recent report on AI in business startups:

> Artificial intelligence is changing the fundamental structure of every industry in areas ranging from agriculture to cybersecurity to commerce to healthcare, and more. We're also interacting with technology in new ways, from giving voice commands to washer-dryers to playing advanced gesture-controlled video games. Governments are competing to establish superior AI research, seeing AI as a lever for greater economic influence and power. We are also in the early stages of drastic shifts in the labor market. [11, p.1]

At the microlevel, or in terms of the decision structure, these trends are also changing the very core of entrepreneurial decision-making by employing sophisticated data analytics. According to a 2017 Wall Street Journal article,

> . . . [in] recent years, a small group of emerging venture firms have been testing ways to remake the art of venture capital and turn it into more of a science. They are relying to varying degrees on what are, for their industry, radical new uses of software, and data to help guide their investments . . . In Silicon Valley, SignalFire uses software, data science, and analytics in an effort to capture superior returns for its investors by both picking the right companies to invest in and helping them thrive. The firm's $53 million first fund aims to make 35 investments, and is about halfway there. With former Google and Yahoo machine-learning experts on its staff, SignalFire says it finds investment opportunities by tracking millions of data sources in real time, such as monitoring capital flows into startups and movements of key employees [12, p. 1].

A related trend is the need for knowledge workers with data and analytics capabilities. According to Devras [13], a lack of the right talent (e.g., highly educated and talented AI and

analytics professionals) to support these capabilities can significantly deter companies from scaling up new AI business ventures. Currently, the AI sphere is facing a paucity of qualified professionals. Consequently, aside from developing analytics products, these new ventures are also changing their development and delivery processes to exploit data- and analytics-based business opportunities, or to adjust their operational processes to account for the evolving nature of knowledge-based work.

To deepen this discussion about emergent entrepreneurial knowledge and technology ventures' operational processes, we must consider the three eras of data and analytics identified by Davenport [14]: 1) an early era involving small amounts of structured data; 2) a mid-era featuring large and unstructured data; and 3) a recent era that combines both types. However, these data are not sufficient to help entrepreneurs make decisions, and necessary tools are analytical models that relate these data to decisions that invariably involve tradeoffs. These data evolution eras rely on unique analytical approaches that feature descriptive, descriptive and predictive, and prescriptive models, respectively. We also observed that the entrepreneurship field has witnessed a similar evolution in the use of analytical models and decision-making approaches.

More specifically, Lévesque [15] and Minniti and Lévesque [16] offer examples of the early era to mid-era discussions of the use of mathematical models to build theory in the field of entrepreneurship. Lévesque [15] describes the scope of decision variables, objective functions, and feasible solution sets, and identifies dynamic programming, Markov processes, and optimal stopping as relevant optimization methodologies of choice. Minniti and Lévesque [16] draw upon the importance of bounded rationality, rule following, institutions, cognition, and evolution to argue that economics can be a fruitful field through which to study entrepreneurship, while pointing to the relevance of broader heuristics and biases. These scholars also point to the evolving use of analytical models and decision-making approaches in the entrepreneurship field (and in data- and analytics-driven capabilities to improve entrepreneurs' decision-making) with Burmeister-Lamp and colleagues [17] offering a convincing illustration by examining an entrepreneur's limited time–a crucial resource and consistent with the 4Rs–through boundedly rational time-allocation decisions between working at a wage job and starting a business (i.e., hybrid entrepreneurship [18]).

While the use of data- and analytics-driven capabilities to improve decision-making is blooming in the entrepreneurial context, we must examine it in terms of the underlying tradeoffs associated with the shortages of the 4Rs that populate all stages of the entrepreneurial lifecycle. Following our own work [4], the entrepreneurial lifecycle can be viewed in terms of the following four consecutive stages in the evolution of a new business venture.

1) *Discovery*: When the entrepreneur recognizes and assesses a potential business opportunity.
2) *Commitment*: When the entrepreneur begins to commit resources, including human and financial resources, to form a business.
3) *Organization*: When the entrepreneur identifies the newly formed business' requirements necessary to market a product/service and organizes activities to satisfy those requirements.
4) *Growth*: When the entrepreneur's offering achieves initial market success that warrants future actions to grow the business.

One or more of the 4Rs is often lacking in each of these stages. For instance, on one hand, resources–interchangeable or not, human or financial–are required to prosper locally, nationally, and internationally. On the other hand, a firm without established routines may benefit when initiating its internationalization process in the commitment stage because the firm may not have to unlearn established know-how, although adapting existing routines can reduce the likely high experimentation cost. Data- and analytics-driven capabilities can shape many aspects of the timing of decisions and the related 4R tradeoffs, thus we call for novel modes of decision-making in the realm of technology entrepreneurship, which we explore next.

## IV. A shift in the Nature of Decision-Making in Technology Entrepreneurship

Theories in the entrepreneurship realm have been rapidly moving toward a more dynamic view of capabilities and related microfoundations [19]–[24]. The resulting strategies have been based on survival and competitive considerations, such that technology enterprises pivot rapidly once receiving emergent market feedback. According to March, adaptive decision-making is "predicated upon skill at understanding the environment and responding to it. Many adaptive strategies involve monitoring the environment, understanding its causal structure, storing inferences drawn from that understanding, and retrieving the implications of those inferences at the appropriate times and places" [25, p. 252].

Nevertheless, corresponding adaptive decision-making studies seem to be lacking, even though decision models should adaptively capture tradeoffs in the aforementioned 4R decisions, either continuously or at a variety of venture milestones, as updated information is revealed. For instance, optimal stopping models have explored the appropriate elapsed time from the start of the discovery stage to the start of the commitment stage to investigate market entry decisions [26]. Other models and empirical work have investigated various types of resources across the entrepreneurial lifecycle and aim to help managers decide when to switch resource allocations (e.g., marketing versus R&D expenses [2]). We also observe that data availability is a common feature across most of the literature that adaptively considers decisions when studying tradeoffs associated with 4R shortages. For instance, some researchers assume that key factors driving these tradeoffs (e.g., market demand, wages, R&D productivity) are fixed upfront. In other words, these factors are known based on prior data collected at the start of new business ventures that have operated in similar settings, or they are based on anticipated data for a new venture that is being analyzed. In other studies [e.g., 27], key factors are assumed to come from a fixed probability distribution.

TABLE II
FRAMING THE TIMING OF DECISIONS BASED ON INFORMATION AVAILABILITY

| | | Timing of decisions | |
|---|---|---|---|
| | | Reviewed at fixed lifecycle milestones | Reviewed in real time (i.e., frequently between milestones) |
| Availability of 4R information | Fixed upfront or fixed probability distribution | **Models for *ex-ante* insights**<br>Marvel & Patel identify time as the key outcome variable for a regression model that can be used for *ex ante* assessment of the tradeoffs associated with self-leadership and the radical nature of innovation. | n/a |
| | Updated at predefined stages<br>or<br>Updated between stages when new information becomes available | **Multi-stage models**<br>Bailey & Tatikonda focus on the assessment of timing outcomes by stages for accelerating venture milestone achievement.<br>Luo & Yin describe a two-stage assessment of business startup selection by venture accelerators to show that decision criteria are altered when moving from an early to a late selection stage.<br>Huang, Yoo & Gokpinar examine the impact of consumer peer learning and incumbent reaction on resource allocation decisions based on a two-stage game-theoretic model, where learning can be used in the second stage to update the initial allocation. | **Real-time models**<br>***Adaptive decision-making***<br>Canakoglu, Erzurumlu & Erzurumlu call for ongoing business opportunity evaluation with imperfect information, based on a Markov model with uncertain information that can be generated over the entire lifecycle of the business venture. |

However, an adaptive decision-making approach brings two additional types of analyses. First, models can be updated by stages as they are based on new data collected in stages, such as stage I and stage II of financing. Second, models can be updated between stages when new information becomes available, meaning that data are revealed frequently in real time, such as when entrepreneurs need to fine-tune an aspect of the business model (e.g., level of customer support) through the lifecycle of the business startup being analyzed. In other words, the collection of data between the entrepreneurial lifecycle stages opens up the possibility of revising the decisions more frequently in order to enhance the competitive position of business startups. As shown in Table II, we frame the decisions examined in emerging research and, more specifically, the compiled five articles discussed in Section II, based on the nature of the data they encompass (i.e., when these data become available and, in some instances, when they are updated) and how such data affect the timing of decision.

In summary, adaptive decision-making can yield two additional model types for the models for exante insights, as shown in Table II. Specifically, the first type corresponds to multistage models with emergent information updates on the tradeoffs associated with 4R shortages at fixed time points. The second type, on the other hand, corresponds to real-time models also with emergent information updates, but these updates are reviewed in real time and frequently between lifecycle milestones. This second model type enables adaptive decision-making that can impact the tradeoffs associated with the shortages of one or more of the 4Rs.

## V. OPPORTUNITIES FOR NEW CONTRIBUTIONS IN TECHNOLOGY ENTREPRENEURSHIP

We draw upon evidence from five compiled articles to assess how the role of time, information availability, and information usage requires a shift in decision-making processes for technology entrepreneurs. The role of time, and information availability and usage also point to the need to develop pertinent theories, models, and algorithms for adaptive decision-making. Entrepreneurs and their stakeholders, such as investors, suppliers, and customers, may use the resulting data upfront to gain insights and then make predictive decisions based on models that can forecast longitudinal time trends to shape their decisions. They may also use data in real time to make ongoing and prescriptive decisions informed by decision-support recommendations. This underscores the essential question that we raise in the title of this article: Can data- and analytics-driven capabilities inform tech entrepreneur decisions that generate tradeoffs associated with the shortages of the 4Rs?

The IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT journal's aim and scope are "Management of technical functions such as research, development, and engineering in industry, government, university, and other settings. Emphasis is on studies carried out within an organization to help in decision making or policy formation for RD&E" [28]. Our editorial perspective is, therefore, directly aimed at both engineering management scholars and technology management scholars. Said differently, scholars with interests in technology, innovation management and entrepreneurship, which is the broader scholarly area where

this editorial perspective lies, could be trained in an engineering or a management discipline. Regardless, these scholars are researching at the intersection of both fields and, more specifically, interested in informing decision-making in technology entrepreneurship.

The emergence of practices relying on data- and analytics-driven decisions gives rise to two main avenues for research in engineering and technology management. The first is algorithmic analysis and application of machine learning techniques for conditioning or classifying data. Scholars trained in an engineering discipline in general, and engineering management in particular, can methodologically address technology entrepreneurship questions that consider the tradeoffs associated with the shortages of one or all of the 4Rs. Many scholars have training in algorithmic and AI techniques. The focus on rapid AI-driven pattern recognition and more adaptive decisions may shift the locus of entrepreneurial decision-making from upfront to more distributed and frequent engineering-centered choices. For instance, the decision to outsource an entire software development project need not be made myopically upfront. Such a project could be broken down into small engineering tasks, each of which could be insourced or outsourced based on the availability of suitable in-house engineering capabilities when the execution decision for a task needs to be made. Thus, these task-sourcing decisions can be made adaptively.

The second avenue for research on engineering and technology management is to build and test theories from behavioral economics, the humanities, or social sciences around adaptive-decision making by using the results from these algorithms or analytical models. Scholars trained in technology management, and entrepreneurship in particular, can help with the time and timing aspects we highlighted by providing theoretical and practical insights and advancements. For instance, they could use theories from behavioral economics to examine individuals' behavior and apply data- and analytics-driven capabilities that can assist entrepreneurs in making technology decisions, including time- (often in shortage) and funding-allocation decisions. Both research avenues may reveal new situations that require attention to the use of heuristics and biases, and adaptive choices in entrepreneurial decision-making.

Given the need to focus on adaptive decision-making, we also draw the attention of scholars working at the intersection of technology entrepreneurship and engineering management to three specific contexts that might be particularly data rich: digital entrepreneurship and finance, millennial mindset and entrepreneurship, and the sharing economy. We discuss each of these three topics next.

*1) Digital Entrepreneurship and Finance:* An area of growing interest is digitization and its impact on entrepreneurial finance, with crowdfunding as a booming tool in the landscape of technology entrepreneur [29]. The growth of crowdfunding is not only exploding in the U.K., where it was by far the dominant investor type in seed investing in 2015 [30], but it is also becoming a central digital infrastructure component to stimulate entrepreneurship across the world [31]. The real-time and emergent data that become available through these increasingly popular portals enable adaptive decision-making for technology entrepreneurs and investors alike. Digitally trained entrepreneurs, many of whom have engineering and computer science backgrounds, are more likely to get funded because they garner above-average valuations from investors, and their ideas have the potential to disrupt an industry and create innovations and 'unicorns'—startups that rapidly reach the billion dollar valuation mark following the initial investment [11]. These entrepreneurs have a natural affinity for implementing engineering practices, such as systems engineering and process design, into their work. And the resulting productivity and valuation gains can help balance the tradeoffs associated with 4R shortages. Digital entrepreneurship and finance thus represent a new area of enquiry for technology entrepreneurship and engineering management researchers.

*2) Millennial Mindset and Entrepreneurship:* Another area to consider is an extension of hybrid entrepreneurs—those holding full-time jobs as they simultaneously build their new business ventures [18], [26]—to include a common millennial mindset: multiple-business entrepreneurs who simultaneously engage in more than one business venture [32]. Most scholars studying multiple-business (also called serial, habitual, repeat, portfolio) entrepreneurs consider sequential entrepreneurial moves. However, the recent popularity of, for instance, app development for recent engineering graduates or soon-to-be graduates is enabling young technology entrepreneurs to engage in more than one business idea simultaneously. Statista [33] reports that the number of coding boot camp graduates in the U.S. and Canada was 2200 in 2013 and rose (over 10-folds) to an estimated 23000 in 2017. As entrepreneurs engage simultaneously in multiple ventures, they can leverage their know-how and gather real-time information that can be transferred from one venture to another. Of particular interest is the ability of these multiple-business entrepreneurs to leverage social media data [34]. Consequently, adaptive decision-making can play a crucial role in growing their startups as these entrepreneurs balance this flexibility advantage against their limited capacity to engage fully in any of their ventures. The assessment of the social media metric and of the resulting idea generation and adaptive business growth may represent a new arena of enquiry for technology entrepreneurship and engineering management scholars.

*3) Sharing Economy:* Yet another area of growing interest within scholarly communities is the sharing economy. Digital platforms are the backbone of transactions at firms such as AirBnB [35] and Uber [36] (both founded in 2009), which are now multibillion-dollar enterprises. They access both their suppliers and customers through data-driven digital platforms, with our understanding of their suppliers' (e.g., Uber drivers) and customers' (e.g., individuals willing to pay surge prices) decision-making being a matter of intense scrutiny [37]. Uberization [38] has become a boundless phenomenon so much so that Uber is being challenged by local business startups in many countries for taking their business away and Uber-like platforms are becoming the staple of new business venture efforts in many other industries ranging from hospitality [39] to food services [40]. These technology entrepreneurs often face novel regulatory questions (e.g., traffic congestion and insurance/safety concerns in different cities/countries [41]), some of which are, ironi-

cally, being addressed via AI technologies [28]. These developments represent a fertile new area of enquiry for technology entrepreneurship and engineering management researchers, with focus on when and how AI-driven entrepreneurship enhances survival probabilities for new business ventures, and the role and impact of adaptive decision-making on startup hiring practices.

The ingenuity of the entrepreneur knows no bounds. Access to data- and analytics-driven capabilities will unleash numerous adaptive decision-making opportunities, and allied decisions involving time, to capitalize on shortages in resources, routines, reputation and/or regulations that characterize the entrepreneurial lifecycle. Hence, we anticipate that scholars working at the intersection of technology entrepreneurship and engineering management will contribute substantially to advancing methodologies, theories and practices associated with data- and analytics-driven decision-making.

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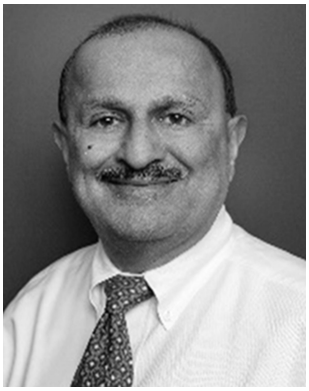

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